Week 1

What is a forest?

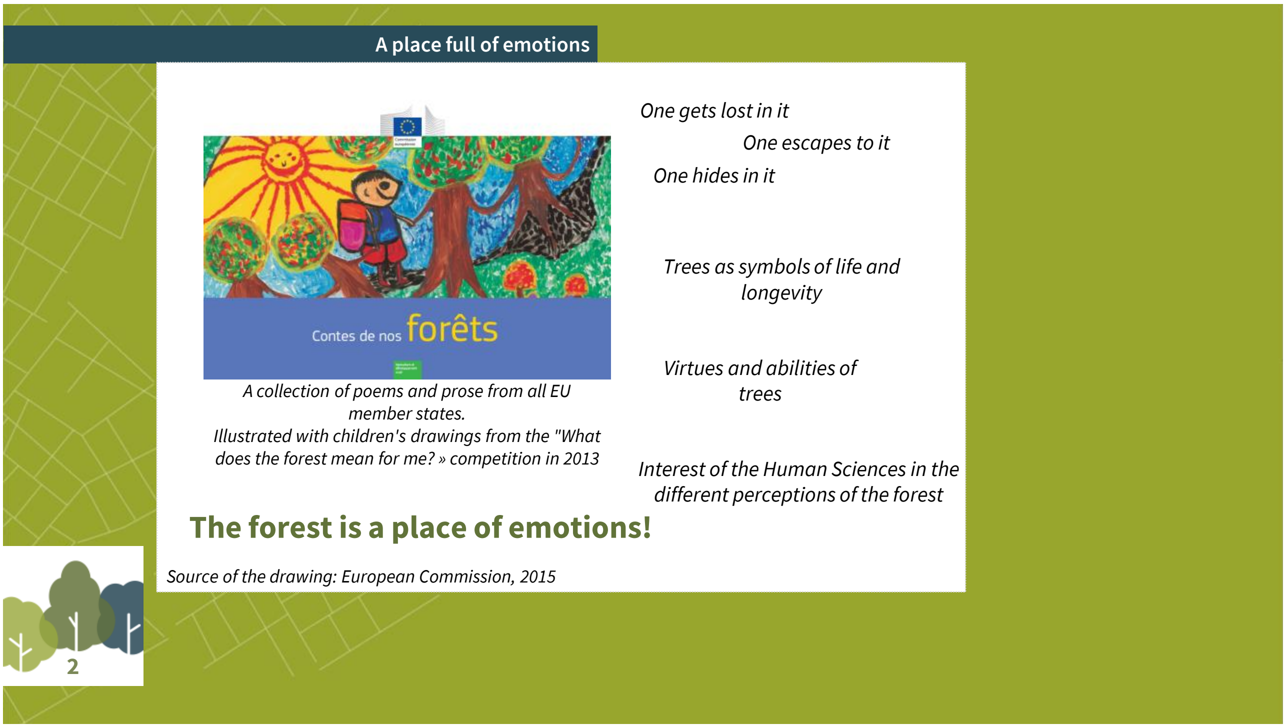
Vidéo 1

What is a forest?

In this first video, we ask ourselves "What is a forest?“

We will approach the subject in the most objective way possible.

The idea is to give definitions of what differentiates this form of land use from others.



A place full of emotions

A collection of poems and prose from all EU member states.
Illustrated with children's drawings from the "What does the forest mean for me? » competition in 2013

One gets lost in it

One escapes to it

One hides in it

Trees as symbols of life and longevity

Virtues and abilities of trees

Interest of the Human Sciences in the different perceptions of the forest

The forest is a place of emotions!

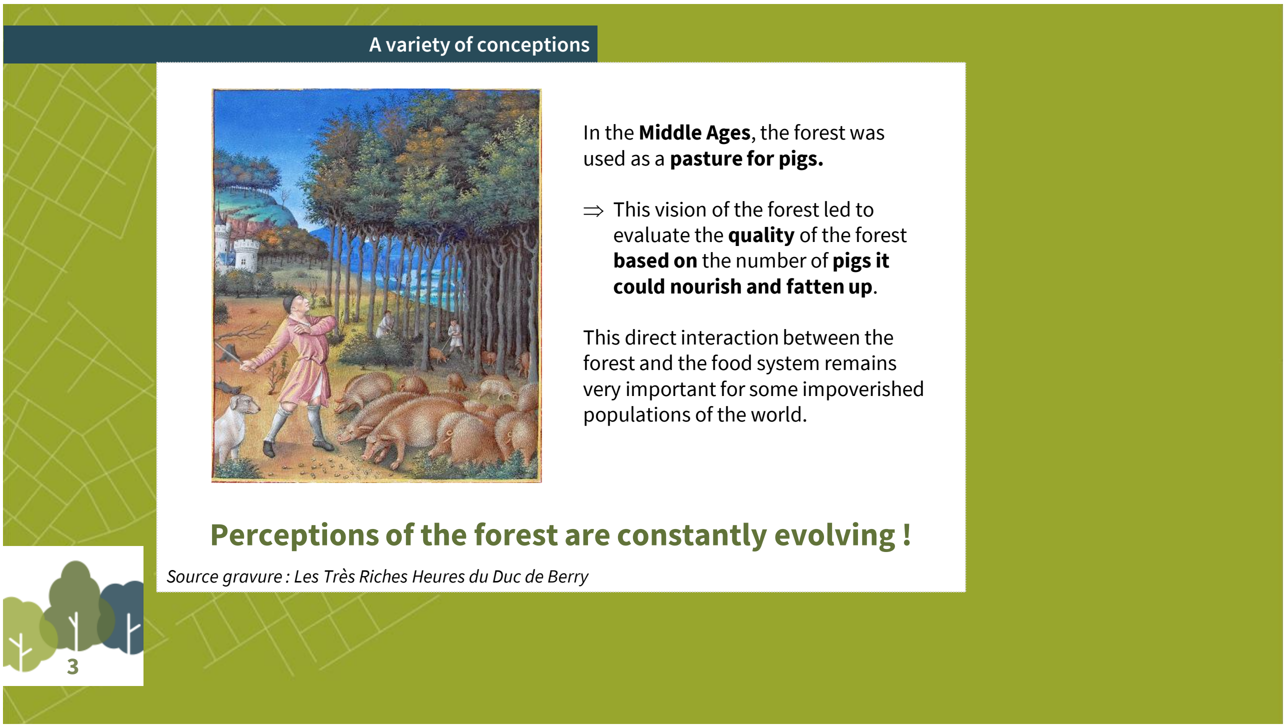
Source of the drawing: European Commission, 2015

Anybody can go for a walk in the forest: the forest is above all a place of emotions, of dreams, a place where one hides, where one goes to pick mushrooms.

The perceptions of the forest are very different depending on where you are or who you are. The way these perceptions differ between you and me is something that is of interest to the human sciences.

This illustration, for example, is the cover of a collection of children's drawings. This collection is the result of a study in which sociologists tried to evaluate the different perceptions of the forest among children throughout Europe.

Link to the European Commission's work :
https://op.europa.eu/fr/publication-detail/-/publication/01103750-26fd-4eee-aed8-87fcc2e1b5e0/language-fr/format-PDF/source-259104820



A variety of conceptions

In the **Middle Ages**, the forest was used as a **pasture for pigs.**

⇒ This vision of the forest led to evaluate the **quality** of the forest **based on** the number of **pigs it could nourish and fatten up**.

This direct interaction between the forest and the food system remains very important for some impoverished populations of the world.

Perceptions of the forest are constantly evolving !

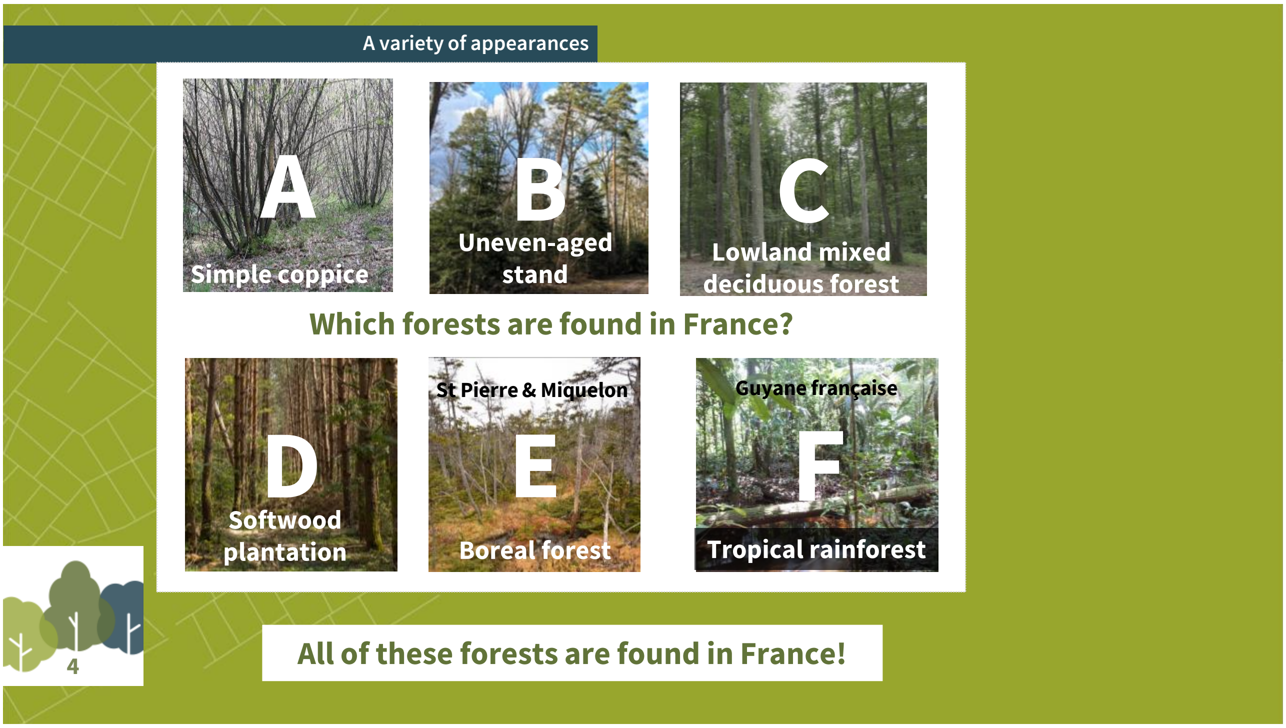
Source gravure : Les Très Riches Heures du Duc de Berry

It is interesting to see how perceptions of the forest change over time.

Here we see a famous engraving where we can see pigs in a forest: the illumination is called "La Glandée".

In the Middle Ages, forests were a pasture for pigs. This view of the forest led to the idea that the quality of a forest was determined by the number of pigs it could fatten. Today, this link between the forest and the food system is no longer as important in our developed countries, but it remains highly pertinent for many of the world's poor.

In this first video, we will see how forest managers characterize the forest. We will then give an objective definition of what a forest constitutes, independent of the emotions and social and cultural references of each person.



A variety of appearances

A Simple coppice

B Uneven-aged stand

C Lowland mixed deciduous forest

Which forests are found in France?

D Softwood plantation

St Pierre & Miquelon E Boreal forest

Guyane française F Tropical rainforest

All of these forests are found in France!

So let’s go beyond our perceptions and ask ourselves what makes these pictures, forests? Look closely, which ones are in France? ... Well, they all are! We are incredibly lucky to have such diverse forests in France, which we will learn to describe and better understand in this MOOC.

A. The first is a **simple coppice**, which can be oak, hornbeam, or chestnut, which is typical of southern France

B. The second is a **uneven-aged mixed stand**, a system very characteristic of the mountain regions (Jura, Alps)

C. The third one is a **lowland mixed deciduous grove**, typical of our landscapes outside of mountainous areas, found all over France

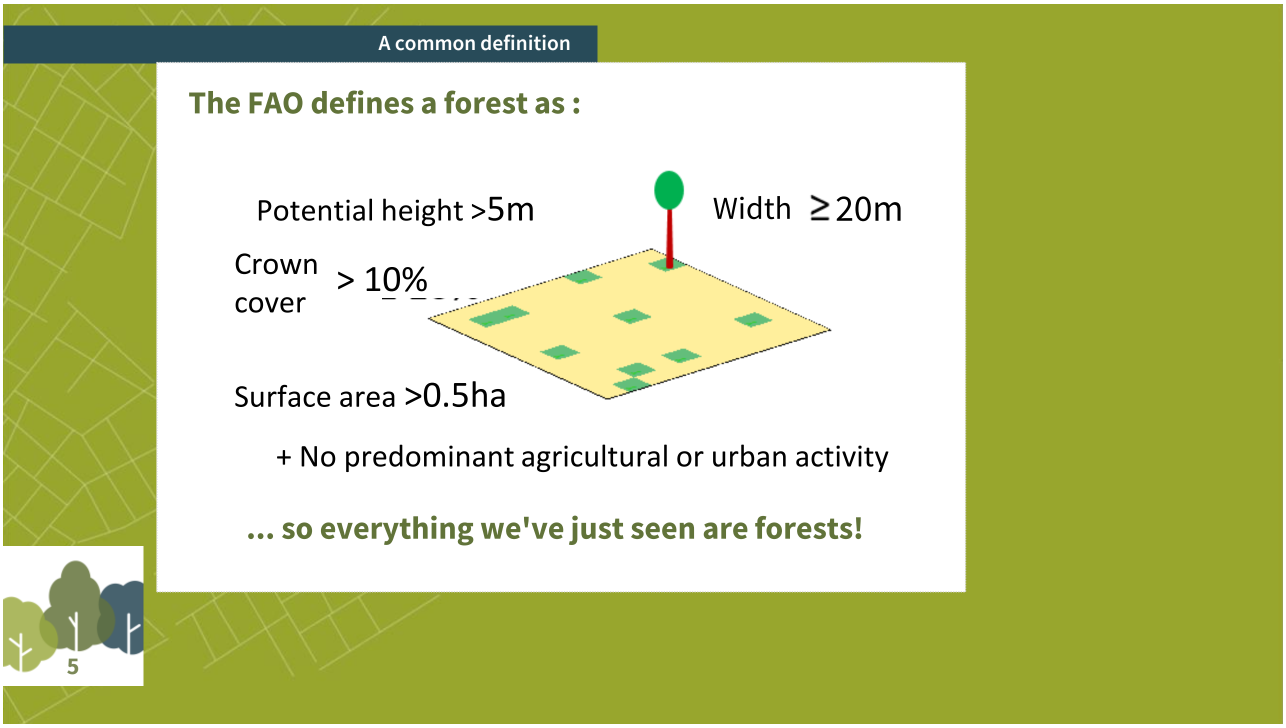
D. Further down, we encounter **softwood plantations**; we will have the opportunity to talk about this particular type of forest.

The last two forests are a bit special

E. The **boreal forest** is found mainly in Canada, Scandinavia, and other northern countries, but in France, they can be found on the islands of Saint-Pierre and Miquelon.

F. The **equatorial forest**, which is typical of the Amazonian Forest but also found on the African and Asian continents. France has tropical rainforests in French Guiana that cover 8 million hectares.

The Forest is a diversity of ecosystems and management systems, all grouped under the name of Forest.



A common definition

The FAO defines a forest as :

Potential height >5m

Width ≥20m

Crown cover > 10%

Surface area >0.5ha

+ No predominant agricultural or urban activity

... so everything we've just seen are forests!

The definition of a forest at the international level is determined by the FAO (Food and Agriculture Organization)

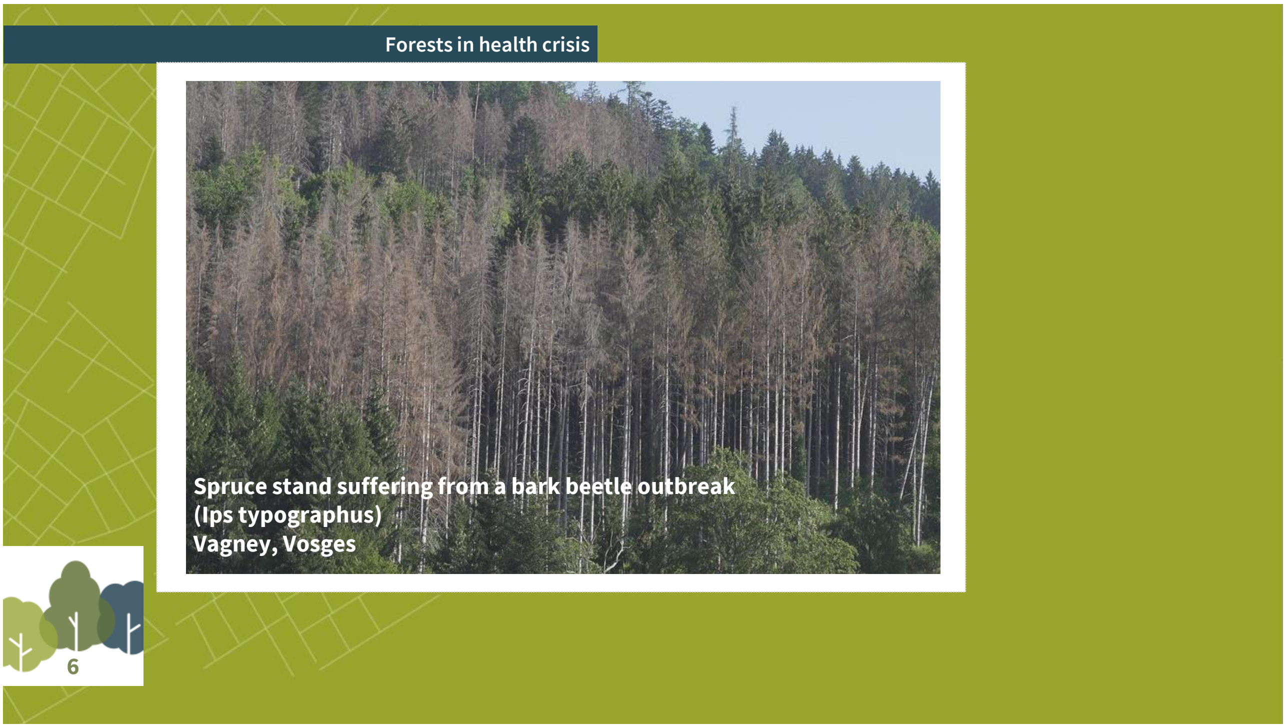
A forest is obviously defined by the presence of trees, which must meet three physical criteria:

- Potential height >5m (different from thickets and other scrublands)
- More than 10% of the ground covered by the projection of the crowns (see chart)
- Surface area >0.5 ha; otherwise it is a small bush or a small grove but not a forest.

Another criterion, more subtle yet important for the purpose of characterizing what differentiates a forest from other land uses:

- These trees must grow in a context that is neither agricultural nor urban (for example, an orchard or an urban park are not forests).

We will now apply this definition to different situations.



Forests in health crisis

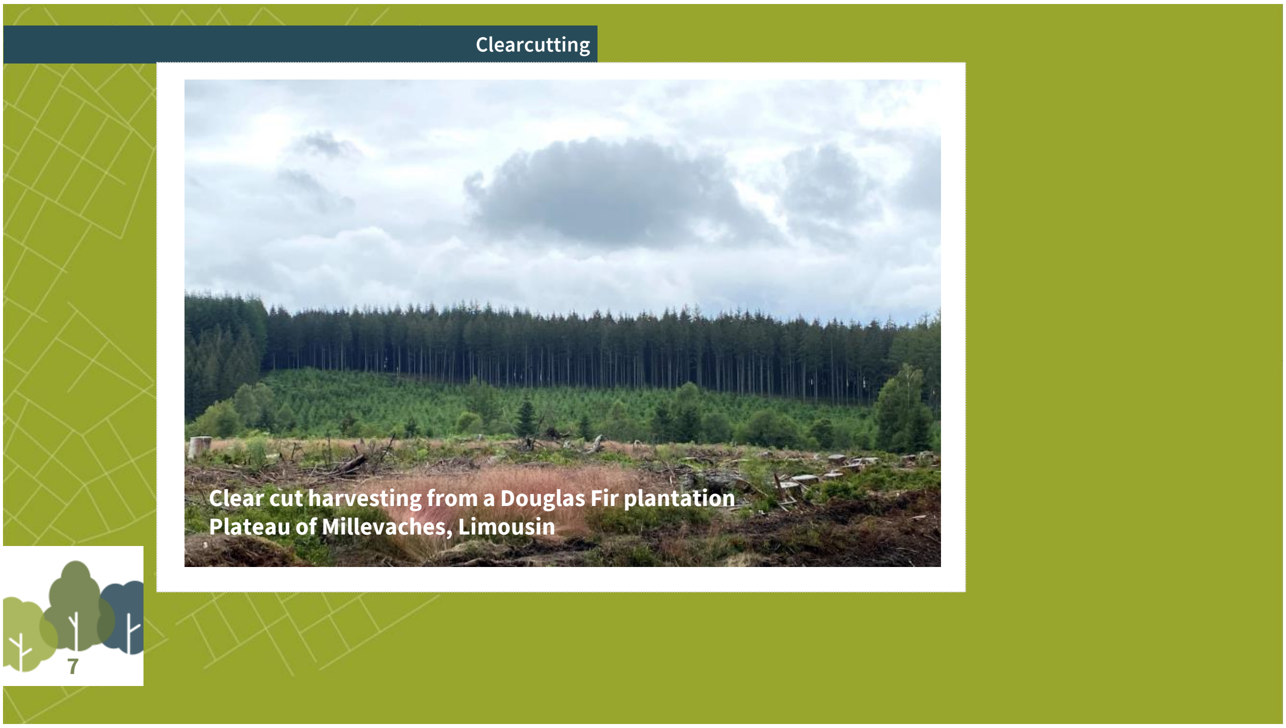
Spruce stand suffering from a bark beetle outbreak
(Ips typographus)
Vagney, Vosges

This image shows **an unhealthy forest**, where an insect outbreak is causing massive **dieback** of trees.

Nevertheless, in our classification, **it is still considered a forest** as long as there is no evidence of other land use.

In France, the law imposes to maintain the wooded state of forest lands; forests in health crisis must be managed and regenerated.

Of course, we can worry about our ability to restore these forests, but at the stage of the photo, we are still in the forest.



Clearcutting

Clear cut harvesting from a Douglas Fir plantation
Plateau of Millevaches, Limousin

In this picture, in the foreground, you can see an area where there are no trees left. This is a **clearcut.**

According to our definition, this is no longer considered a forest. Nevertheless, there is a temporal dimension in that if this clearcut is reforested, replanted and quickly returns to a wooded state (as we can see in the background), we do not declassify the land use. We continue to classify these clear cut areas as forest because their land use remains forest.

Young plantation

Douglas fir saplings (in juniper shrubs)
Plateau of Millevaches, Limousin

This is the stage that follows clearcutting: the regeneration of the forest by seedling planting.

In this photo, although young trees are present, they do not occupy more than 10% of the soil cover and are not yet 5 m tall. Nevertheless, it will potentially become a forest one day and based on this fact we can consider these young plantations as forests.

Bocage and hedgerows

~~Forest~~

Width <20m !

Hedgerow,
Broye, Saône-et-Loire

Although in this photo you can see trees that are more than 5m high and cover more than 10% of the ground, this is not a forest.

It is a linear woodland with a spread of less than 20 m: it is called a hedge, a strip of trees or shrubs that can be found along some roads. It is not a forest!

TB1

Oil palm groves

~~Forest~~

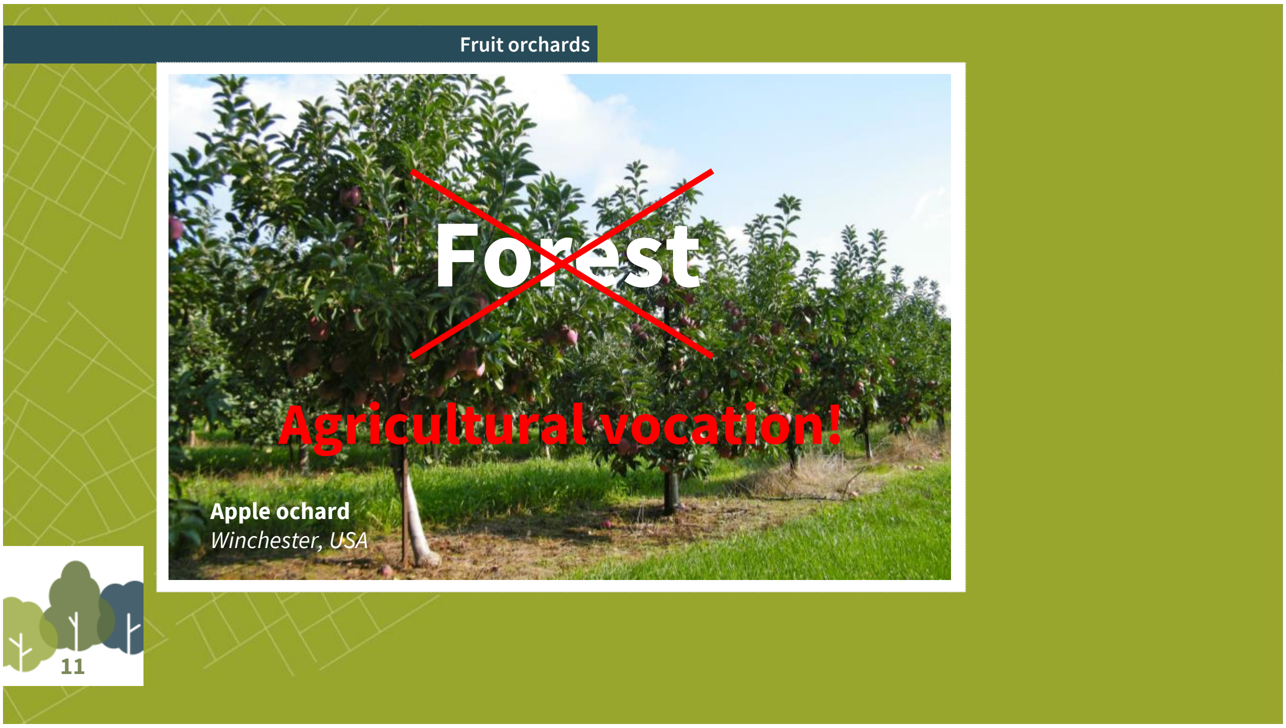
Agricultural vocation !

Oil palm plantation
District de Kunak, Malaisie

This is an oil palm plantation.

In the physical sense this looks like a forest as there are trees which are more than 5m tall, covering more than 10% of the ground, over a width of more than 20m.

Nevertheless, in accordance with the FAO definition, this cannot be deemed a forest due to the land being used for agricultural and industrial purposes.



Fruit orchards

~~Forest~~

Agricultural vocation!

Apple ochard
Winchester, USA

Here, you see an orchard.

These are fruit trees. Again, according to the FAO definition, this is also not considered a forest because of its use i.e. agricultural purposes.

Forest regeneration

Oak natural regeneration
Claudon, Vosges

And this one? Is this a forest?

There are trees which are over 5m tall, but it is not certain that they cover 10% of the ground.

It is nevertheless a forest because it is an oak stand, in a specific stage of regeneration.

If we look closely at the surface, young oak seedlings are already growing, so potentially the trees that will grow beyond 5m and cover more than 10% of the forest floor. They are there!

A difficult regeneration

Forest soil disturbed by wild boar foraging behavior

There is something amiss here!

This is an oak forest, yet on the ground, there are no oak seedlings.

The mature oaks are there, and there is hope to regenerate this forest to restore it, but the acorns have failed to sprout to establish that regeneration.

That's worrisome for foresters.

This is called a regeneration blockage (bottleneck to regeneration), in this case, due to heavy wild boar pressure: too many wild boars are foraging, eating the acorns, and preventing the seedlings from taking root. It is therefore a forest, but it is not certain that it will remain so in the future.

So we are still in a forest, but a forest that forest managers are concerned about. They don't know **if it can remain a forest in the future.**

Special case: Sahel forests

White acacia (*Faidherbia albida*) park
Niger

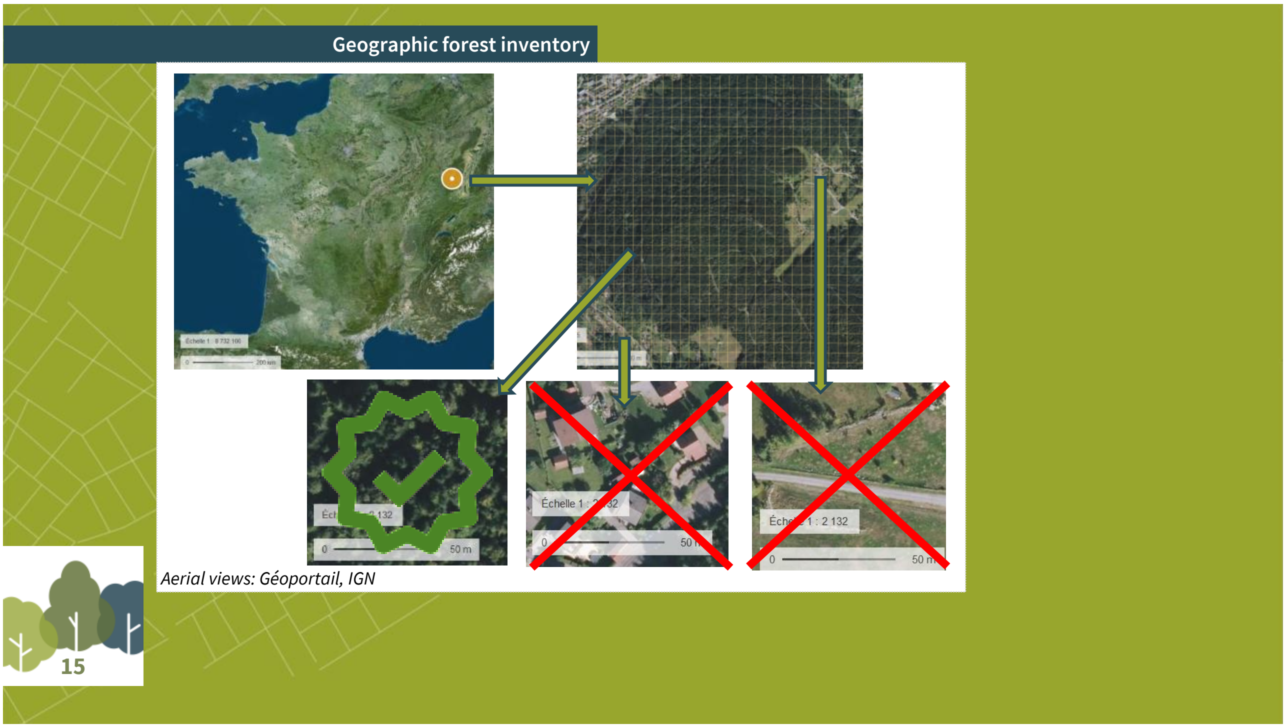
Here we have traveled to the Sahel region of Africa, between Niger and Senegal, to a white acacia (*Faidherbia albida*) woodland park.

Is it a forest?

One would have to determine whether the vegetation cover reaches 10%, perhaps more on the right than on the left.

But for the Sahel region, where the climate is very dry, this is the best we can achieve in terms of a forest.

In Niger, it is considered an important forest.



Geographic forest inventory

Aerial views: Géoportail, IGN

We have just seen many very different vegetation types that constitute "forest" according to the FAO definition.

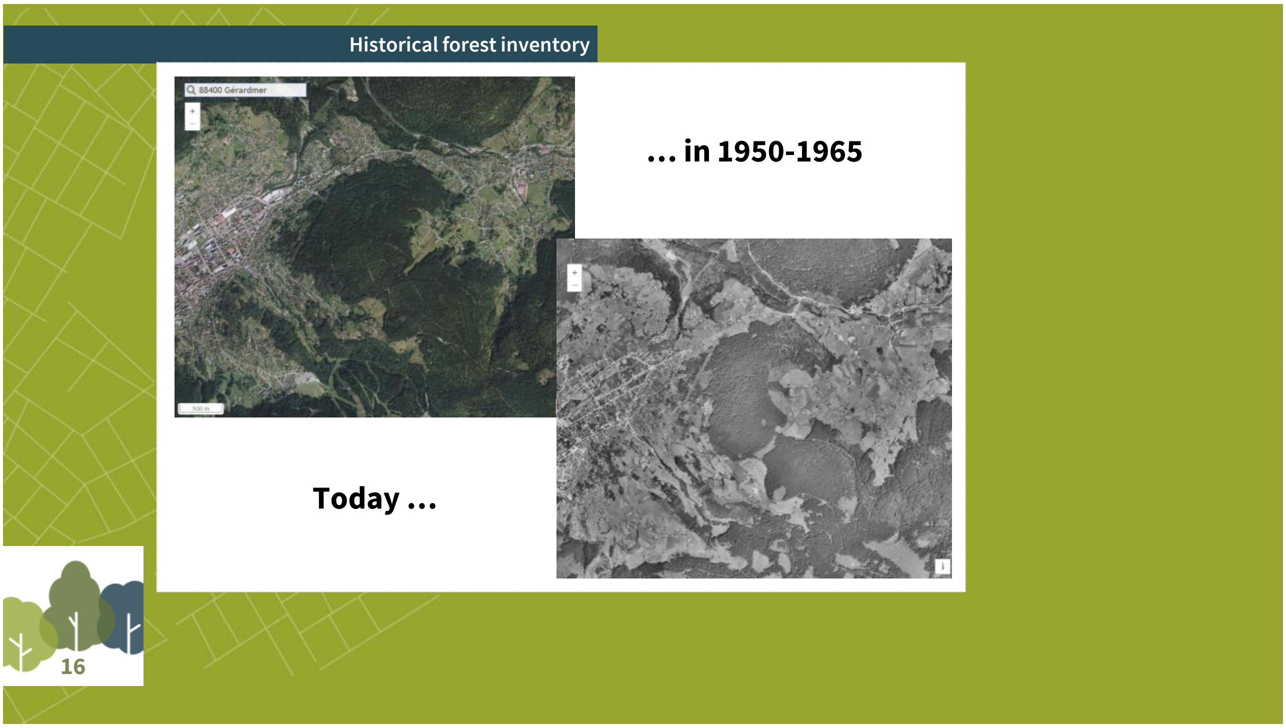
The utility of having a definition that can be transmitted and shared is to keep track of forests around the world and to monitor the dynamics of land use. For example, to be able to identify areas of deforestation or, conversely, the transition of other land uses, particularly those related to agriculture, to forests.

To find out what areas are occupied by French forests, we rely on the services of the IGN (National Institute of Geographic and Forestry Information = *Institut National de l'Information Géographique et Forestière*).

To see how it works, we are going to use aerial photos IGN provides. If we zoom in, for example on this small area of the Vosges, we can determine where there are trees or where there is something else. On a picture like this, if we make a grid with small squares (25m by 25m), we can examine each small square to see if there is forest there or not, and by counting all the squares we will know what the surface area occupied by the forest is, on a given territory.

Site of the IGN forest inventory:

https://inventaire-forestier.ign.fr



Historical forest inventory

… in 1950-1965

Today …

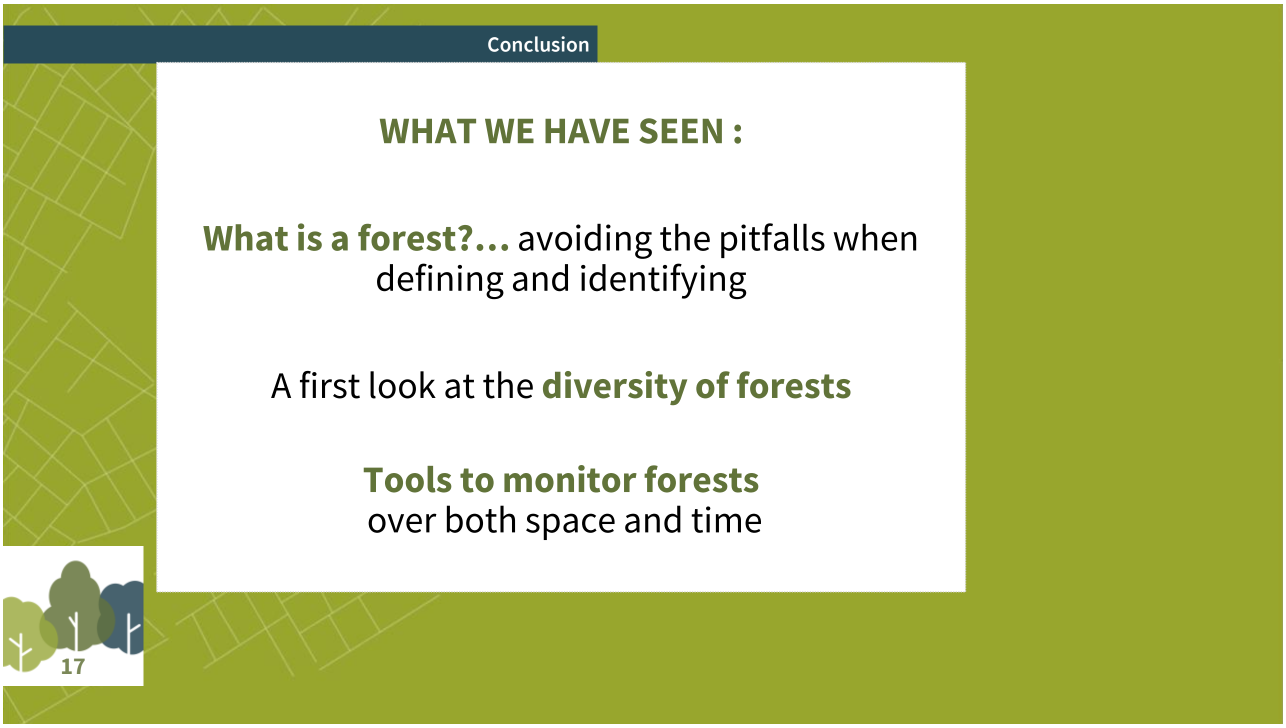
The interest of this information is also to be able to look back in time.

IGN provides us with a highly intriguing tool called "Go back in time » in which you can find current and old photos of your territories.

Let’s go back to the previous photos of this territory as an example. We start by doing a search for an older photo on the website (here for the period 1959-1965), and we can see the existing forest was already present in 1950-1965. However, if we look closely, in detail, we can also see areas where the forest was absent in 50-65, as well as where it have since been restored.

The IGN site is therefore a valuable source of information for monitoring our forests, knowing whether a forest was already there 100 years ago or whether it is recent.

Image : captures d’images du site « remonter le temps » de l’IGN : https://remonterletemps.ign.fr/



Conclusion

WHAT WE HAVE SEEN :

What is a forest?... avoiding the pitfalls when defining and identifying

A first look at the **diversity of forests**

Tools to monitor forests
over both space and time

The objectives of this first video were to :

- establish a common definition of what constitutes a forest, as objectively as possible, while avoiding the pitfalls: oil palm plantations, orchards, hedgerows that are not forests, forests in the harvesting or regeneration stage that are forests even though the mature trees are not present.
- go over some of the diversity of forests. This entire MOOC will be aimed at helping you find your way through this diversity.
- get an initial idea of the existing tools available to learn about forests, their diversity over space and their evolution over time.

References and bibliography

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A variety of conceptions	« La glandée » Enluminure. *Les très riches heures du Duc de Berry*. Jean Colombe (1430–1493) ; Musée Condé (Château de Chantilly, Oise)
A common definition	*Forest Resource Assessment*, FAO, 2015, p3 Termes et Définitions http://www.fao.org/3/ap862f/ap862f00.pdf
Historical forest inventory	Site« Remonter le temps » IGN https://remonterletemps.ign.fr/

Photographs

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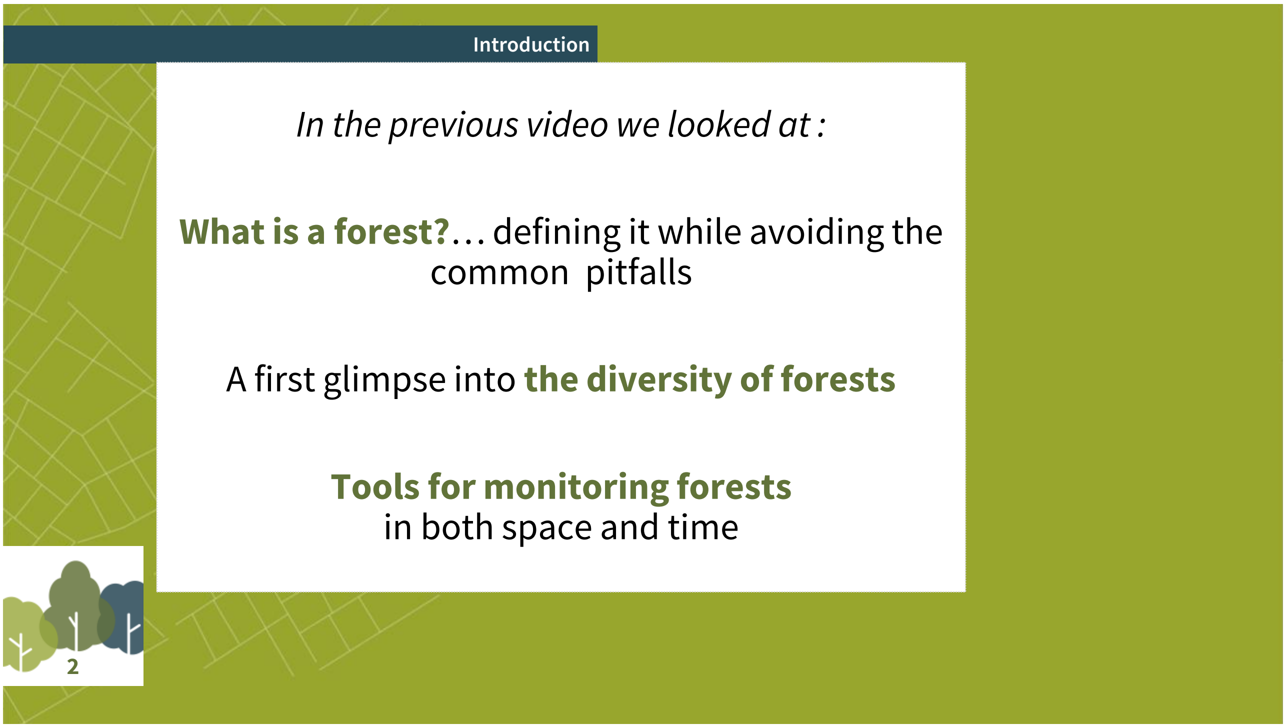
Week 1

What is a forest?

Video 2

Where are forests and where do they come from?



Introduction

In the previous video we looked at :

What is a forest?… defining it while avoiding the common pitfalls

A first glimpse into **the diversity of forests**

Tools for monitoring forests in both space and time

In the first lesson we asked ourselves "what is a forest?»

Also in the first lesson, we looked at how to recognize and define a forest based on its location and land use.

Today we are going to look at where they are and how they have evolved over time.

National Forest Inventory

UN INVENTAIRE FORESTIER ANNUEL
sur l'ensemble de la France métropolitaine

IGN
INSTITUT NATIONAL DE L'INFORMATION GÉOGRAPHIQUE ET FORESTIÈRE

Inventory is not management!

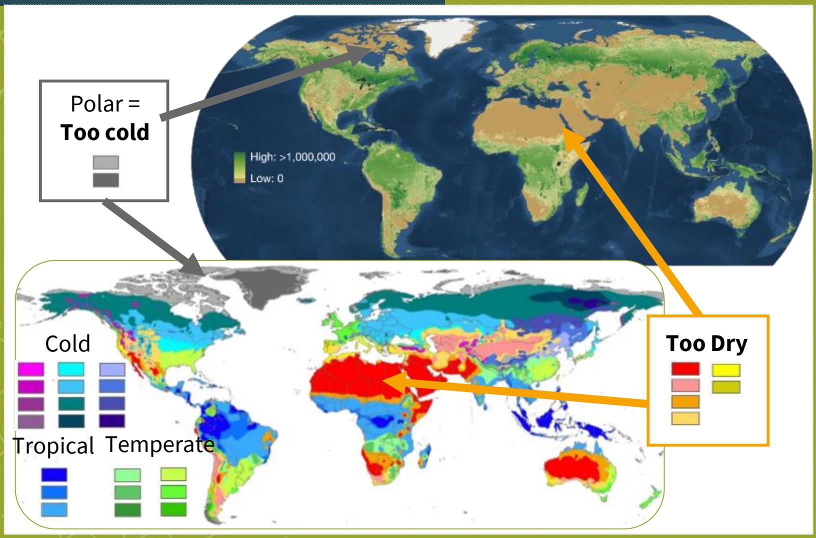
In many countries around the world, there is an entity in charge of collecting data on the location, composition and distribution of forest resources, called the "National Forest Inventory".

In France, the IGN is in charge of this function. Be aware, it is not the "ONF" (Office national des forêts).

IGN is not the same entity as the ONF, which is responsible for the management of public forests. We will explore this further in the second week.

The large-scale management of forests, whether public or private, is not at all the same as monitoring and reporting on the state of a country's forests. It is imperative that the monitoring of the forests remains independent from the private interests of managing the forests. More on this next week.

Forests around the world



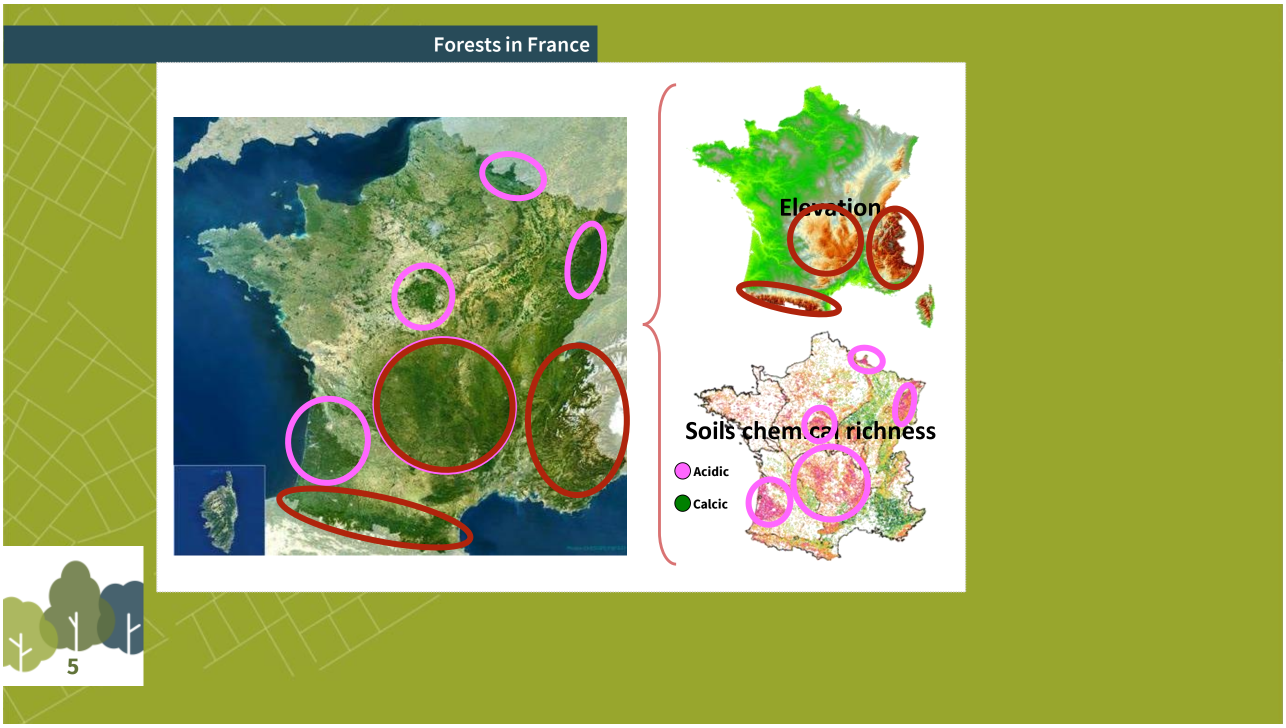
On the macro scale of the world, let’s have a look at where the forests are.

Here, we have two maps: the top one showing the location of forests and the bottom showing climate.

So if overlay these two maps, where are the areas with no forests ?

Are they where it is too hot ? No, because as you can see there are many forests located at, or near, the equator.

If you look closely, what really limits the growth of forests are dry (arid) areas, like the Sahara, or excessively cold areas, like Greenland.



Forests in France

Elevation

Soils chemical richness

● Acidic

● Calcic

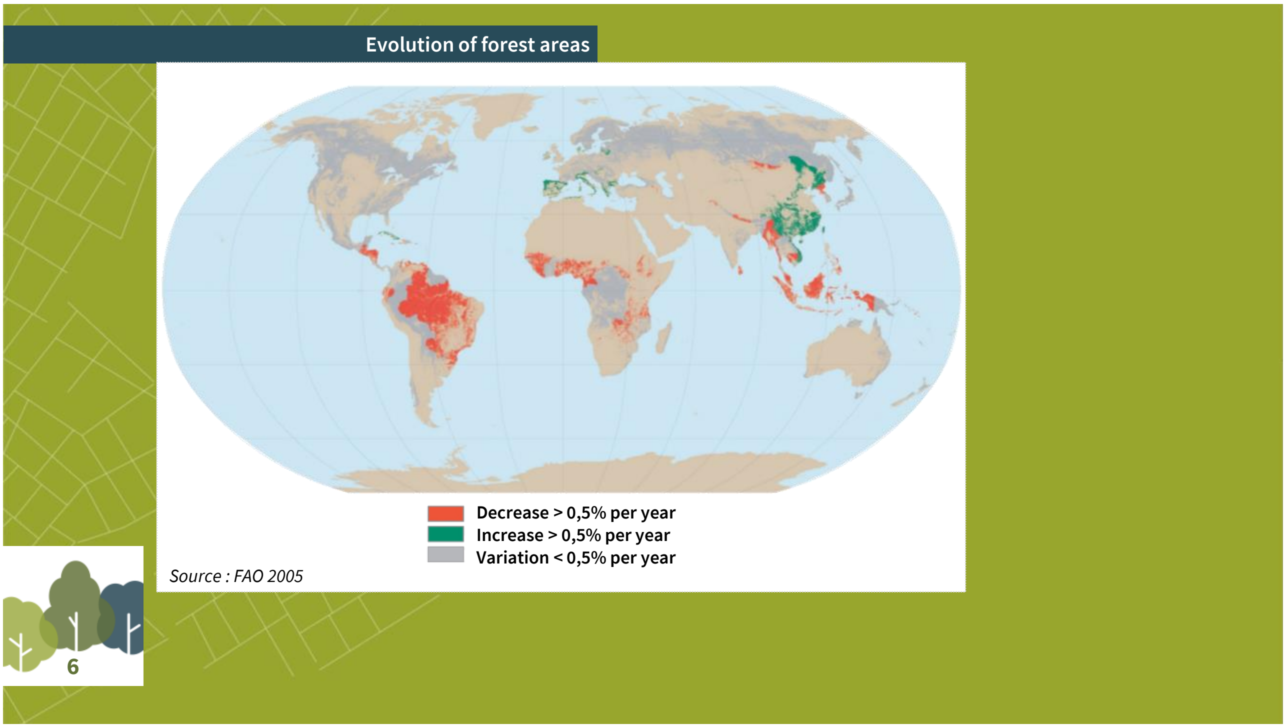
In France, this logic does not work. On the topographic map of France on the left, you can't say that there are no forests in the areas which are too cold or too dry because France has neither.

To help you understand the location of the forests, we have provided you with the two maps on the right. The topographic map which shows you where the mountains are and a map of the chemical richness of the soils, contrasting poor soils (acid) with rich soils (calcareous).

This shows that forests are either in mountainous areas or where the soils are poor (e.g. the large pink areas where forests are sure to be found).

This means that forests in France are in areas unsuitable for agriculture.

In France, the location of the forest is the result of the history of agriculture, which preempts the soil on the forest. There might be forests everywhere (except on the top of mountains) but there are none where man has been practicing farming and grazing since the Gallo-Roman era.



Evolution of forest areas

🟥 Decrease > 0,5% per year
🟩 Increase > 0,5% per year
▨ Variation < 0,5% per year

Source : FAO 2005

Source : FAO Forest Resource Assessment 2005

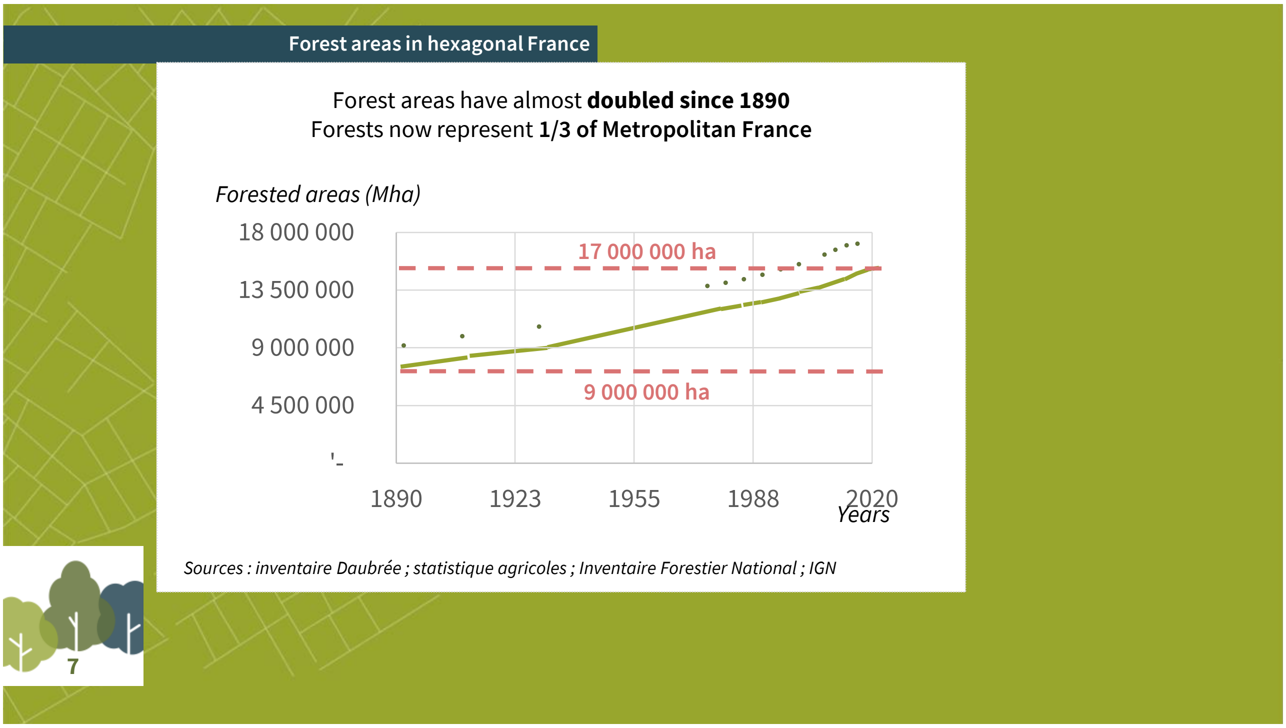
Now, how does this work over time?

Let’s start on a global scale. Here is a map where we highlighted the rate of deforestation (i.e. conversion of forest land to other land uses) in red which has been more than 0.5% per year.

In contrast, the green areas are areas where the forest has increased by more than 0.5% ground area per year.

In the intertropical zone, there is a massive disappearance of forests; this is called tropical deforestation.

But there are also green areas. For example, in China, Spain, Italy, and other parts of Europe, forests cover increasingly more land.



Forest areas in hexagonal France

Forest areas have almost **doubled since 1890**
Forests now represent **1/3 of Metropolitan France**

Sources : inventaire Daubrée ; statistique agricoles ; Inventaire Forestier National ; IGN

Please note that these figures are for mainland France only. The French overseas territories are not taken into account.

As this graph illustrates, forest areas have been increasing by leaps and bounds . The surface area today is 17 million ha, whereas it was only 9 - 10 million ha in the 19th century and just 12 million ha after the Second World War.

What does this increase mean?

When you walk through a forest today, you have a one in three chance of being in a forest that did not exist in 1945! French forests are relatively very young.

And now, what is the reason for this increase?

Forest growth in France 1/3

Unrestricted development from abandoned agricultural land.
Sainte Hélène, Vosges

Photo : Jean François HAMARD

What is the reason for this increase ?

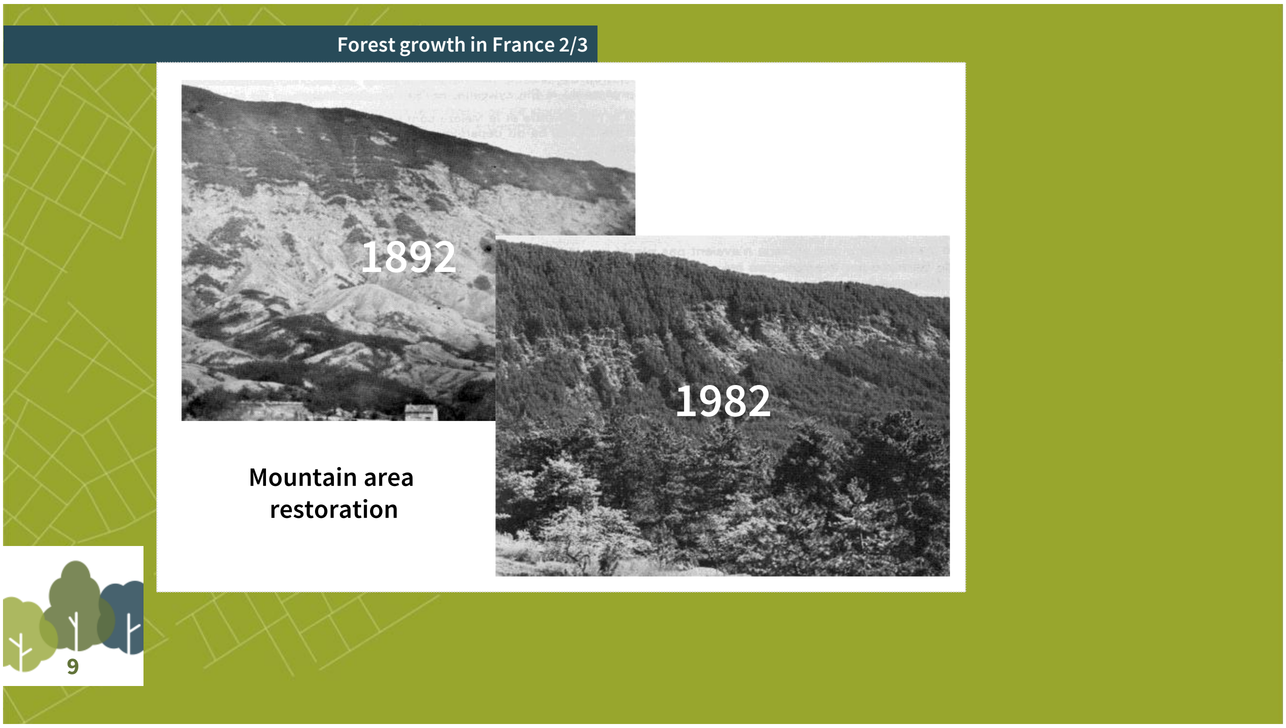
Let us recall what was said in the previous lesson: agricultural land is not considered as forest land. The increase of the forest area in France is therefore explained by the decrease of agricultural land. This is what is known as agricultural abandonment.

In this picture, we have a typical view of what we call forest thickets; a forest which is allowed to grow naturally after the abandonment of agricultural land.

We can also observe that this forest is very young, about 20 years old.

For many forests, only an expert eye could tell if this forest was in existence 50 or 100 years ago.

For us, old-growth forests (i.e. forests older than 100 years) are different and quite fascinating, especially from a biodiversity point of view.



Forest growth in France 2/3

1892

1982

Mountain area restoration

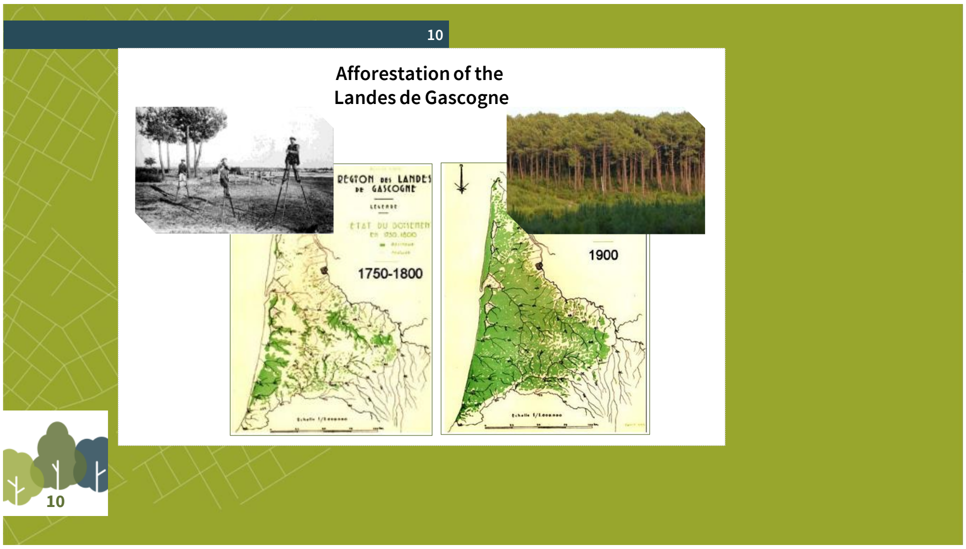
In the 19th and early 20th centuries, forest areas increased in France due to voluntary afforestation policies.

There was an increasing awareness that there of the need for more forested cover in France with very little cover.

The restoration of mountain terrain (RTM) is an example of these major works policies.

It has planted trees to help stabilize steep slopes degraded through pastoralism among others factors, and to fight against erosion.

This photo is located in the Cevennes.



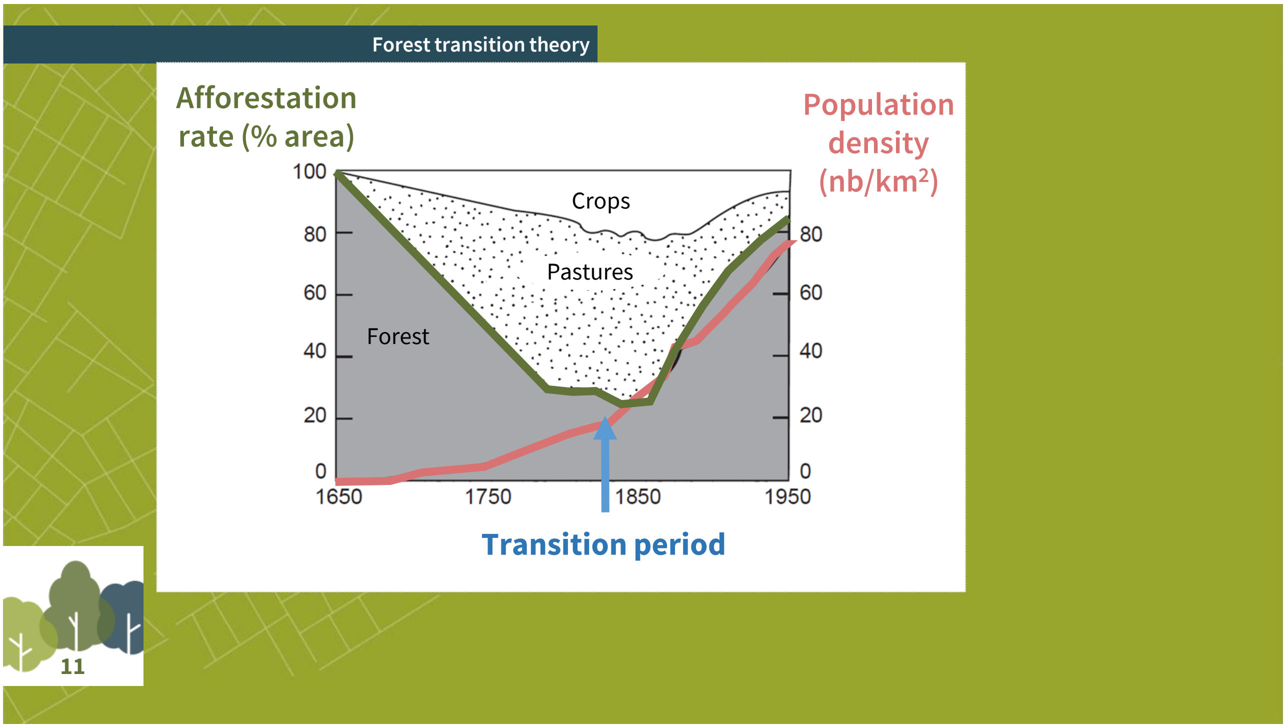
Afforestation of the Landes de Gascogne

Another well-known example is the afforestation of the Landes de Gascogne. As their name suggests, these moors were areas of subsistence agro-pastoralism on very poor soils (we can see the image of the Landes shepherds on their stilts). In 1857 a law ordered the communes to reforest their land, which had previously been free to use, in order to develop this area. This was similar to colonisation by the state, which brought progress, and colonisation had very positive values in the 19th century.

This was followed by major afforestation work using a local species, the maritime pine, which had already been growing along the coast.
This is the very unique history of this more than one million hectares massif of pine forest on very poor and very acidic soils.

As a consequence of all this, the forest in France is young as there aren't any large relict forests where man has had little impact for hundreds of years. These are what we call primary forests, they can be found in North America or in other Central European countries. In France, the forest is linked to the history of societies and I encourage you, every time you go to a forest, to ask yourself about its history.

Sources des Images Wikimedia commons : - 1750-1800 : https://commons.wikimedia.org/wiki/File:Boisement-landes-1750-1800_def.jpg?uselang=fr - 1900 : https://commons.wikimedia.org/wiki/File:Boisement-landes-1900_def.jpg?uselang=fr - Bergers Landais : https://commons.wikimedia.org/wiki/File:BergersLandais3.jpg - Forêt landaise : Larrousiney (Wikimedia) https://fr.wikipedia.org/wiki/Loi_relative_%C3%A0_l%27assainissement_et_de_mise_en_culture_des_Landes_de_Gascogne#/ media/Fichier:ForetLandes.JPG



Forest transition theory

An attempt can be made to explain changes in the forest area by the theory of forest transition. It is illustrated here with the example of Massachusetts from 1650 to 1950, which has the advantage of a having a short history since we can date the beginning of settlement exactly because of recent colonization.

In France, it is more complicated, as we have to go back to an earlier history.

In Massachusetts, in 1650, when the first Europeans settled, forests occupied 100% of the area (shown in grey).

They cleared the land to install sedentary agriculture which lead to a decrease in forest areas (deforestation).

Then, at some point, approximately in the 19th century, it was realized that forests were becoming too scarce in these developing countries.

But above all, the industrial revolution brought about a complete change in lifestyle and production, especially with regards to the development of energy and mines (especially oil and coal), people concentrated in cities, agriculture intensified and more people were fed with less land. Forests grew despite the increase of the population (pink curve).

The theory of forest transition (Mather 1992) states that these evolutions are always the same and inherent to universal development dynamics.

Although this theory is controversial, it may lead us to look at the dynamics of global deforestation and reforestation differently: countries in the southern hemisphere with the highest deforestation rates may simply be doing what we did in the 17th or 18th century. China has recently made a transition to forestry, with impressive reforestation programs, just as we did in the 19th century.

Conclusion

Forests can grow (just about) anywhere!

Unless it is too cold or too dry.

Forests grow where humans let them grow

Humans use the land for its many purposes, but historically

The development of societies has made it possible to stop deforestation!

(notion of forest transition)

The forest is a slow ecosystem.
Forests are the result of a long history.

A 30, 50 or even 100 year old forest is a young forest!

The decisions we make for our forest today will impact generations at the end of the century.

That's it for today. Three essential things to remember:

- A forest, based on the definition given in the first video, can grow just about anywhere except in areas which are too cold or too dry (later, we will see that not just any forest can grow anywhere).

- It is the influence of man, who needs the land and uses it for many other purposes (e.g. agriculture), that we do not find as many forests as nature would otherwise support.

- The growth of societies has historically halted deforestation. Forests are therefore a slowly evolving ecosystem; the result of a long history. A 30, 50, or even 100 years old forest remains a young forest.

- So the next time you find yourself in a forest, remember that in France the forest is young. There is very little chance of being in a forest that has existed since prehistoric times. On the contrary, something interesting to do the next time you are in a forest is to wonder about its more recent history: what it was 100 years ago and what will it become in the next 100 years? The decisions we make for our forests today will affect the generations at the end of the century.

Bibliographic references

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Forests in the world	Forests map: Crowther et al. 2015, Mapping tree density at a global scale Climates map : Peel et al. 2007, Updated world map of the Köppen-Geiger climate classification
Forest area in hexagonal France	*IGN data available on the forest inventory portal:* *https://inventaire-forestier.ign.fr/*
Forest transition theory	*Mather, A. S. (1992). The forest transition. Area, 24(4) :367–379* *https://www.jstor.org/stable/20003181?seq=1*
Evolution of forest areas	« Global Forest Resources Assessment - Progress towards sustainable forest management", FAO 2006 http://www.fao.org/3/a0400e/a0400e00.htm

Photographs

Jean-François HAMARD

Wikimedia Commons

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Week 1

What is a forest ?

Video 3

Open and dense forests, basal area

Today we will discuss a new concept: basal area

Lowland hardwood forest

Beech Forest in the middle of the cycle
Saint Hélène, Vosges

Let’s take another walk in the forest. This is a forest that looks like the so-called lowland hardwood forest.

In this module, we begin by introducing you to the measurements that foresters make on trees to extract interesting information.

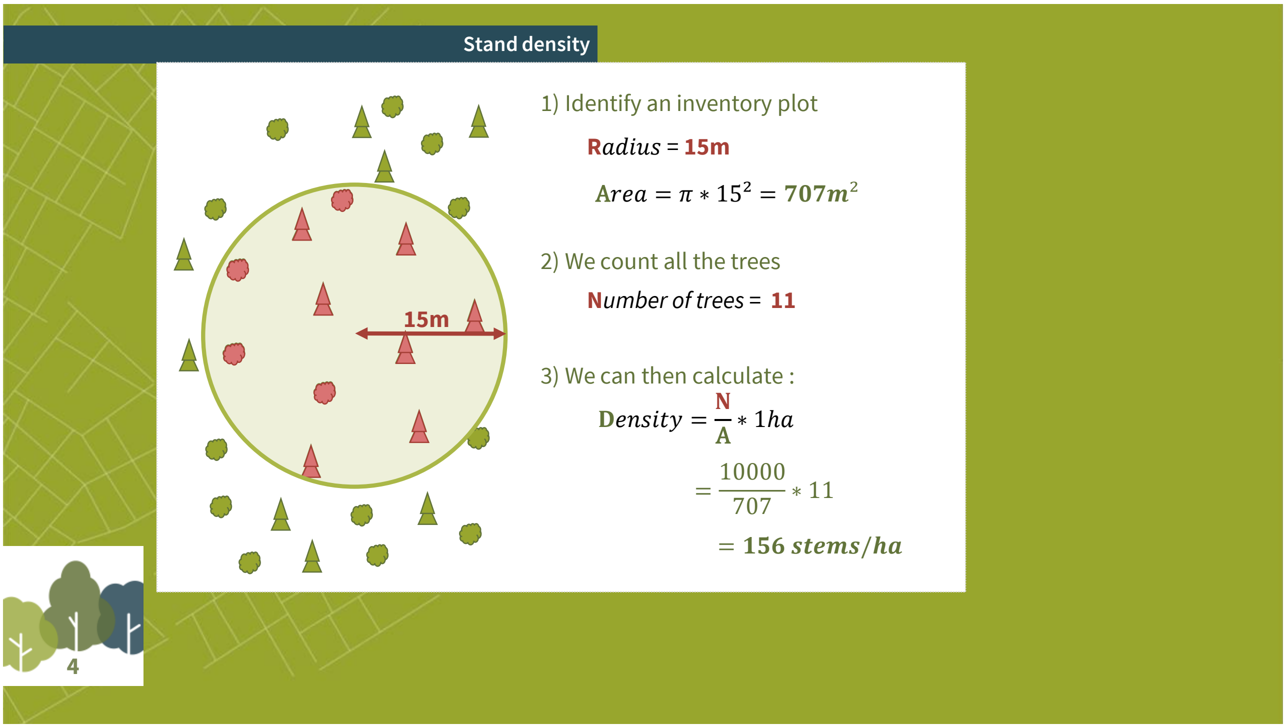
Measuring trees is referred to as **DENDROMETRY**

Another lowland hardwood forest

Naturally regenerating oak forest
Claudon, Vosges

Like in the previous photo, this is another lowland deciduous forest; it is a naturally regenerating oak forest.

If we look for a simple indicator to quantify the difference between these two forests, we can say that the previous one contains many more trees than this one.



Stand density

1) Identify an inventory plot

Radius = **15m**

$Area = \pi * 15^2 = \mathbf{707m^2}$

2) We count all the trees

Number of trees = **11**

3) We can then calculate :

$$Density = \frac{\mathbf{N}}{\mathbf{A}} * 1ha$$

$$= \frac{10000}{707} * 11$$

$$= \mathbf{156\ stems/ha}$$

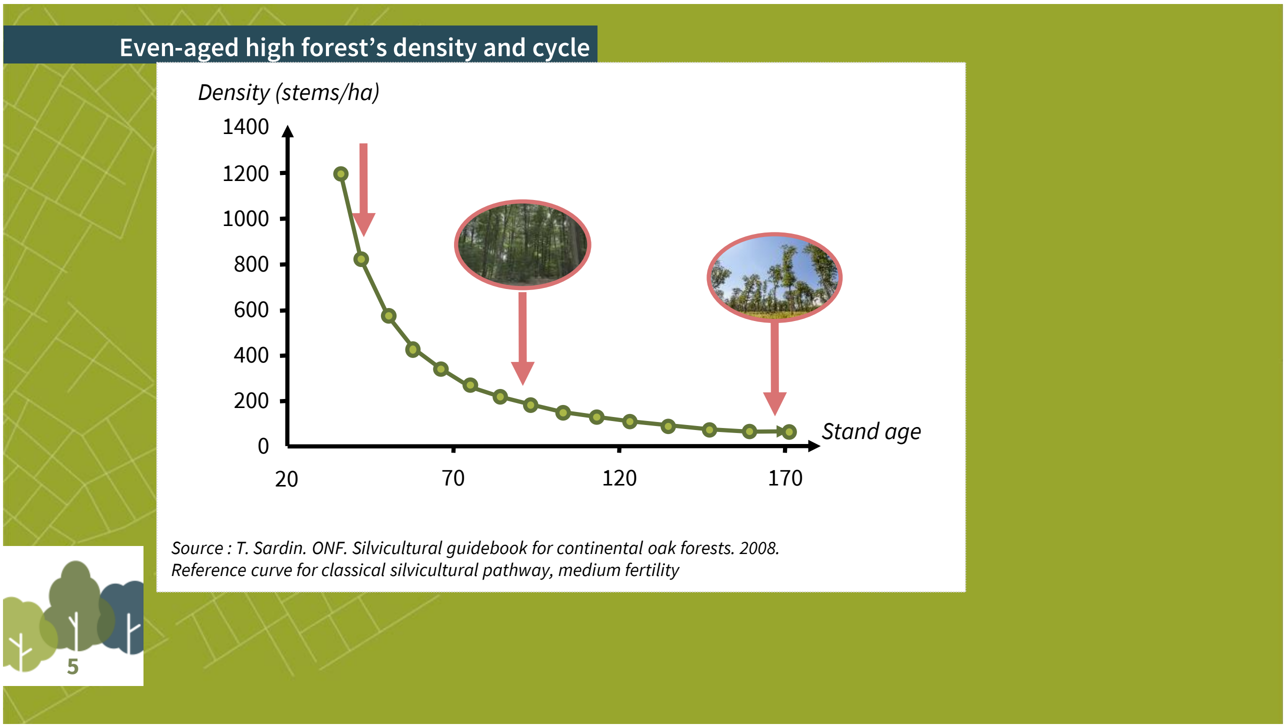
So, the first simple measurement is to count the number of trees in a given area: **Stand density**

To do so :

1. We are going to set up what we call an inventory plot: shown by the circle, with a radius of 15m, thus an area of 707m²,
2. Then, we will count all the trees inside the circle, in this case 11.
3. What we call the density of this stand is the number of trees, here 11, divided by the surface area of the plot, converted in hectare (10 000 m^2). This is to have a basis for comparison that does not depend too much on the size of the plot.

Please note that: 1ha is 10 000 m².
707m2 is 707/10000 = 0.0707ha.

So, here, we have a stand density of 156 trees / ha.



Even-aged high forest’s density and cycle

Source : T. Sardin. ONF. Silvicultural guidebook for continental oak forests. 2008.
Reference curve for classical silvicultural pathway, medium fertility

Let's go back to our oak forests at two different stages: one was a forest that was found to be quite dense; the other rather open. And we have just learned to characterize them by stand density.

This graph is taken from a silviculture guide used by the “Office National des Forêts”. It shows you how stand density should evolve along with the cycle of a regular oak forest: you regenerate the forest, then, at the end of the cycle, you get to the final harvest, and finally you start regenerating the forest again.

Our two forests are indicated by the red arrows. You can see that at the end of the cycle there are almost no trees left, and then we start over again on a cycle where we regenerate the forest. The early stages of the cycle (thickets, saplings, pole stage) have even higher densities.

Early stages with high density

And this is indeed what the forest looks like in these early stages: you have lots of small, young trees.

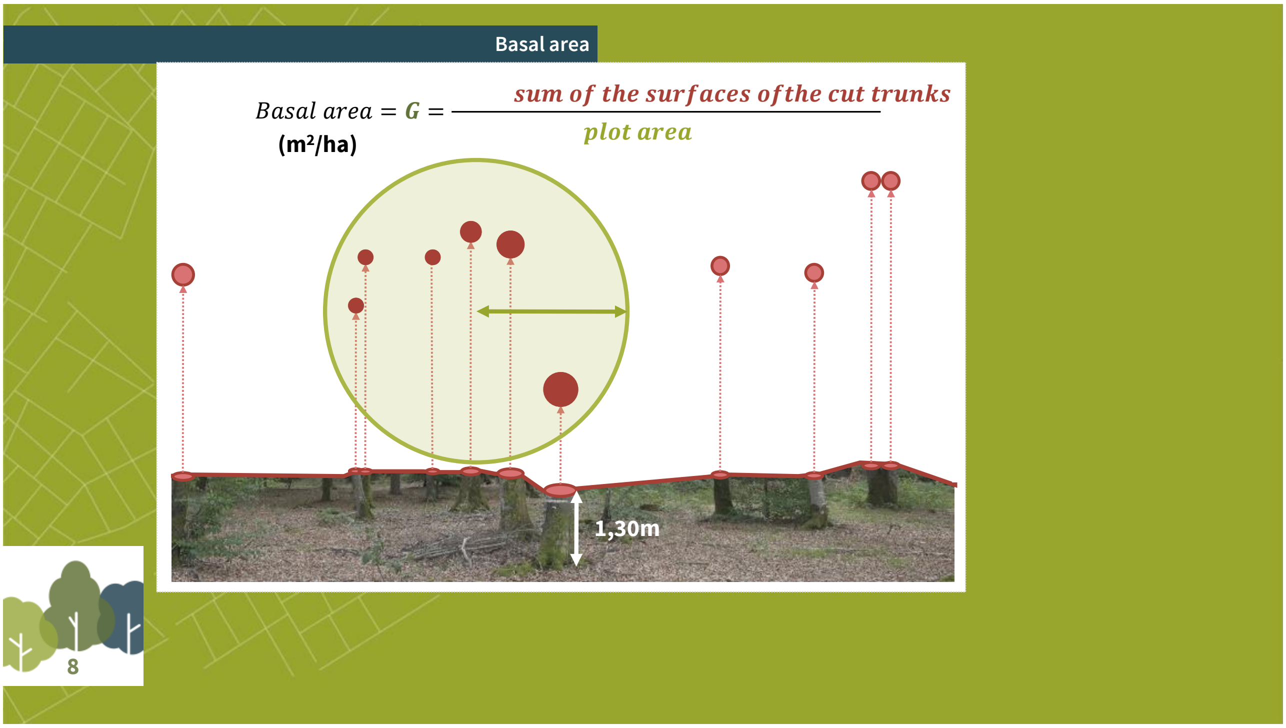
Other indicators?

Try to practice measuring stand density and you will see for yourself that, although it looks fairly simple in theory, in practice it is not. In fact, it raises many questions.

- How do you choose the plot area ?
- Do you have to count all the trees, even the very small ones? The problem with the density is that it places just as much importance on a small tree as a large one.

In this forest, when measuring the density, you may not be able to differentiate between the area in the background with large trees and the area in the foreground on the left , where there are small seedlings.

So, in this case we will need to look for other indicators.



Basal area

$$Basal\ area = G = \frac{sum\ of\ the\ surfaces\ ofthe\ cut\ trunks}{plot\ area}$$

(m²/ha)

Ideally what we would like to measure is a notion of the volume occupied by the trees, at least aerially.

And since it is not easy to measure tree volumes because of their complex geometry due to their size and branches, foresters have come up with a very simple technique of measuring their approximate volume.

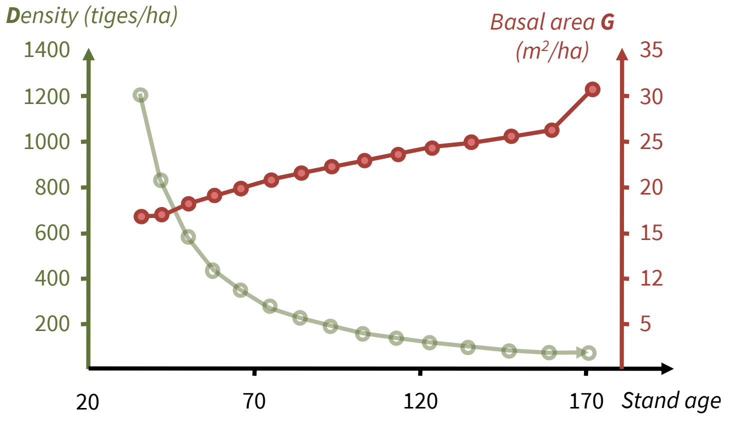
The principle is that you measure the diameters of the trees to estimate the volume they occupy.

The forester measures what is called the **BASAL AREA** (G)

To understand this, you have to imagine that you have cut (virtually, of course) the tree stand at 1.30m high, and then you will view this cut from above.
And in relation to the density measurement, you're going to add NOT the number of trees, but the surface area occupied by these trunks cut at 1.30 m, which we will reduce to the surface area of the plot.

Here, for example, we have 21m²/ha.

Density and cycle of regular forest



Source : T. Sardin. ONF. Silvicultural guidebook. Continental oak forests. 2008.
Reference curve for classical pathway in medium fertility

This graph illustrates, as previously, stand density, in addition to basal area. In theory, a basal area should vary from zero (no trees) to 10,000 = all the space is occupied by trunks. In reality, it varies far less.

You can see that this basal area starts at around 15m^2/ha.

Compared to the 21m^2/ha measured in the previous forest., this is rather low, even though there are many trees.

Yes, there are a lot of trees, but since the trees are quite young and therefore smaller, the cumulative area of cut trunks is not very large.

As the stand grows, the trees age and foresters cut down some of them to control basal area in order to steadily increase it overall (yes, trees are regularly removed but the others benefit and grow). In the later stages, we reach basal areas of about 22 - 25 m2/ha. By letting them grow, the basal area increases to values up to 30m2/ha.

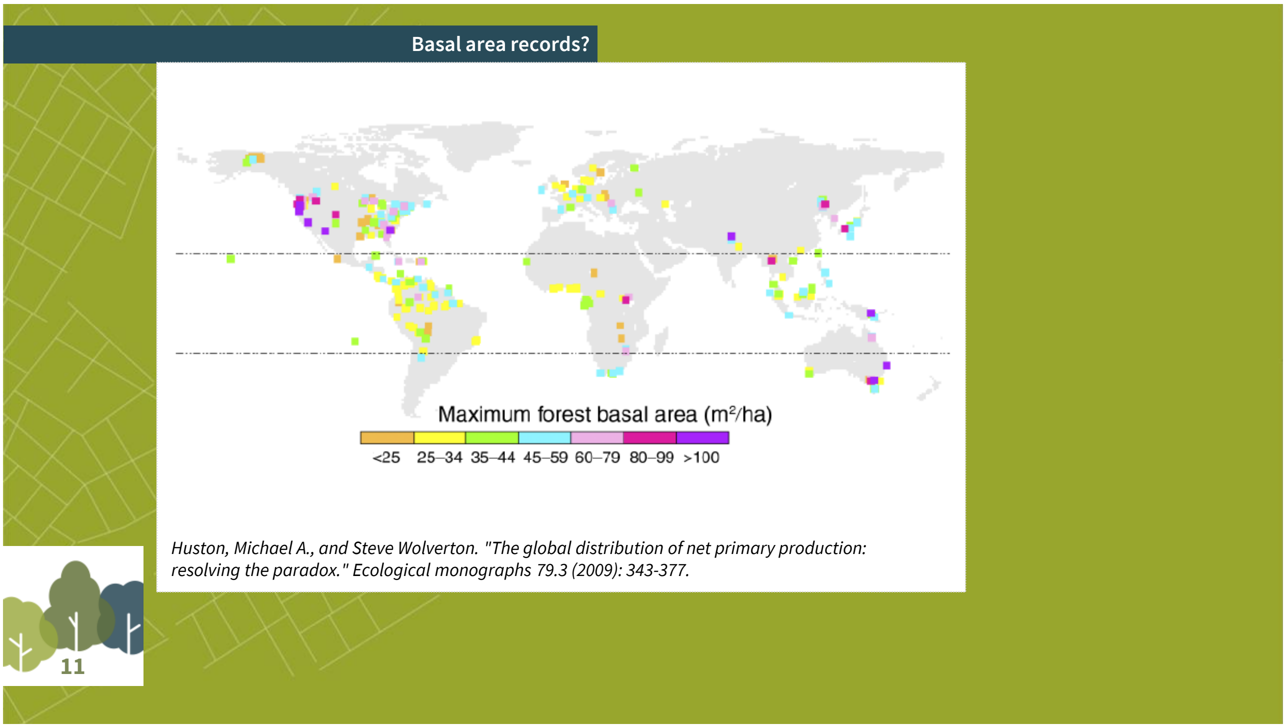
Now let’s go on the field to see if what is shown in the silvicultural guidebooks is a reality in practice!

To the extreme limit!

10

I have always wondered whether there is a maximum attainable basal area. Obviously, because tree trunks and crown are round and take up a lot of space, it would be impossible to reach 10,000 m²/ha without the forest becoming very compact.

Nevertheless, we should be able to increase the basal area much higher than 30-40 m²/ha. I know, by doing this, would already make quite dense forests.



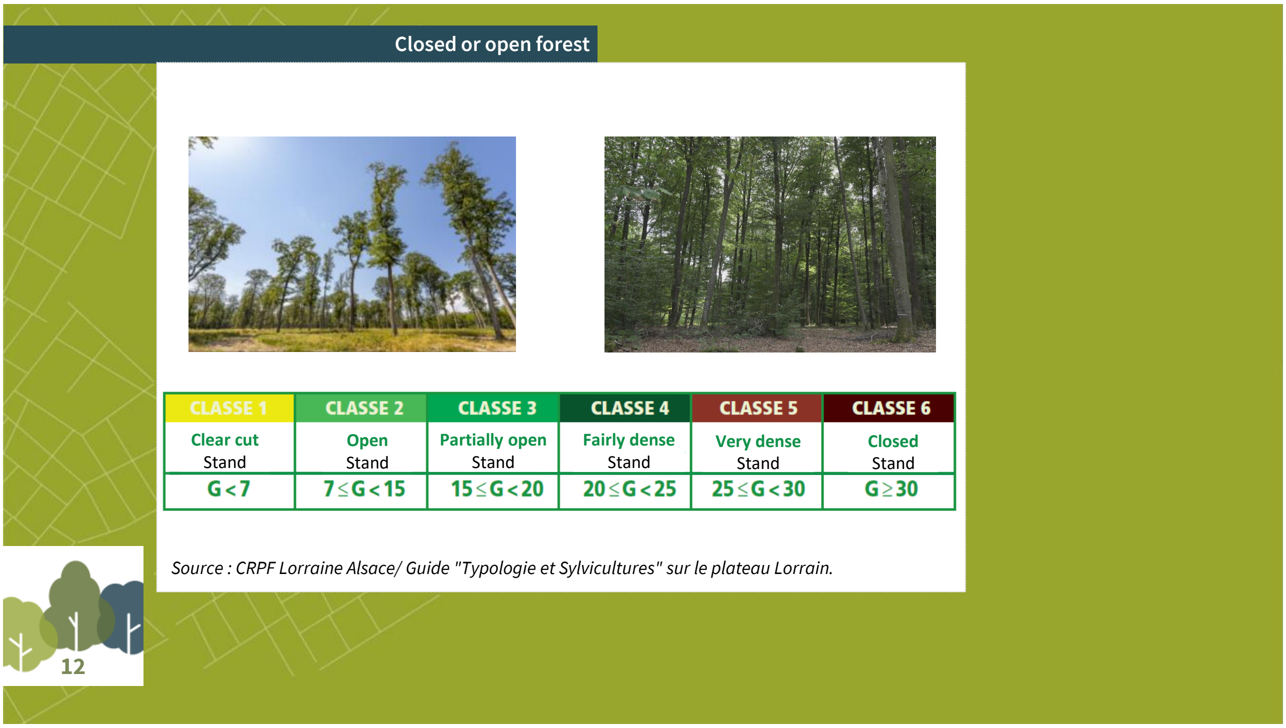
Basal area records?

Huston, Michael A., and Steve Wolverton. "The global distribution of net primary production: resolving the paradox." Ecological monographs 79.3 (2009): 343-377.

This publication has listed the basal area records reported in several places around the world. You can see that the maximums exceed 100 m²/ha (in fact they go up to 140 m²/ha).

This is much more than the typically very dense forests of France and the rest of Europe or even the lush tropical forests.

Indeed, these maxima can be observed on rich soils such as those of some softwood forests on the west coast of the United States.



Closed or open forest

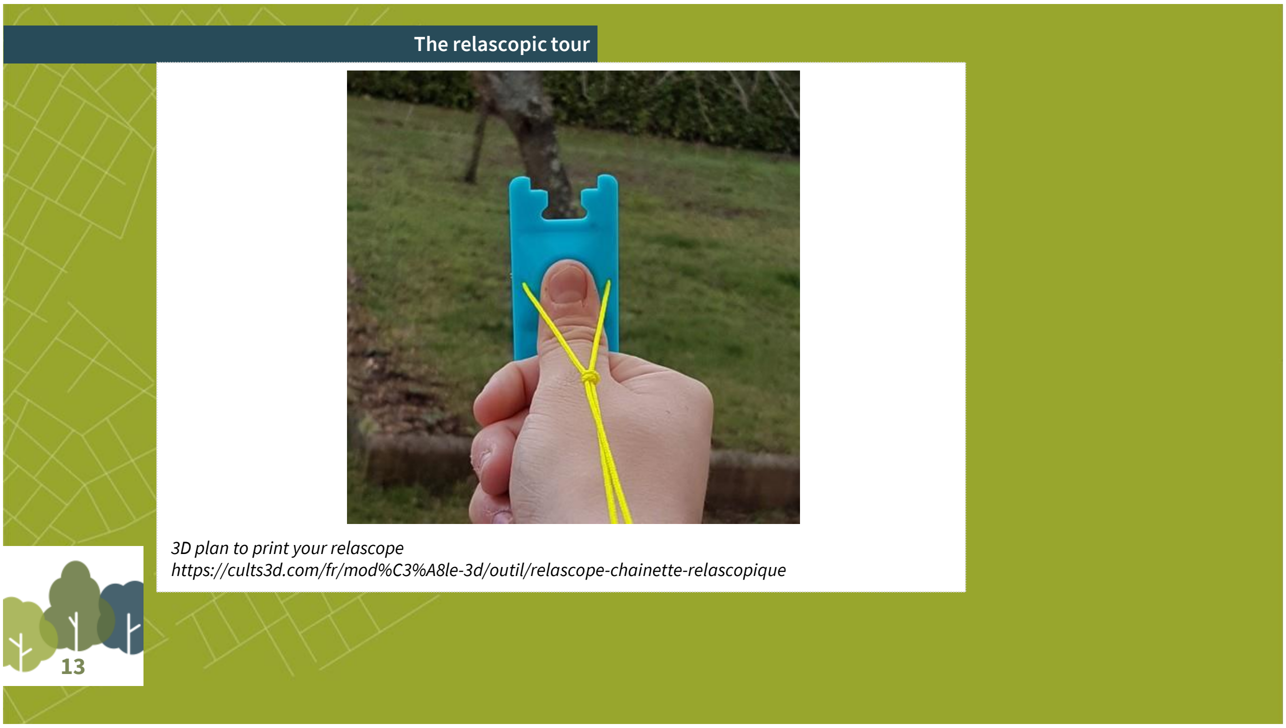
CLASSE 1	CLASSE 2	CLASSE 3	CLASSE 4	CLASSE 5	CLASSE 6
Clear cut Stand	Open Stand	Partially open Stand	Fairly dense Stand	Very dense Stand	Closed Stand
$G < 7$	$7 \leq G < 15$	$15 \leq G < 20$	$20 \leq G < 25$	$25 \leq G < 30$	$G \geq 30$

Source : CRPF Lorraine Alsace/ Guide "Typologie et Sylvicultures" sur le plateau Lorrain.

The basal area is an excellent indicator to quantify, quite intuitively, the notion of closed or open forest. Here, you see how private forests classify the stands of the Lorraine plateau according to their basal area.

- Below 7m2 it is a very clear stand called a »clearing",
- between 7 and 15, it is open
- more than 25 , is very dense
- more than 30 , is a closed forest.

For the silviculturist, the basal area is a precious indicator to know the situation of their forest, in terms of capital, and to make decisions of what needs to be done.
We will talk more about silviculture in the coming weeks.



The relascopic tour

3D plan to print your relascope
https://cults3d.com/fr/mod%C3%A8le-3d/outil/relascope-chainette-relascopique

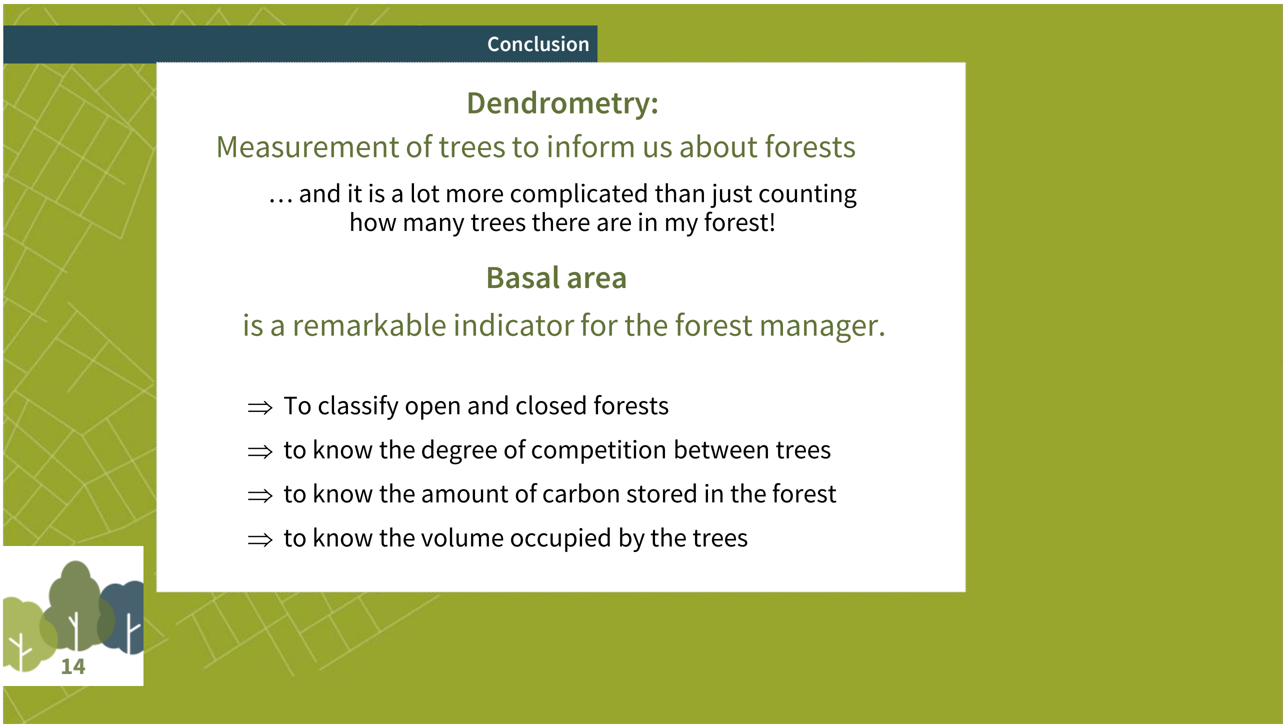
What is even more remarkable is that we can measure this basal area with a very simple tool, the relascope. The measurements can be made quite easily, without the need to measure the diameter of the trees.

Would you like to give it a try? Here's a link to make your own relascope:

Make your own relascope with your 3D printer or at your local FabLab?
https://cults3d.com/fr/mod%C3%A8le-3d/outil/relascope-chainette-relascopique

The relascope as understood by mathematicians
https://images.math.cnrs.fr/Le-relascope.htm

Fabriquer soi-même son relascope *avec son imprimante 3D ou au FabLab du coin ?*
https://cults3d.com/fr/mod%C3%A8le-3d/outil/relascope-chainette-relascopique



Conclusion

Dendrometry:

Measurement of trees to inform us about forests

… and it is a lot more complicated than just counting how many trees there are in my forest!

Basal area

is a remarkable indicator for the forest manager.

⇒ To classify open and closed forests

⇒ to know the degree of competition between trees

⇒ to know the amount of carbon stored in the forest

⇒ to know the volume occupied by the trees

Let's recap. We started by exploring what dendrometry is (the science of measuring trees). As we've seen, it's a little more complicated than just counting trees.
BASAL AREA (G) = A remarkable indicator to classify open and closed forests

- G provides information on the volume occupied by the trees (and the carbon stocks contained in the forest) and helps to make the right management decisions.
- With a more ecological vision, G also informs the forester on the degree of competition between trees, which also helps to make the right management decisions
- G is easy to measure in relation to the volume or biomass concepts we are trying to approach.

Bibliographic references

Density and basal area T. Sardin. ONF. Guide des sylvicultures. Chênaies continentales. 2008. http://www1.onf.fr/lire_voir_ecouter/++oid++908/@@display_media.html

Forest stand openness classes CRPF Lorraine Alsace/ Guide "Typologie et Sylvicultures" sur le plateau Lorrain. https://grandest.cnpf.fr/data/guide_plateaulorrain_1.pdf

Basal area records *Huston, Michael A., and Steve Wolverton. "The global distribution of net primary production: resolving the paradox." Ecological monographs 79.3 (2009): 343-377.* https://esajournals.onlinelibrary.wiley.com/doi/10.1890/08-0588.1

Photographers

Jean-François HAMARD

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Densité et surface terrière
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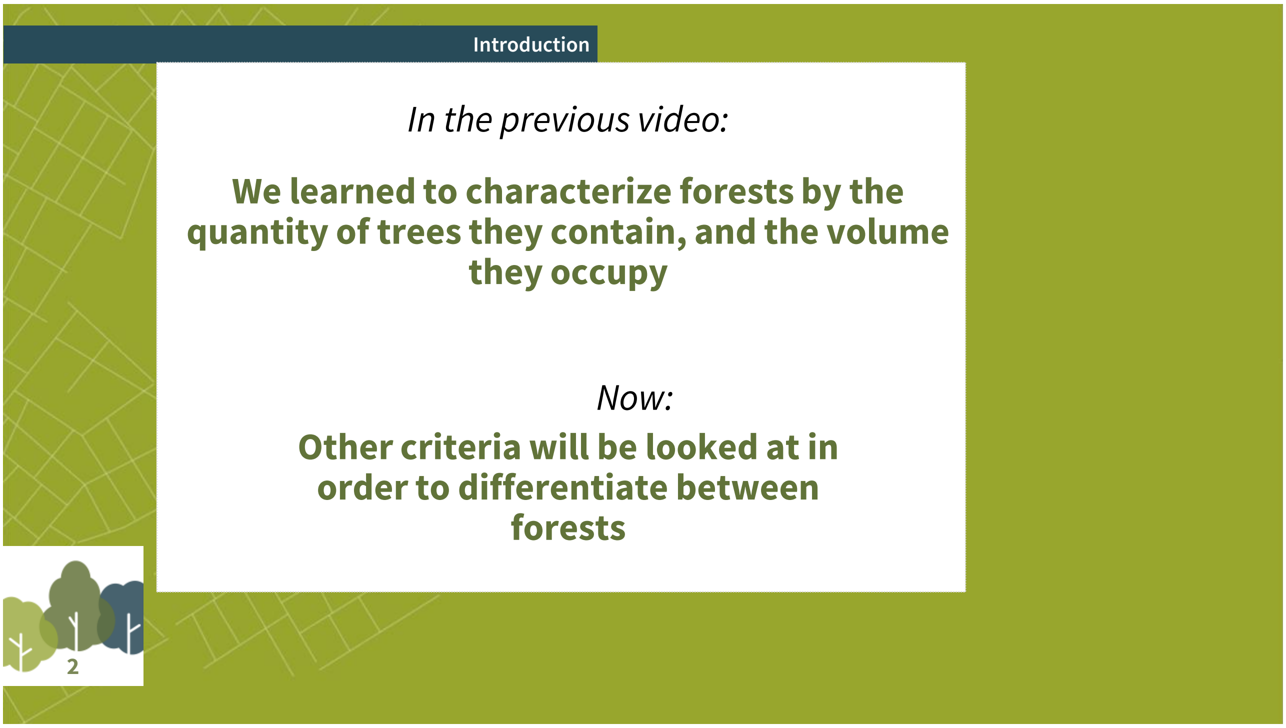
https://esajournals.onlinelibrary.wiley.com/doi/10.1890/08-0588.1

Week 1

What is a forest?

Video 4

Forests that are more or less intensively managed



Introduction

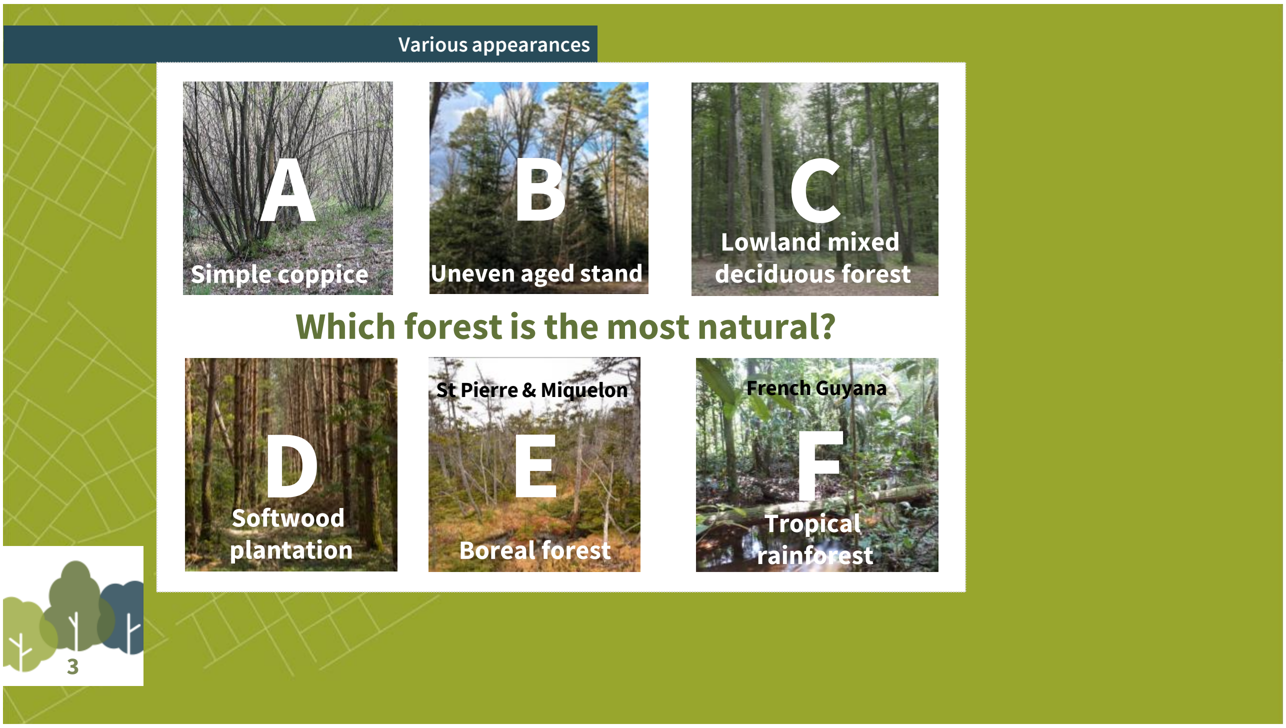
In the previous video:

We learned to characterize forests by the quantity of trees they contain, and the volume they occupy

Now:

Other criteria will be looked at in order to differentiate between forests

After learning how to account for forest areas, and then characterize them according to the number of trees they contain and the volume they occupy, we will now look at how to assess other criteria, based on forest management intensity, that is used to differentiate the various types.



Various appearances

A Simple coppice

B Uneven aged stand

C Lowland mixed deciduous forest

Which forest is the most natural?

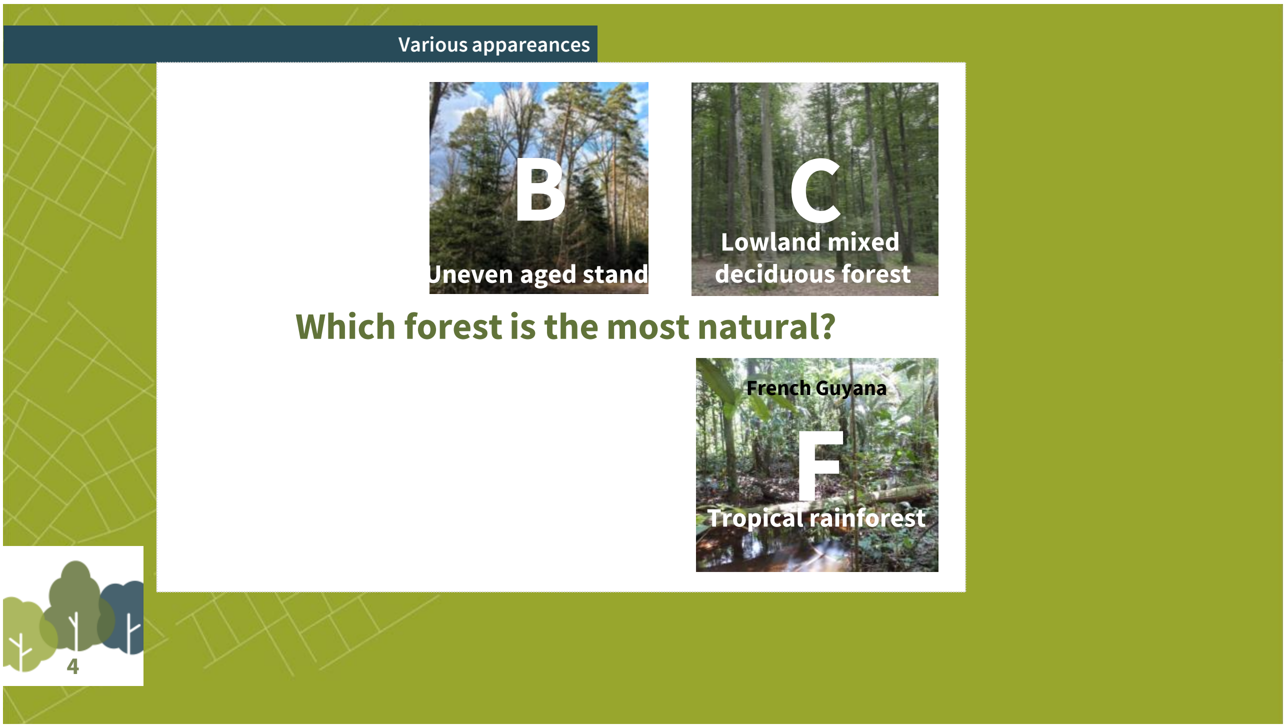
D Softwood plantation

St Pierre & Miquelon
E Boreal forest

French Guyana
F Tropical rainforest

Let's go back to the forests from the first video. We asked ourselves, "which ones are found in France »?

Today, the question has changed to Which of these forests is the MOST NATURAL?

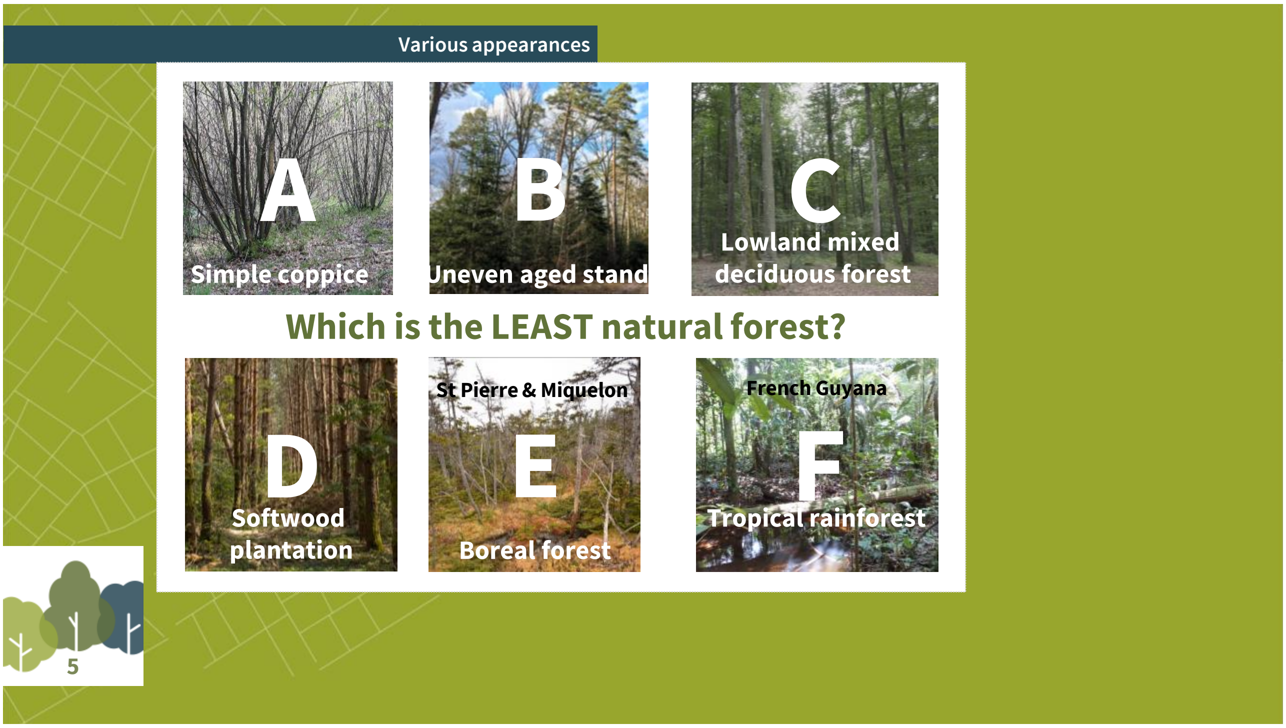


Various appareances

Which forest is the most natural?

Without a doubt, you are probably thinking it is one of these three.

These forests "feel" like nature with their diversity of structures or their diversity of species.



Various appearances

A Simple coppice

B Uneven aged stand

C Lowland mixed deciduous forest

Which is the LEAST natural forest?

D Softwood plantation

St Pierre & Miquelon
E Boreal forest

French Guyana
F Tropical rainforest

Now, let’s change the question again: Which of these forests is the LEAST NATURAL ?

Various appearances

A

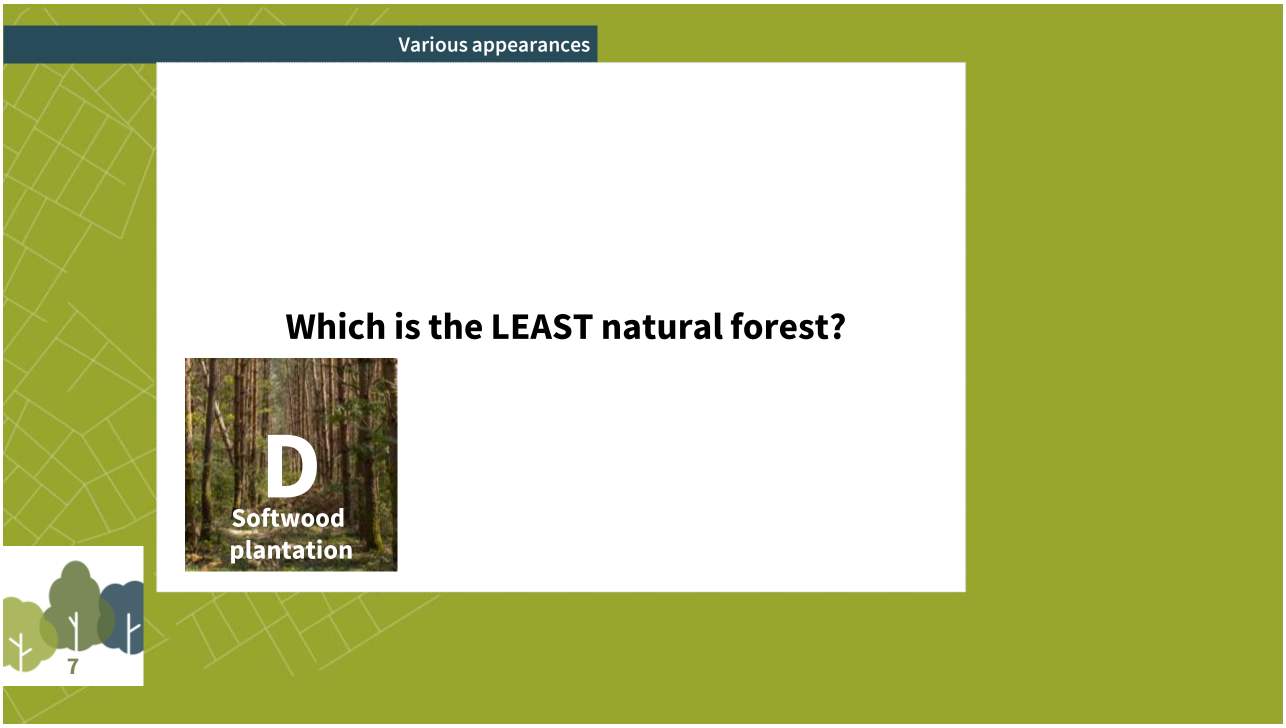
Simple coppice

Which is the LEAST natural forest?

D

Softwood plantation

You are probably thinking of one of these two? They look simple, man must have simplified things in the case of the simple coppice and the softwood (conifer) plantation. They feel less "natural".



Various appearances

Which is the LEAST natural forest?

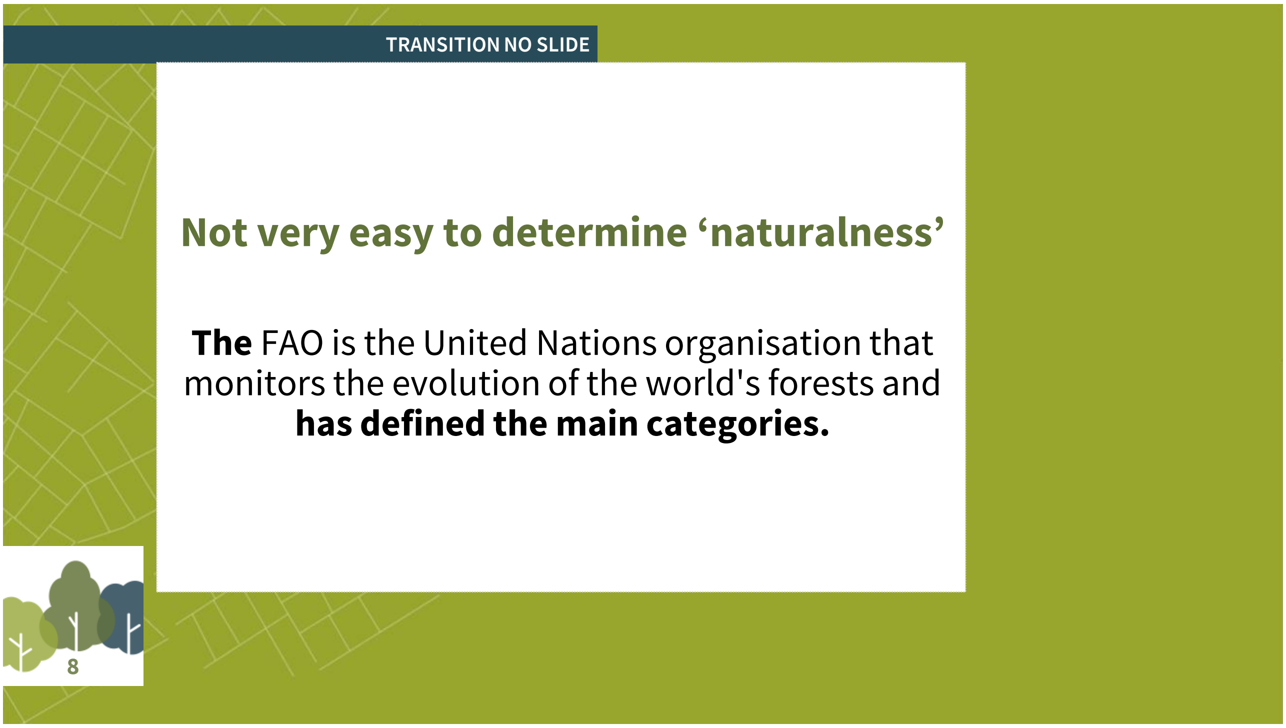
D

Softwood plantation

Perhaps if you consider what defines a natural or artificial forest is the investment and the amount of work put into it, you may say that the softwood plantation is the least natural?

However, let us be wary of this criterion!

In the forests that have been eliminated, there are some that look very natural but which if fact require a lot of work, such as the planted high forest.



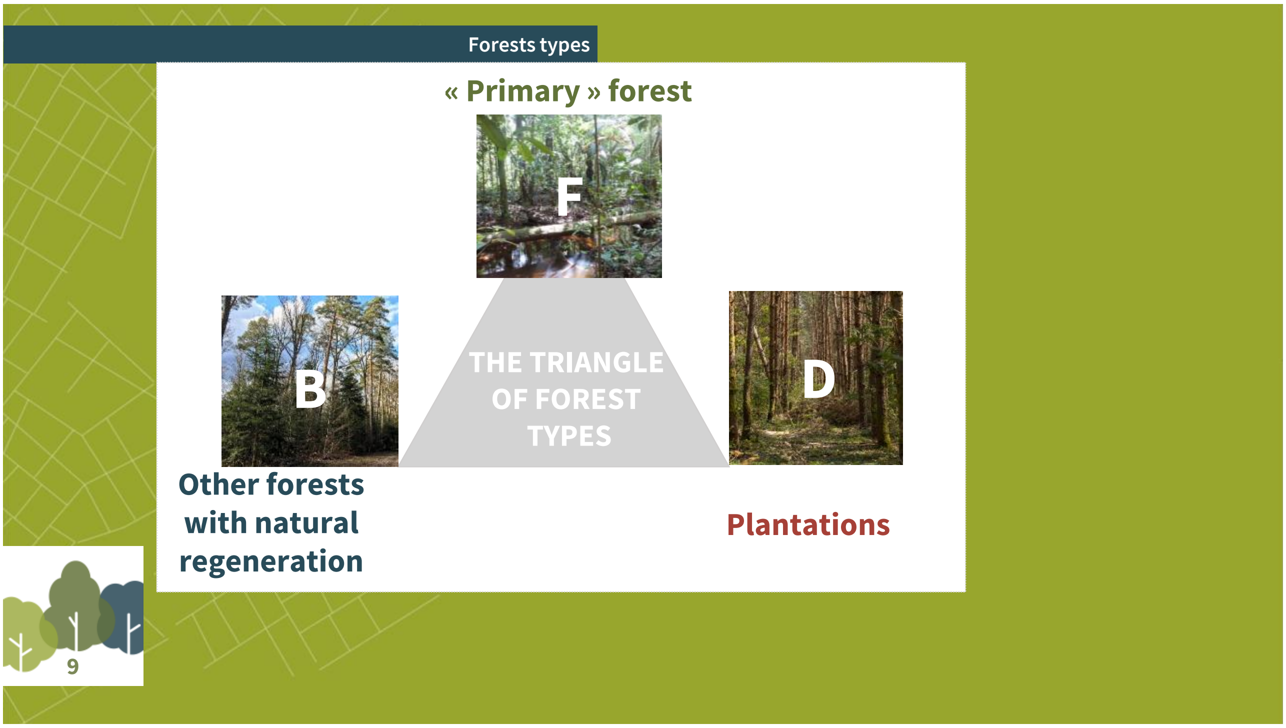
TRANSITION NO SLIDE

Not very easy to determine ‘naturalness’

The FAO is the United Nations organisation that monitors the evolution of the world's forests and **has defined the main categories.**

All this to say that it is not very simple to define the "naturalness" of forests. Nevertheless, we have classifications according to this criterion. The FAO, which is the United Nations organization that monitors the evolution of the world's forests, has defined broad categories, so when accounting for forest areas in the world, we cannot mix forests, which are in fact very different, according to their degree of ‘naturalness’.

FAO = Food and Agriculture Organisation (*Organisme des Nations Unies pour l’alimentation et l’agriculture*)



Forests types

« Primary » forest

F

THE TRIANGLE OF FOREST TYPES

B

D

Other forests with natural regeneration

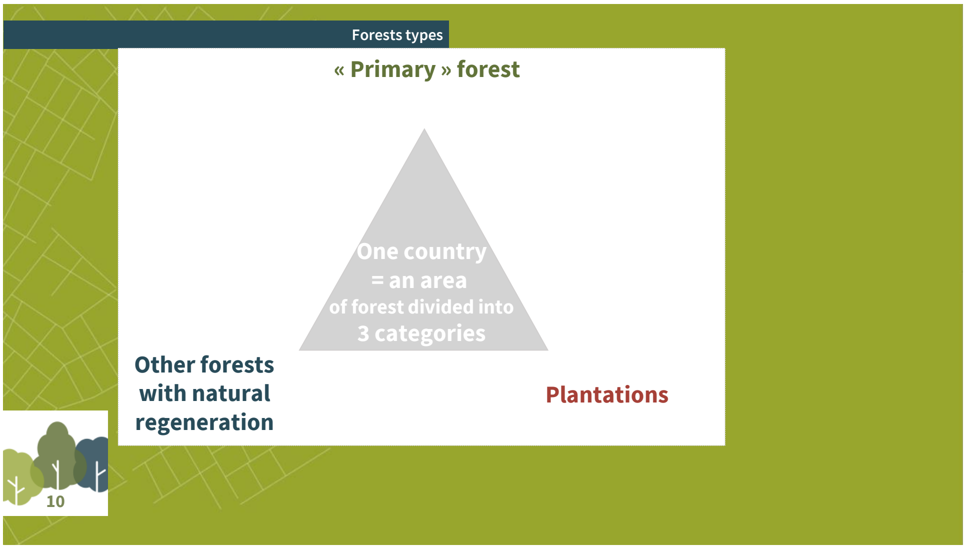
Plantations

Here are the categories to consider. They are arranged in a triangle:

1) **Primary forests**: the most natural ones, in which human activity is not visible. Humans have had very little activity and hence impact on these forests.

2) **Plantations**: all the trees in these forests have been planted deliberately by humans. They are only there because humans decided to put them there. Therefore, they are considered to be artificial forests in the way that they were created.

3) **Other forests with existing natural regeneration**: they are not planted; the trees are regenerated by the seeds of the existing trees.



Forests types

« Primary » forest

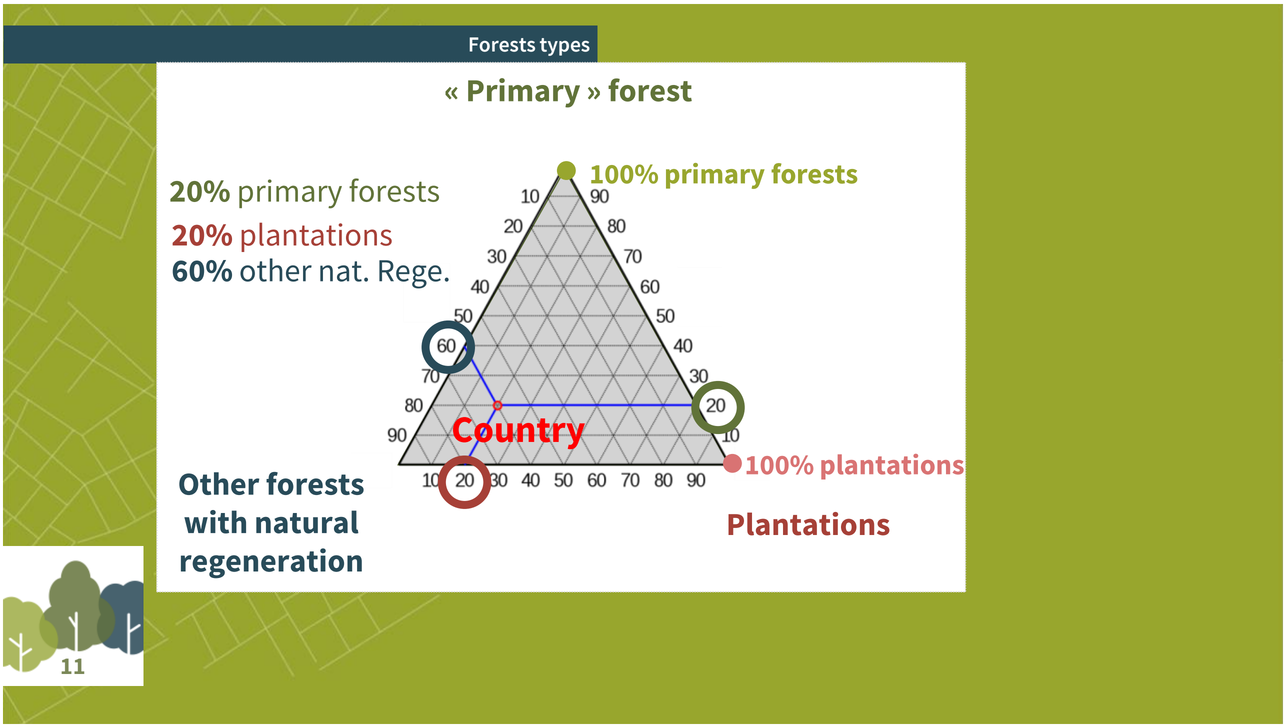
One country
= an area
of forest divided into
3 categories

Other forests
with natural
regeneration

Plantations

Each country has its own data regarding the surface area of their forests, distributed accordingly into these 3 categories.

We are going to use this triangle by placing the data on it, using the texture triangle model.



Forests types

« Primary » forest

20% primary forests
20% plantations
60% other nat. Rege.

100% primary forests

Country

100% plantations

Other forests with natural regeneration

Plantations

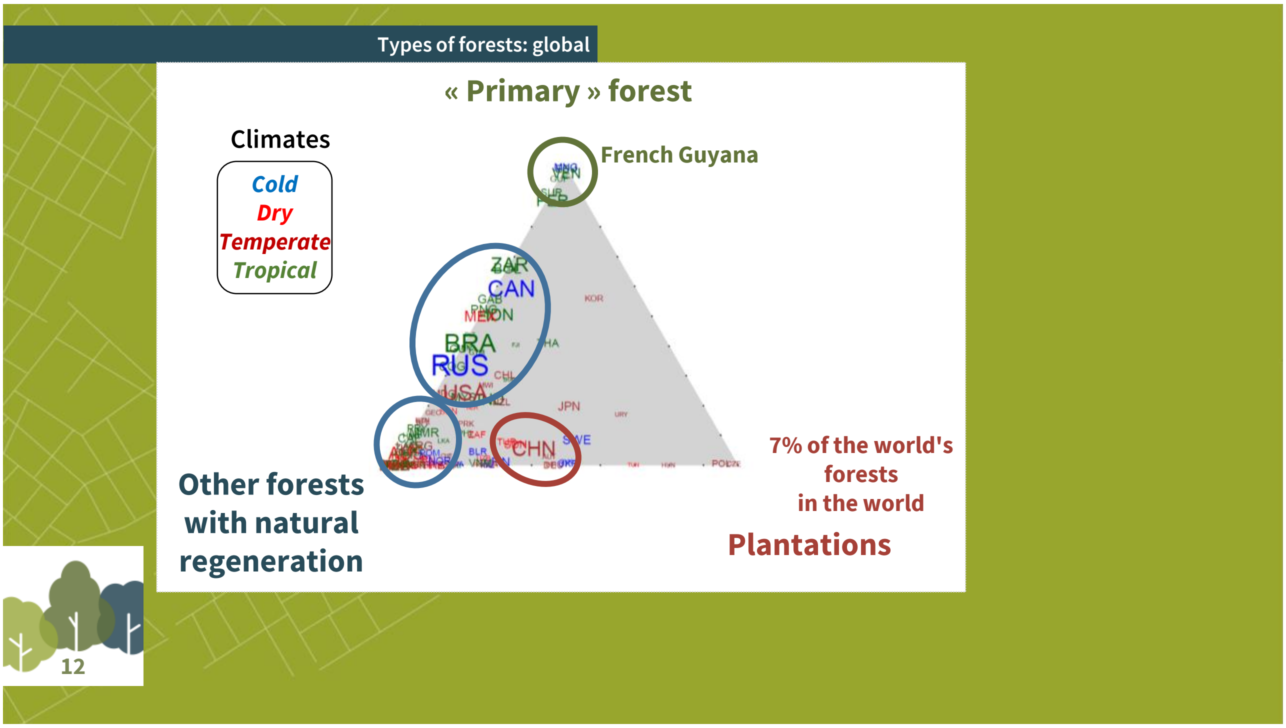
Each country can then be positioned within the triangle in the following way: In this example, this country has 20% of its forest area in the "primary forest" category.

1) If we follow the horizontal line from its position, we will arrive at 20% on the right axis which represents "Primary forests" .

2) If we now follow a parallel line from Its position towards the bottom axis, we will arrive at 20% again, but this time it represents the ‘plantations’.
We can see that this country, from where it is located on the triangle, has 20% plantations.

3) If we follow the last line parallel from its position to the right axis, we arrive at 60%, this time . This axis represents "Other naturally regenerating forests" . This country has 60% of its forest area in natural regeneration.

A country situated on one of the 3 points of the triangle (Primary, Plantations or Others) will only be composed of that one type of forest.



Types of forests: global

« Primary » forest

Climates

Cold
Dry
Temperate
Tropical

French Guyana

Other forests with natural regeneration

7% of the world's forests in the world

Plantations

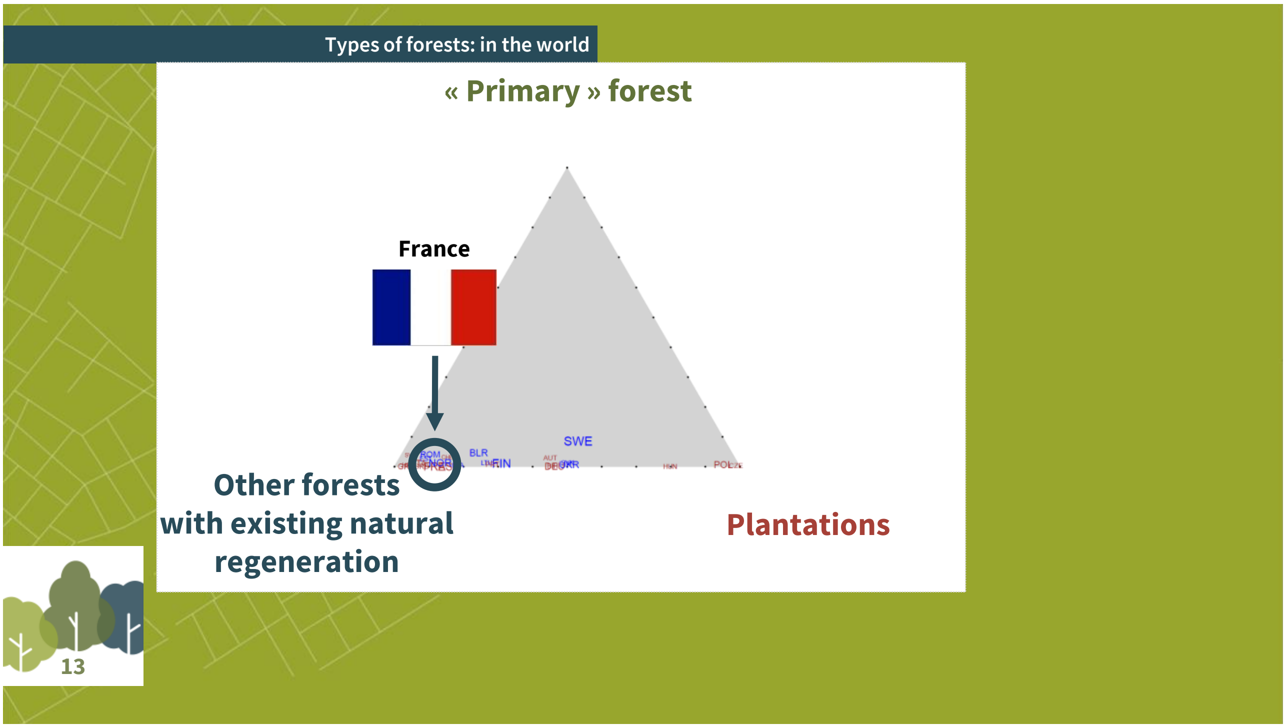
Here, on this triangle, are the countries we have managed to get data from on the FAO website :
- Each country’s name has been abbreviated.
- Each country has been assigned a color according to its climate.
- The size of the letters is proportional to the forest surface area of the country.

First and foremost, you can see that there are many countries near the "Other naturally regenerating forests" point (bottom left hand corner of triangle).
→ The majority of these countries are composed mainly of this type of forest, naturally regenerating but shaped and impacted by humans.

Then , there are the countries with extensive forest areas (Canada, Brazil, Russia), completely opposite the plantations point, on the left axis between primary forests and natural regeneration.
→ These countries have very few plantations (but given their size, there may still be significant quantities). They balance between primary forests and other naturally regenerating forests. They are often very large countries, with a lot of sparsely populated areas (Amazon, boreal zones) and therefore a lot more space that has not been impacted by human activity.

French Guiana is an exception among European forests due to its location on the South American continent. It is almost exclusively composed of primary forests. Another country which stands out , is China. It has very little primary forest, having deforested many areas long ago. However, in recent years it has been investing heavily in plantations and reforestation.

To sum up, we can note that plantations only represent 7% of the world's forests.



Types of forests: in the world

« Primary » forest

France

Other forests with existing natural regeneration

Plantations

Now, we will focus only on Europe.

In Europe, there are no longer any primary forests (hence the interest in French Guiana, which must be a major preservation priority for Europe). The countries, however, are fairly well spread out along the bottom axis, between other forests with natural regeneration and plantations.

Three examples:

France has mostly naturally regenerated forests

→ We have not had any primary forests for a long time. Our forests have been shaped by human activity since the Middle Ages, possibly even further back. Natural regeneration dominates (12% of plantations in France).

Germany is in between

→ There are almost as many plantations as there are naturally regenerating forests.

Poland also stands out.

→ Somewhat like China, but much more in proportion. Poland is restoring forest areas by planting a lot of trees.

The concepts seen in this video

Defining the naturalness of a forest takes time

The typology of forests
according to their **management intensity**

Their **distribution around the world**

To recap:

Defining the "naturalness" of a forest takes time. It can not be done immediately by simply looking at it.

We showed you a typology of forests by classifying three types, according to their intensity of management.

Lastly, we talked about the distribution of these forest types around the world.

References

Data on forest area by country: FAO
www.fao.org/forest-resources-assessment

Photographers

Martin VL (Wikimedia)

Nicolas BILOT

Léo-Pol JACQUOT

Jean François HAMARD

Nathalie DE LACOSTE

Joey ALLEN (Wikimedia)

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www.fao.org/forest-resources-assessment

Week 1

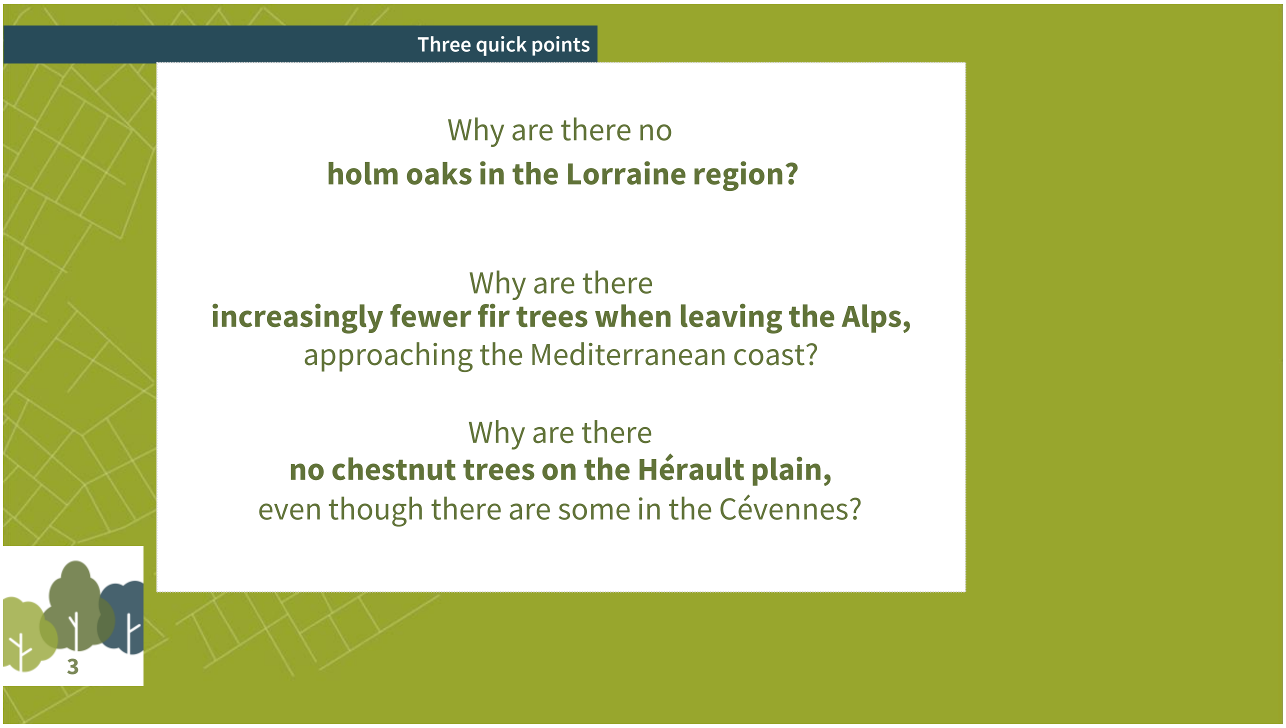
What is a forest?

Video 5

A forest in the reflection of its environment

Forest management **relies on nature** to **produce services**, without radically **transforming the environment**

This approach was adopted in the forest long before the concept of agroecology was invented.



Three quick points

Why are there no
holm oaks in the Lorraine region?

Why are there
increasingly fewer fir trees when leaving the Alps,
approaching the Mediterranean coast?

Why are there
no chestnut trees on the Hérault plain,
even though there are some in the Cévennes?

To address this topic, we must first ask ourselves two questions. This will then help us to formulate a more general question.

Three quick points

Why are there no Holm Oaks in the Lorraine region?

Chêne vert
(Ariège)

It is too cold!
Other oak species are more adapted to this climate.

Photo : Lucas DESTREM (Wikimedia commons)
https://commons.wikimedia.org/wiki/File:Ch%C3%AAne-vert,_Teilhet_(Ari%C3%A8ge).jpg

Three quick points

Why are there fewer and fewer fir trees when leaving the Alps, approaching the Mediterranean coast?

It's too hot!

Photo : Nicolas BILOT

Three quick points

Why are there no chestnut trees on the Hérault plain, even though there are some in the Cevennes?

Chestnut trees loathe calcareous soils!

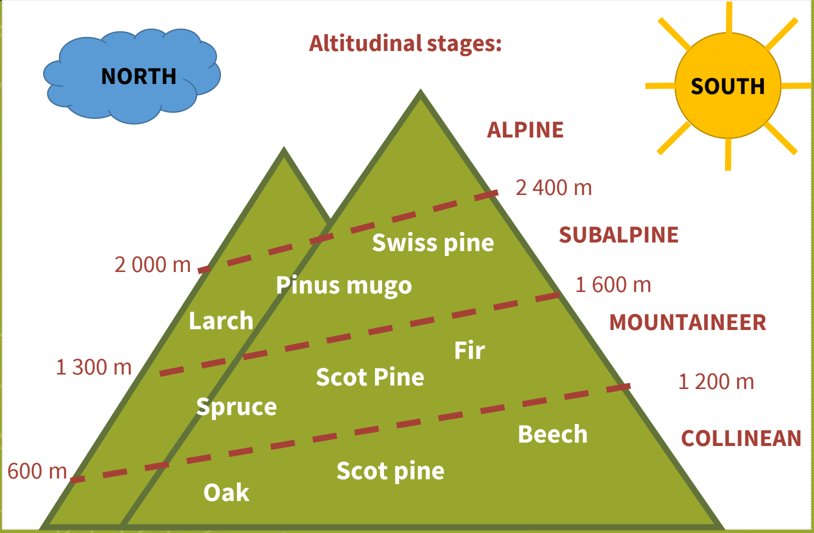
Photo : Zeynel Cebeci (Wikimedia commons)
https://commons.wikimedia.org/wiki/File:Castanea_sativa_-_Anatolian_sweet_chestnut_04.jpg

Three quick points

Tree species do not grow randomly!

Climate and soil factors help explain why a species is or is not found in a particular location.

Staggering of species



Constraining environments

COLD

Boreal peatland

(Saint Pierre et Miquelon)

DRY

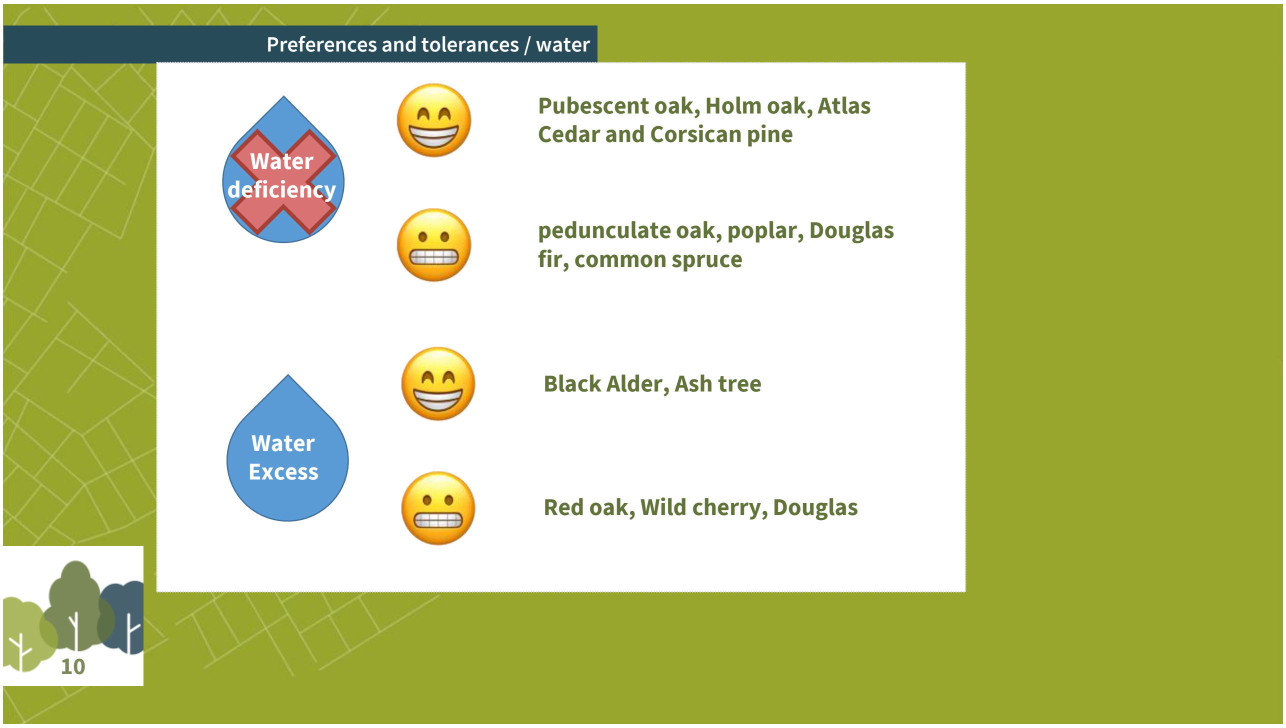
White acacia park

Niger

A large-scale demonstration of this adaptation to its environment.

Previously, we saw that 2 limiting factors which affect the growth of forests in some areas in world are temperature (too cold) and moisture (too dry).

Forests that grow in cold or dry environments are composed of tree species which are well adapted to these constraints. In addition, the trees are not as tall in these forests as they have some difficulty growing in these conditions.



Preferences and tolerances / water

Water deficiency

😁 **Pubescent oak, Holm oak, Atlas Cedar and Corsican pine**

😬 **pedunculate oak, poplar, Douglas fir, common spruce**

Water Excess

😁 **Black Alder, Ash tree**

😬 **Red oak, Wild cherry, Douglas**

Let’s go back to our French forests. If we apply the concept of "autoecology", also referred to as species ecology, to the study of tree species, we can classify them according to their preferences, such as their water requirements. This is the type of knowledge that is provided to us:

- Species that can tolerate a water deficiency: pubescent oak, Holm oak, Atlas cedar and Corsican pine
- Species that require water: pedunculate oak, poplar, Douglas fir, and the common spruce
- Species that can tolerate an excess amount of water : Black alder, Ash
- Species that cannot tolerate an excess amount of water : Red oak, Wild cherry

Mineral in the soils

Poor soil

😁 **Red oak, chêne sessile, Pin maritime**

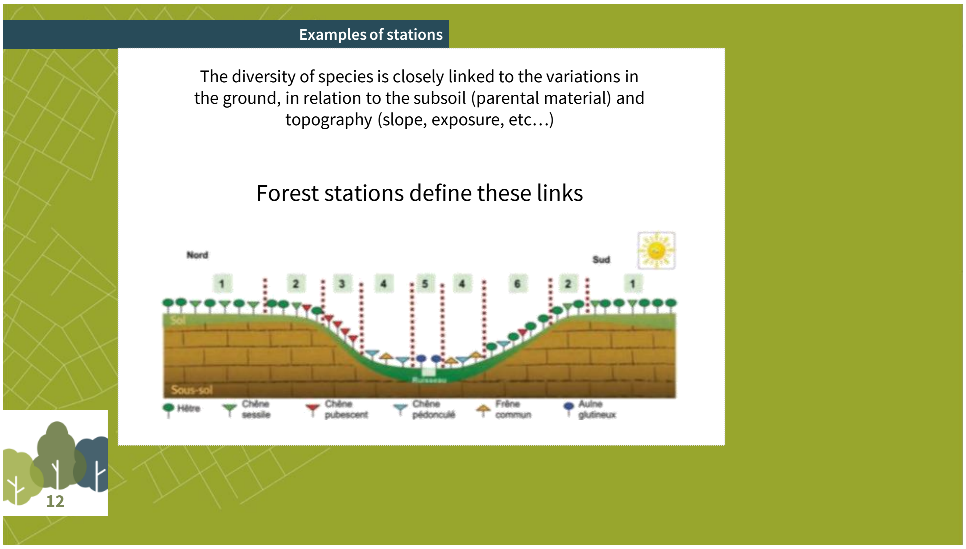
😬 **Pedonculate oak, Ash, Cherry**

Calcareous Soil

😁 **Sessile oak, Beech, Atlas cedar, Fir**

😬 **Chestnut, Red oak, Douglas, Maritime pine**

- Species that tolerate poor soils : Red oak, Sessile oak, Maritime pine
- Species that are more demanding: Pedonculate oak, Ash, Wild cherry
- Species that are tolerant to calcareous soils: Sessile oak, Beech, Atlas cedar, Sapin pectiné
- Intolerant species : Chestnut, Red Oak, Douglas, Maritime pine

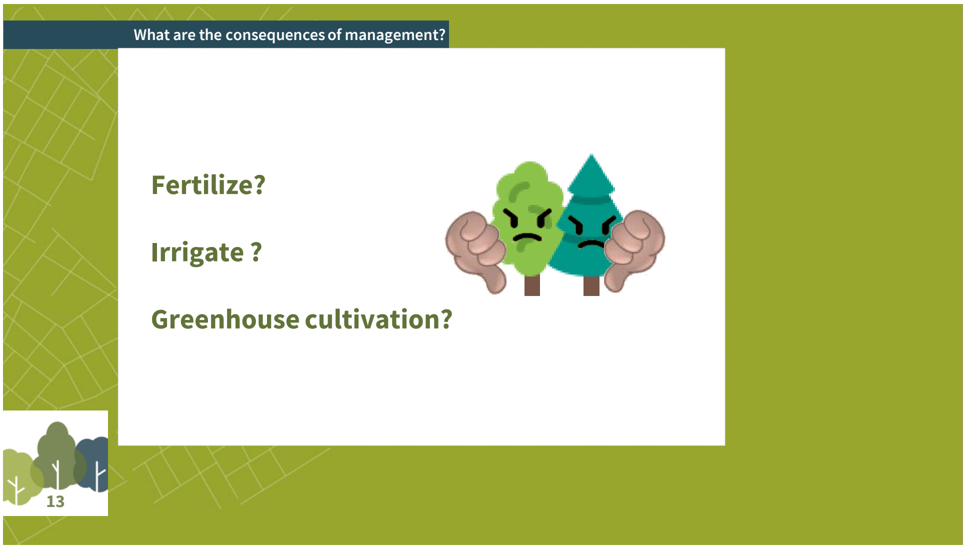


Examples of stations

The diversity of species is closely linked to the variations in the ground, in relation to the subsoil (parental material) and topography (slope, exposure, etc…)

Forest stations define these links

Image : Forêt Privée Française, d’après une illustration modifiée du CRPF Nord-Picardie
www.foretpriveefrancaise.com/n/les-stations-forestieres/n:1030



What are the consequences of management?

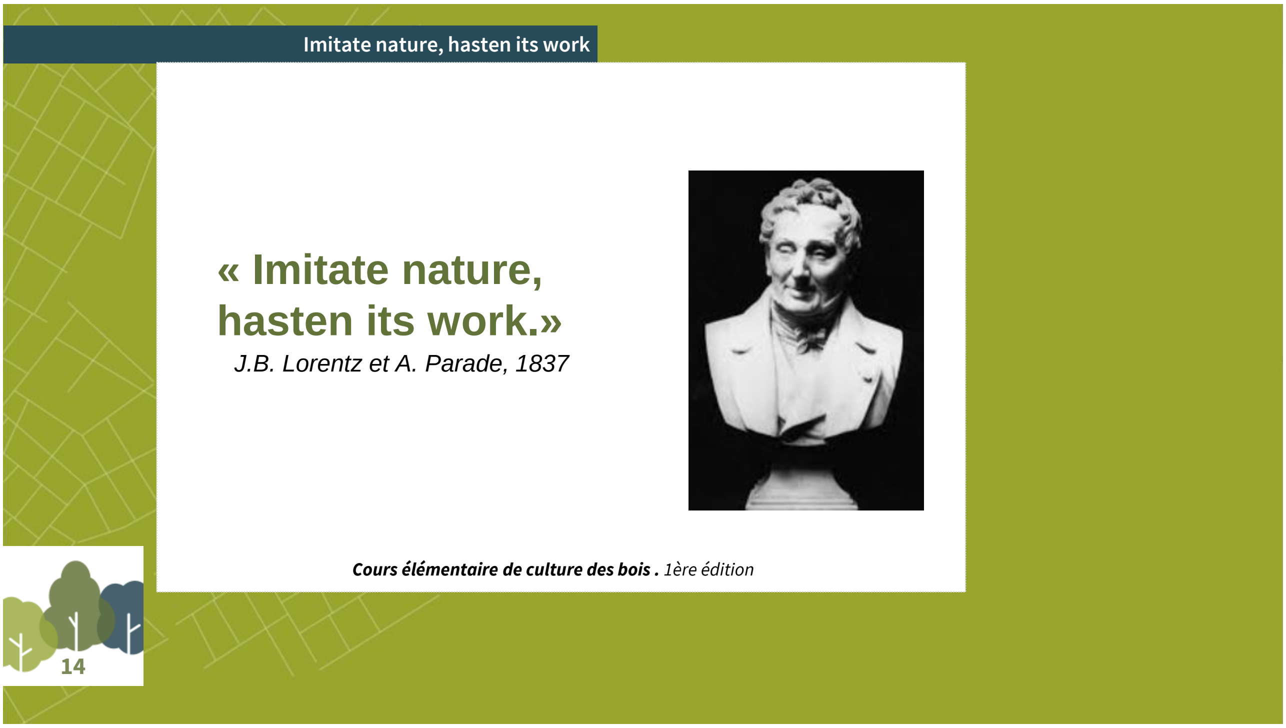
Fertilize?

Irrigate ?

Greenhouse cultivation?

Thus, if you can observe this subtle adaptation of tree species to their environment, it is because forest management does not seek to transform it, it seeks to adapt to it.

- ⇒ We do not fertilize poor soil, no matter how poor it is. An exception may be to add just a little fertilizer when planting seedlings.
- ⇒ We do not irrigate the forest when the climate is arid.
- ⇒ We do not cultivate forests in a greenhouse when the weather is too cold.



Imitate nature, hasten its work

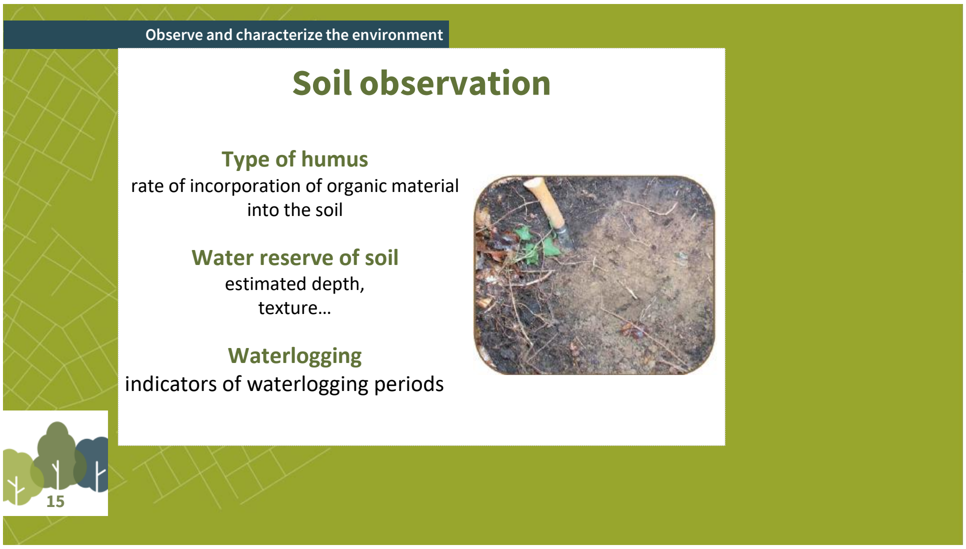
« Imitate nature, hasten its work.»

J.B. Lorentz et A. Parade, 1837

Cours élémentaire de culture des bois . *1ère édition*

When we use cultivation practices similar to those used in agriculture – fertilizer, ground work, weeding – it is in order to help the trees grow better and faster. It is not to have trees grow in areas they are not adapted to. This attitude is reflected in this well-known saying, particularly to foresters, by Lorentz and Parade who were the first directors of the Ecole Forestière de Nancy (before it was called AgroParisTech):

LORENTZ (J .-B .), PARADE (A.) . 1837 — Cours élémentaire de culture des bois . — I re édition . — Paris : Huzard ; Nancy : Thomas, 1837 . — 561 p . (cf . § 380, pp . 169 et 170) .



Observe and characterize the environment

Soil observation

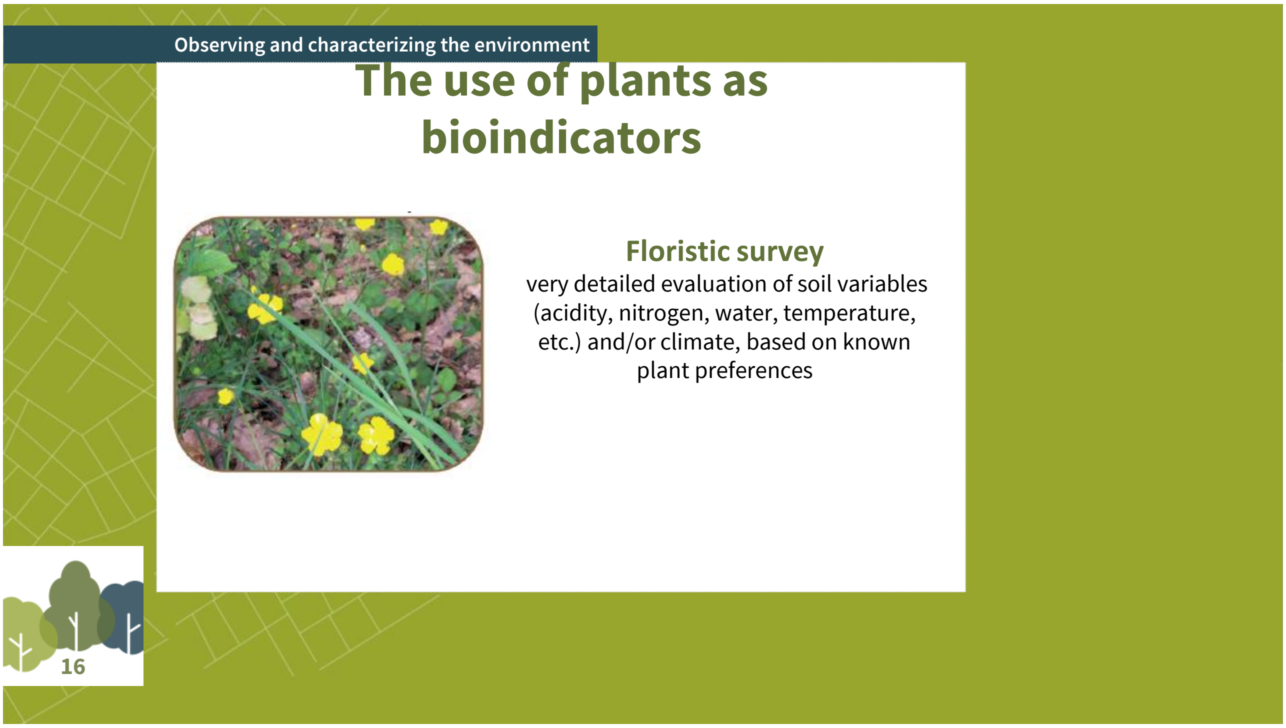
Type of humus
rate of incorporation of organic material into the soil

Water reserve of soil
estimated depth,
texture…

Waterlogging
indicators of waterlogging periods

Image : Plaquette de la méthode IGN : https://inventaire-forestier.ign.fr/IMG/pdf/180920_plaquette-methode_fr.pdf

The basis of the forest manager’s 'savoir faire’ is to know how to carefully observe the environment and be able to determine and predict what will happen by characterizing the soil. Note that the forester rarely does chemical analyses in a lab. Instead, they first do a general soil analysis from either a pit or an auger sample.



Observing and characterizing the environment

The use of plants as bioindicators

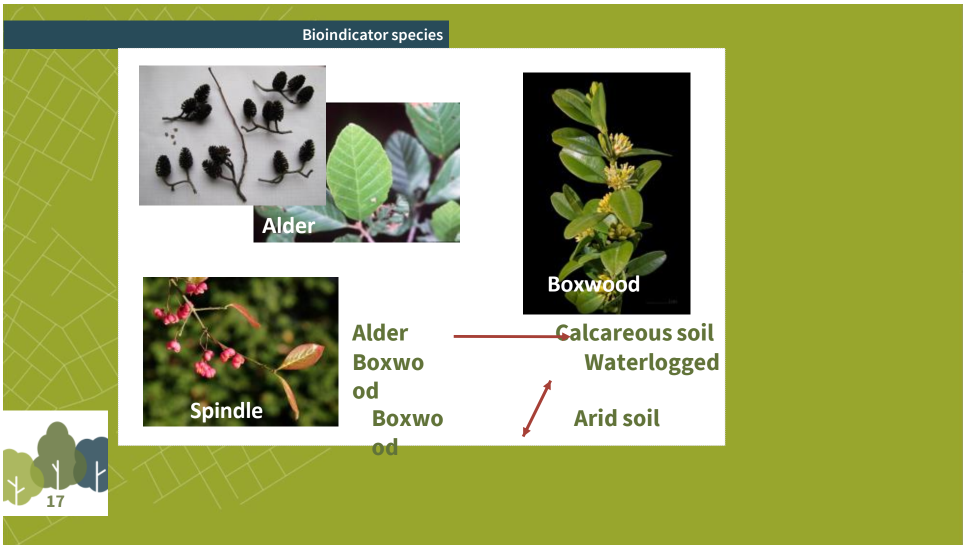
Floristic survey

very detailed evaluation of soil variables (acidity, nitrogen, water, temperature, etc.) and/or climate, based on known plant preferences

Image : Plaquette de la méthode IGN : https://inventaire-forestier.ign.fr/IMG/pdf/180920_plaquette-methode_fr.pdf

As foresters are often very good field botanists, they regularly observe the surrounding flora. They make a note of all the small plants which are present in the soil. Since plants do not grow randomly and their preferences and distribution optima are well documented, foresters are able to obtain very detailed information based on the different variables... We call this **bioindication**.

Bioindicator species



Alder

Boxwood

Boxwood

Calcareous soil

Waterlogged

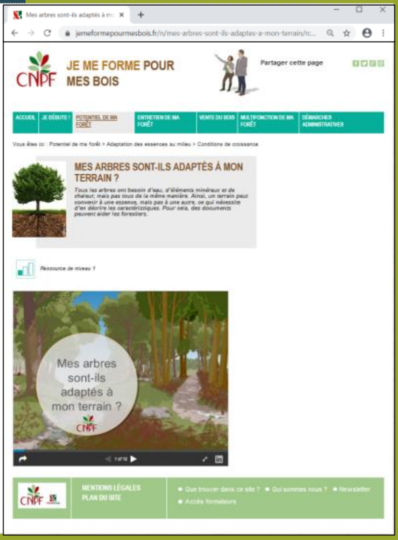
Arid soil

Buis : Didier Descouens (Wikimedia)
https://commons.wikimedia.org/wiki/File:Buisfleurs.jpg
Fusain : JLPC (Wikimedia)
https://commons.wikimedia.org/wiki/File:Fusain_d%27Europe_FR_2012.jpg
Aulne :

- feuilles : Stev HURST (USDA), https://plants.usda.gov/core/profile?symbol=ALSE2
- graines : Réjeane FARCE (Wikimedia) https://commons.wikimedia.org/wiki/File:Strobiles_d%27aulne.jpg?uselang=fr

To explore further

www.JeMeFormePourMesBois.fr



Vous êtes ici : Potentiel de ma forêt > Adaptation des essences au milieu > Conditions de croissance

MES ARBRES SONT-ILS ADAPTÉS À MON TERRAIN ?

Tous les arbres ont besoin d'eau, d'éléments minéraux et de chaleur, mais pas tous de la même manière. Ainsi, un terrain peut convenir à une essence, mais pas à une autre, ce qui nécessite d'en décrire les caractéristiques. Pour cela, des documents peuvent aider les forestiers.

Freedom reigns

Now I'll finish by illustrating that although the forest adapts well to the environment, foresters still have a little freedom/flexibiliy in terms of choice.

We are going to go on a virtual walk in the Vosges forest and zoom in on this area.

We can find spruce trees there and just beside it there is a mix of maple and ash trees.

This configuration is the result of the owner's choice. In this case, the 3 species could have been placed anywhere. It was not the soil or the topography that decided its specific placement. In fact, after having a discussion with the owner's grandson, it was discovered that the probable reason for this configuration was his grandfather's lack of means to plant more spruce trees. It had nothing to do with present day concerns about the environment. Interestingly, this unintentional placement of trees is a beautiful example of an experiment in how to maintain biodiversity.

Trees do not grow randomly

Tree species have marked preferences and intolerances based on factors related to the climate and soil

Foresters does not seek to grow unsuitable species

They carefully observe the environment, station by station, in order to adapt to it, still leaving them with a certain amount of freedom

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IGN, 2018, *Un inventaire annuel sur la France entière*.	https://inventaire-forestier.ign.fr/?rubrique25
Vues aériennes IGN via le **Géoportail**	www.geoportail.gouv.fr
Site internet »Je me forme pour mes bois » du CNPF :	www.jemeformepourmesbois.fr

Photographies

Nicolas BILOT

Nathalie DE LACOSTE

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Week 2

What does it mean to « sustainably manage » a forest?

Video 1

What is the purpose of our forests?

In Week 1, we saw that although the forest is a natural ecosystem, it is marked by human activity. Under all the latitudes and at all (era/periods) times, forests have been a source of resources and benefits for human populations. Although they exists by themselves, regardless of what humans use it for, forests are shaped by these human uses.

For this first lesson, Nicolas visited some of the forests in the Lorraine region to look for traces of human activity in. Let’s discover them together.

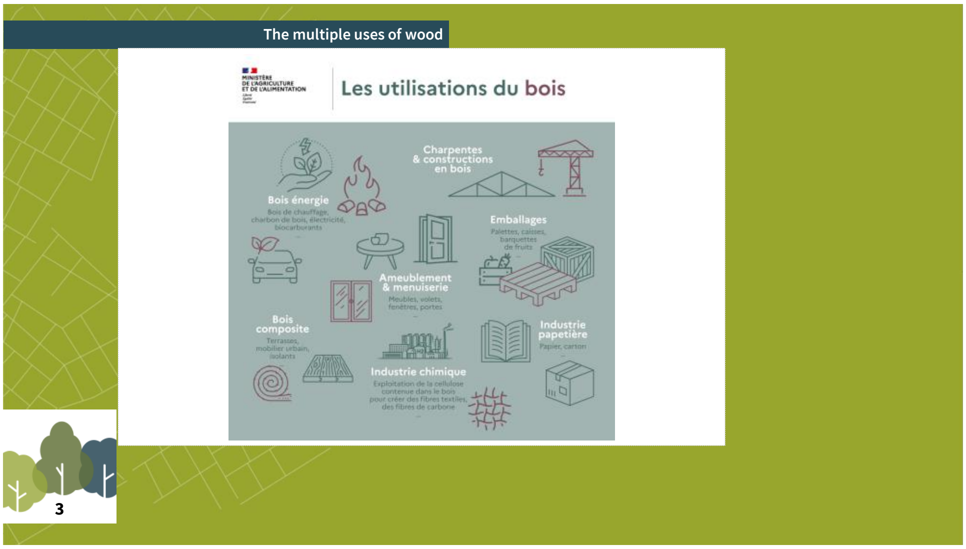
Traces of human activity: wood

Wood is one of the main resources drawn from French forests. This wood can have many uses, sometimes traditional, and this place [showing the library] illustrates one of them.

It's also a very contemporary material, inspiring many innovations - but it has a long history, which we'll talk about next week. There are all kinds of qualities of wood, depending on size, species, uniformity, growth rate, and presence or absence of branches.

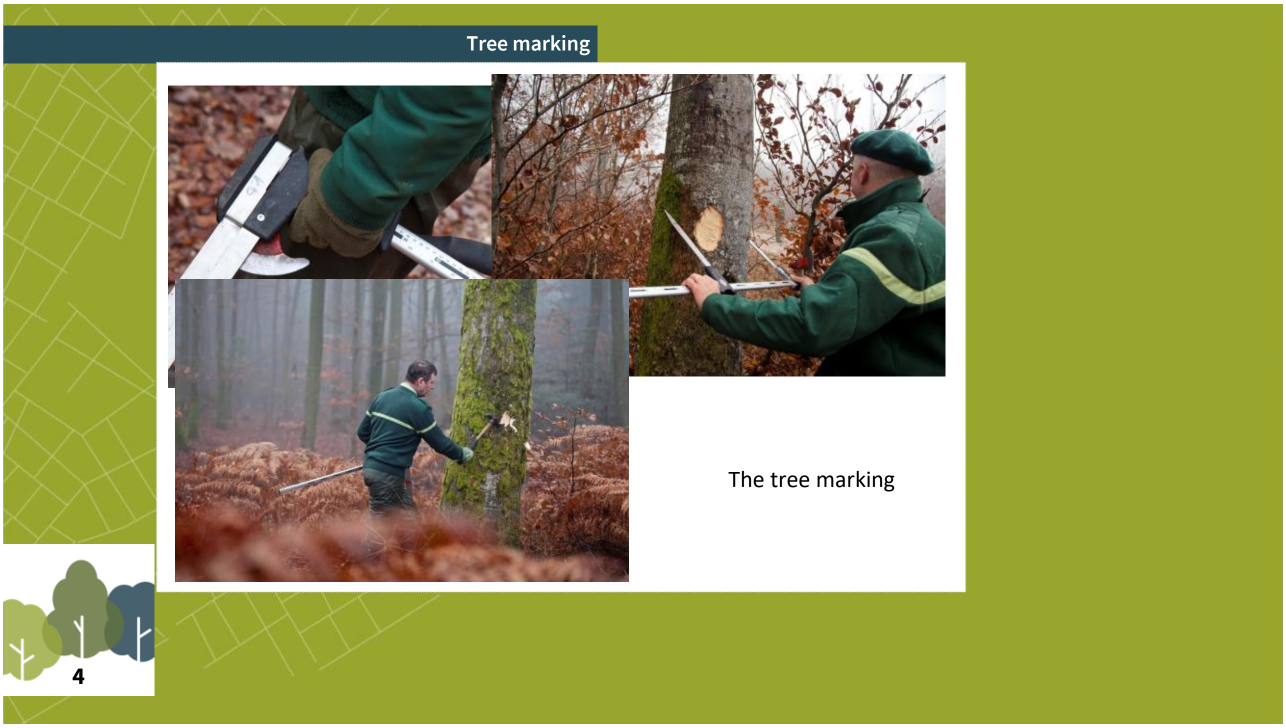
Here, a pile of wood blocks, probably destined to be crushed to produce particleboard or paper; there, beautiful logs that can be sawn to provide lumber for carpentry or construction.

All economic activities related to the production and processing of wood in France support approximately 400,000 jobs, often in rural areas.



The multiple uses of wood

The many uses of wood.



Tree marking

The tree marking

These images of foresters marking trees give us a glimpse into the long process of shaping the forest, of which the final harvest is the culmination.

This particular task is designed to help trees with the most favorable characteristics in terms of processing and utilization of their wood to grow and thrive - characteristics that, depending on the tree species, are the most desired and valuable.

In general, foresters help shape the forest for its purpose, which is not always wood production. In this long process, the expertise and knowledge of foresters are essential.

Hiking

Let’s look at our fourth picture :

One of the advantages of the forest is the simple pleasure to be there, to enjoy nature, the landscape and eventually to practice a physical activity: walking, hiking, biking, or even horseback riding.

This recreational use of the forest is one of its major functions today in France. The idea of going to the forest for simple pleasure is a relatively recent notion that has developed especially from the end of the 19th century. In the 20th century, the forest was considered as an important element of general welfare, to the point that the French state expropriated entire massifs of mountain forests for public utility.

Some forests, such as the Haye forest near Nancy, benefit from a specific protection status because of their importance for the well-being of the population. This well-being goes beyond simple pleasure since it can have real beneficial effects on health, so much so that today there are practitioners of sylvotherapy, which literally translates to being treated by the forest.

Source: ONF, History of the restoration of mountain land in Boscodon

You may wonder, after hearing the word "protection" about the forest, if the forest is the object or the tool of protection.

Indeed, the status of protection forest was created in the 19th century, for some mountain forests. Of course, there is no doubt that the protection of these forests is important, but it is also important that the forest contributes to the protection of the populations of the villages located below.

Forests are indeed a very good protection against the risks linked to the erosion of mountain areas: landslides, torrential floods, and landslides. To ensure this function correctly, the forest must have certain characteristics. In these forests, the service rendered is not the production of wood but the protection of villages against these erosion phenomena.

The Office National des Forêts (ONF) monitors, on behalf of the government, the safety risks related to erosion in mountain areas. This of course requires strong expertise in this field.

The fifth image evokes another function of the forest that we do not always think about, but which is quite important.

The forest soil, very rich in roots and micro-organisms, filters and recycles organic compounds and minerals, thus purifying water. In addition, forest management generates much less pollution than other land uses. By managing the forest for wood production, the forester can also take several precautions to reinforce this protection of water quality.

In France, many water catchment protection areas are located in forested areas.

The forest gives us water to drink, but in many countries, it also contributes to feeding the population. In France, in the past, the forest was also used to feed domestic animals, like pigs. They grazed in the forest and fed on acorns. This is a function that the forest no longer provides in France.

Hunting is no longer considered a necessity for food. Today, it is generally considered a leisure activity for those who practice it. But it is also an important activity for the forest. We will come back to this.

The forest thus provides many resources and services to man, and this remains relevant in 21st-century France! These different uses often meet in the same forest: you have probably already passed in front of a pile of logs and at the same time a watershed without knowing it. This is what we call the multifunctionality of forests.

References

Infographics of the uses of wood :
Ministry of Agriculture and Food
https://agriculture.gouv.fr/infographie-les-utilisations-du-bois

Photographies

Jean François HAMARD

Nicolas BILOT

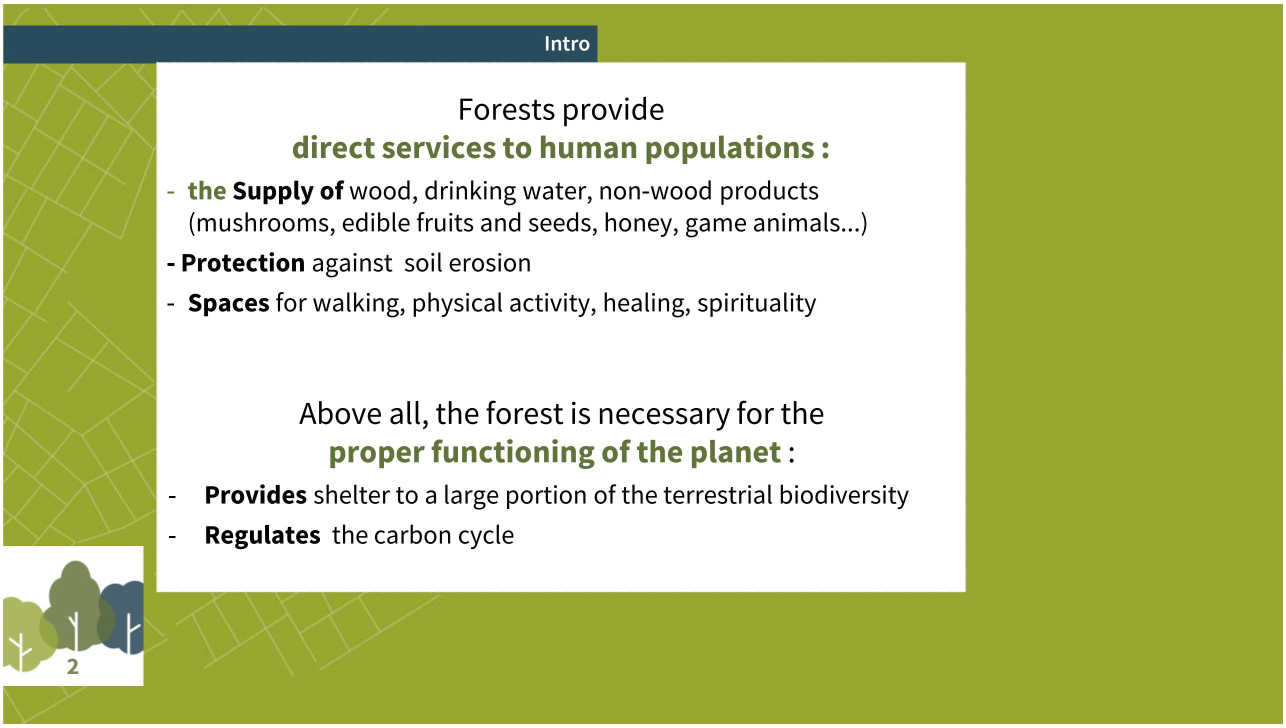
+ Pixabay

Week 2

What is sustainable forest management?

Video 2

Forests are rich in carbon and biodiversity



Forests provide
direct services to human populations :

- **the Supply of** wood, drinking water, non-wood products (mushrooms, edible fruits and seeds, honey, game animals…)
- **Protection** against soil erosion
- **Spaces** for walking, physical activity, healing, spirituality

Above all, the forest is necessary for the
proper functioning of the planet :

- **Provides** shelter to a large portion of the terrestrial biodiversity
- **Regulates** the carbon cycle

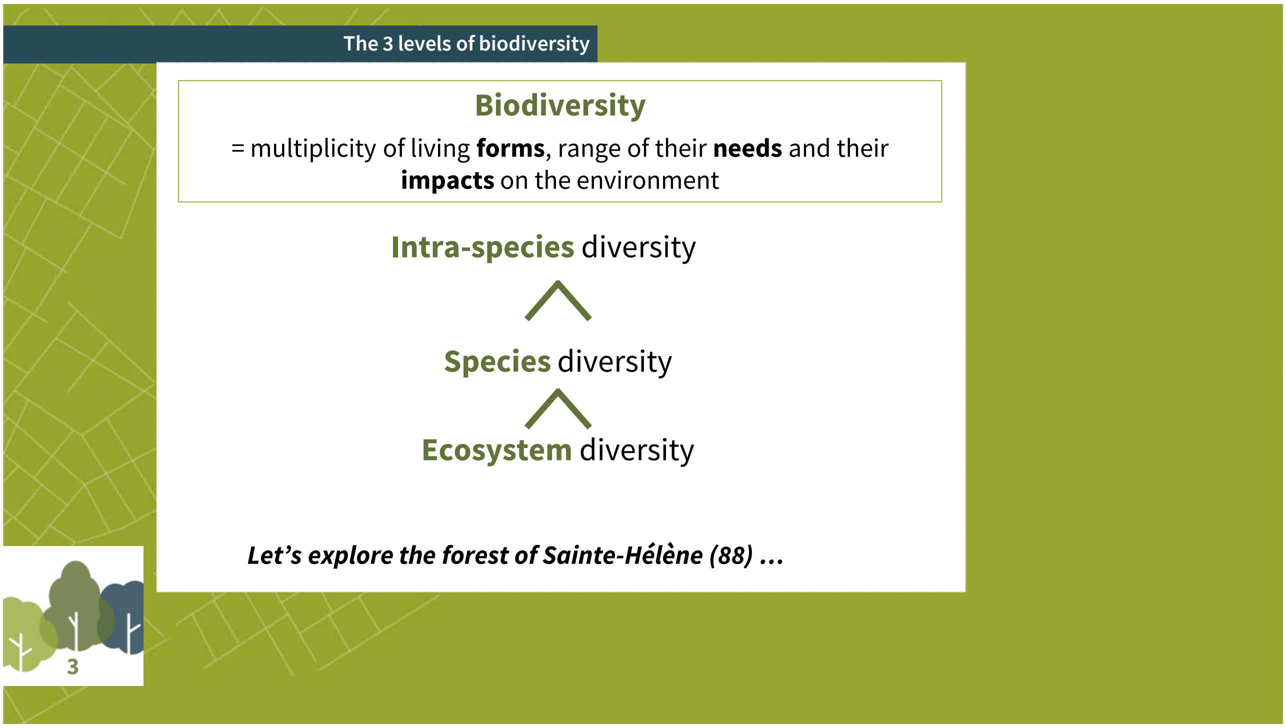
Last week we reviewed a number of services provided by forests:

- They provide us with wood (of various sizes and qualities) and drinking water.
- They protect soils from erosion and, in doing so, they protect people living in mountain areas from the risks of erosion,
- They offer us access to space for hiking, outdoor physical activities, and spiritual nourishment.

Beyond the direct services rendered to mankind, forests are, to a large extent, needed for the proper functioning of the planet, by :

- Sheltering a large part of the terrestrial biodiversity
- Contributing to the regulation, together with the ocean, of the carbon cycle.

This week, we will focus on this second type of service that forests provide - a service that is both less direct and more fundamental.



The 3 levels of biodiversity

Biodiversity

= multiplicity of living **forms**, range of their **needs** and their **impacts** on the environment

Intra-species diversity

Species diversity

Ecosystem diversity

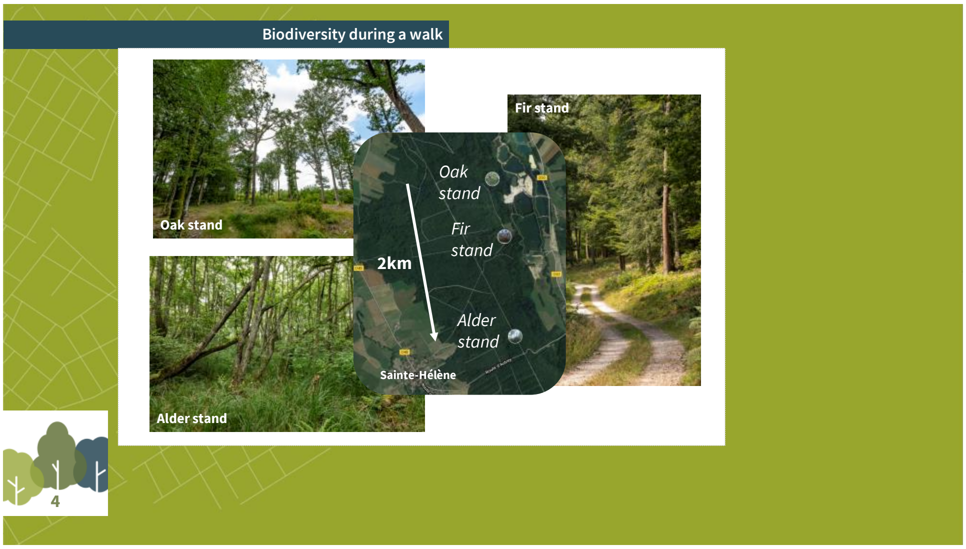
Let's explore the forest of Sainte-Hélène (88) …

First, let's talk about biodiversity.

Biodiversity is the multiplicity of living organisms, the range of their needs, and their impact on the environment.

In general, we can distinguish three levels:
1. Species diversity, which we naturally think of first
2. Then, further down, intra-species diversity (diversity within species)
3. ...and finally, the ecosystem diversity.

To illustrate this, let's explore the forest of St Helene.



Biodiversity during a walk

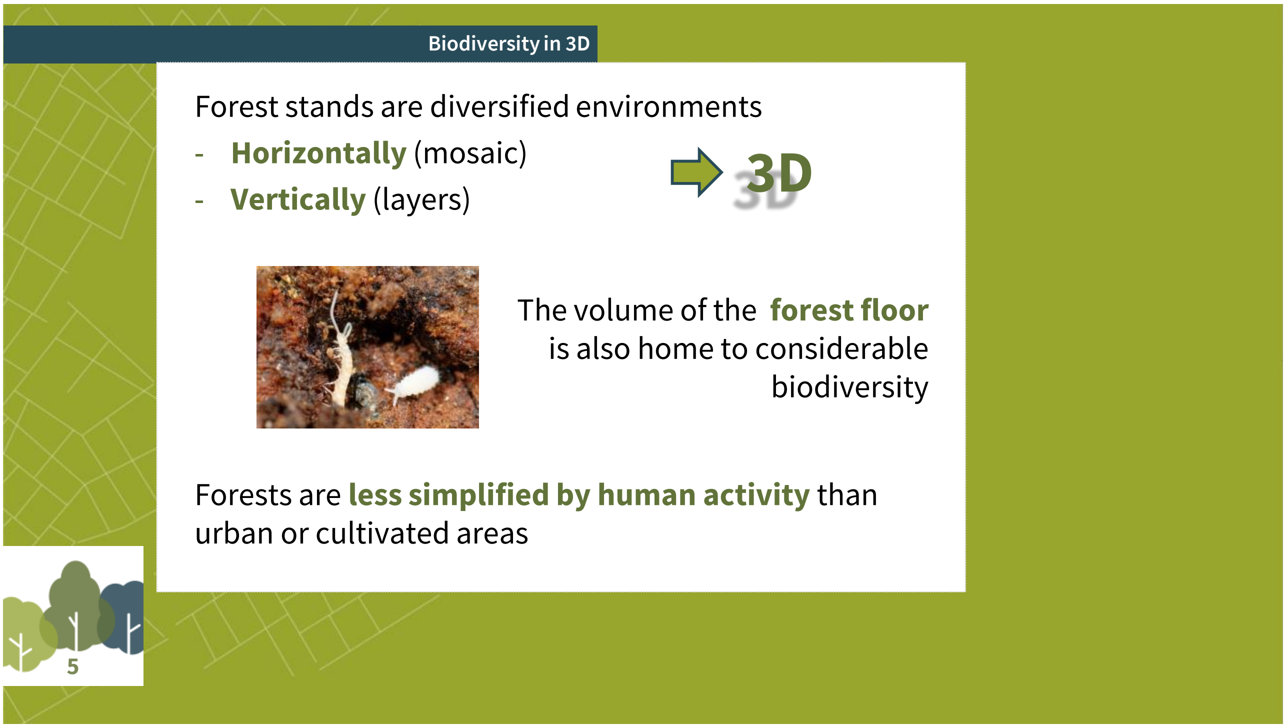
Let’s start the walk in an oak forest:
It is rich in fauna: mammals, birds, reptiles, amphibians, insects, arachnids, bacteria and a flora of mushrooms, mosses, ferns and flowering plants. Forest soils, in particular, are home to a very large amount of biodiversity, composed of animals, bacteria and fungi that recycle the leaves and dead wood of trees into nutrients, which they then feed on.

If we look closely at the oaks themselves, we can notice a great variation between them in terms of the shape of the leaves, the aspect of the bark and the tree for. This variation suggests the genetic diversity of the species, which is considerable. This, along with the interaction of the surrounding environmental conditions, leads to the differences among the trees.

A little further on, we find ourselves in a fir forest

Then, we continue even further and we find ourselves in an alder grove.

In a short distance, we have crossed three slightly different ecosystems.



Biodiversity in 3D

Forest stands are diversified environments

- **Horizontally** (mosaic)
- **Vertically** (layers)

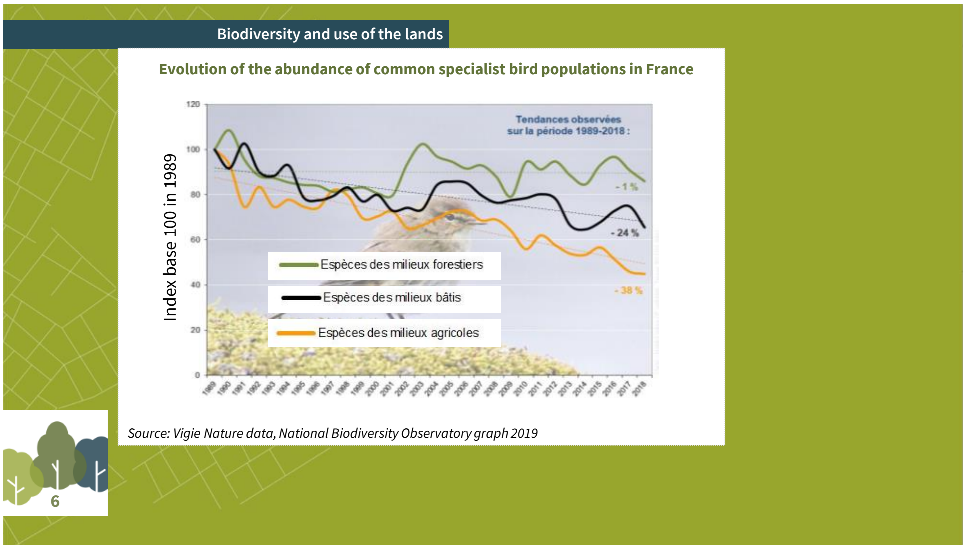
➔ **3D**

The volume of the **forest floor** is also home to considerable biodiversity

Forests are **less simplified by human activity** than urban or cultivated areas

Forests are a place where we find the three dimensions of biodiversity. Forests are diversified environments: horizontally (in mosaic), vertically (in strata), without forgetting the forest floor which shelters considerable biodiversity.

They are also environments less simplified by human activity than urban or cultivated areas.

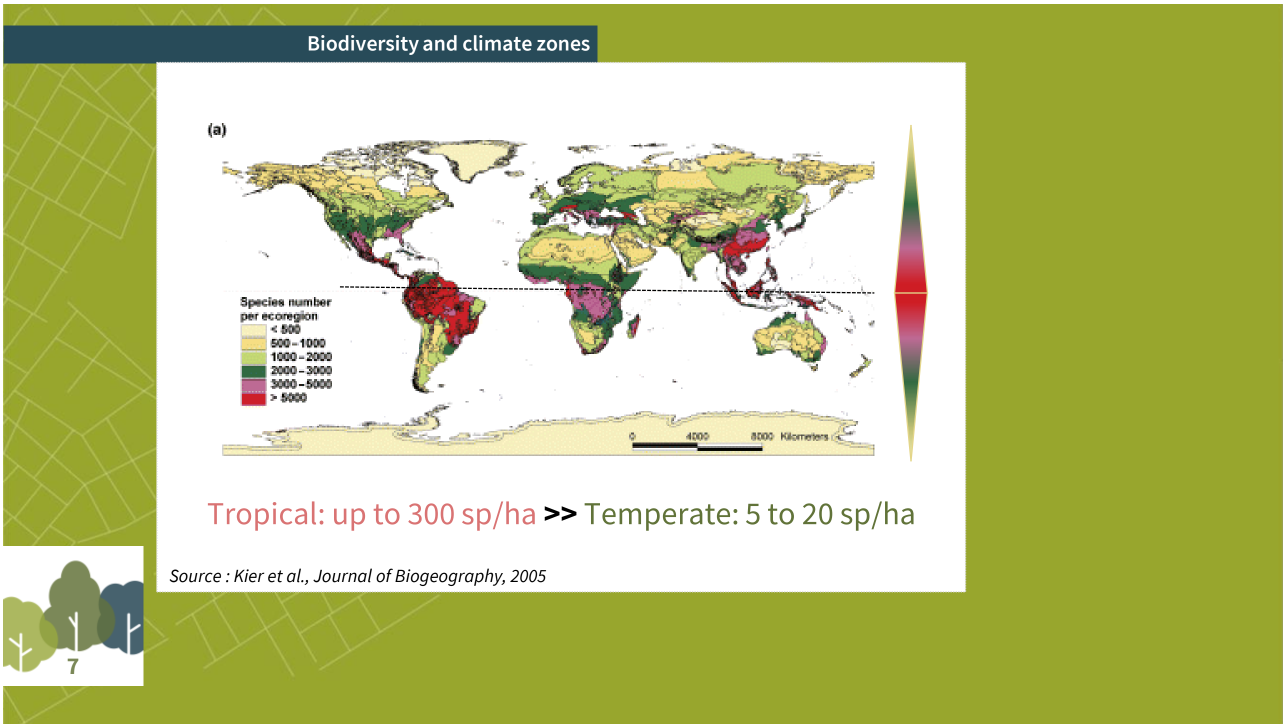


Biodiversity and use of the lands

Evolution of the abundance of common specialist bird populations in France

Source: Vigie Nature data, National Biodiversity Observatory graph 2019

We can illustrate this rather healthy biodiversity with this graph which shows the evolution of the populations of common specialist birds in France. As you can see, the curve representing forest species has remained steady in the forest environment while the populations in built or cultivated environments has decreased.



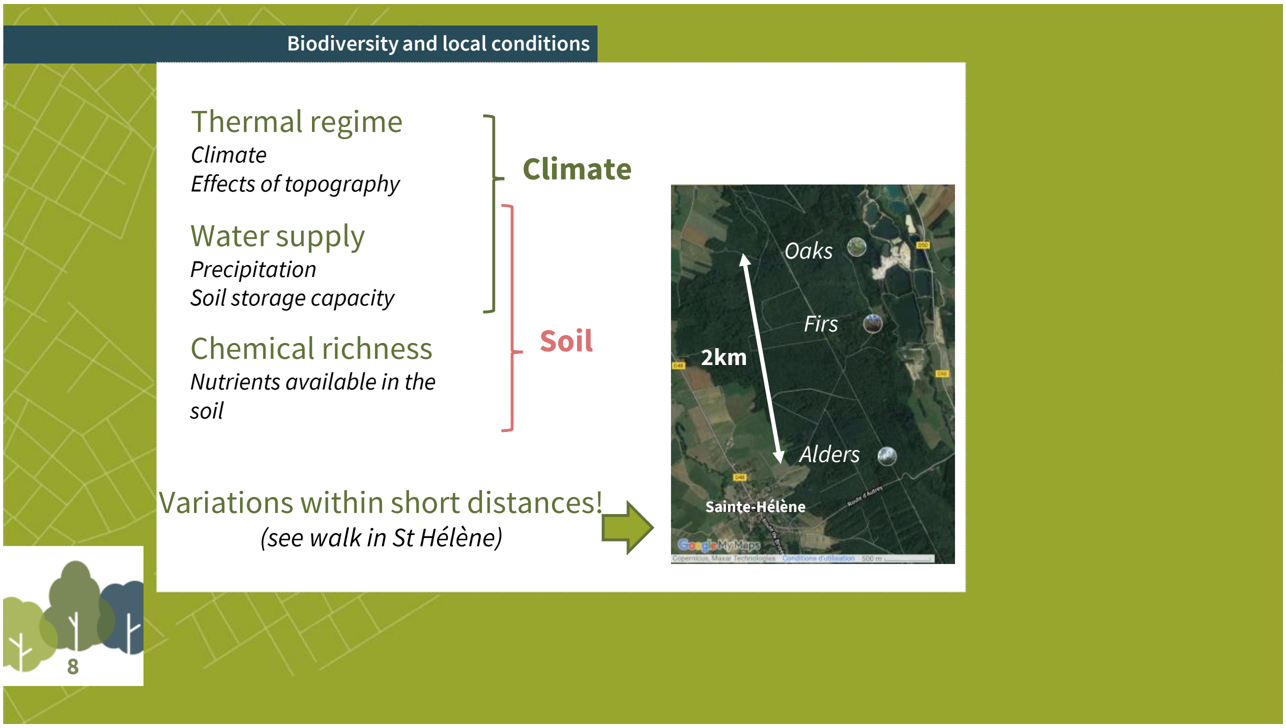
Biodiversity and climate zones

Tropical: up to 300 sp/ha **>>** Temperate: 5 to 20 sp/ha

Source : Kier et al., Journal of Biogeography, 2005

However, this biodiversity varies greatly from one type of forest to another. On a global scale, it depends on climatic zones. As can be seen on the map, the maximum density of species is reached in tropical rainforest areas, for example in Guyana.

On the other hand, it tends to decrease towards the North and South poles. Thus, we can count about 300 species of trees on a hectare of tropical forest, compared to 5 to 20 in temperate forests.



Biodiversity and local conditions

Thermal regime
Climate
Effects of topography

Water supply
Precipitation
Soil storage capacity

Chemical richness
Nutrients available in the soil

Climate

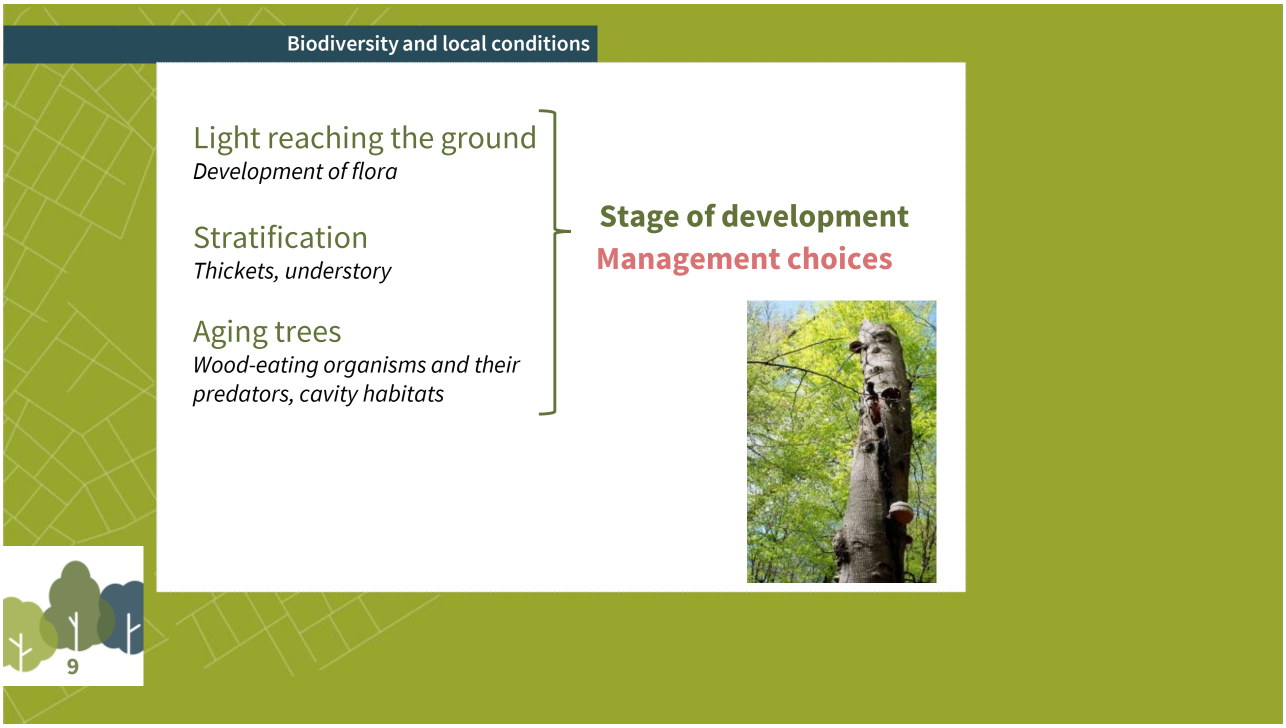
Soil

Variations within short distances!
(see walk in St Hélène)

Biodiversity also varies over short distances, depending on soil and climatic conditions. In forests, the flora, especially the trees, is closely linked to the characteristics of the environment. The distribution of species in association with plant types is related to :

- The thermal regime
- The water supply, which results not only from precipitation but also from the water storage capacity of the soil. This storage capacity depends on the depth of the soil.
- The chemical richness of the soil, which depends on geological conditions.

In short, these conditions vary from one region to another, but they can also vary over very short distances, within the same mountain range. We had an example of this during our little walk in the forest of Sainte-Hélène.



Biodiversity and local conditions

Light reaching the ground
Development of flora

Stratification
Thickets, understory

Aging trees
Wood-eating organisms and their predators, cavity habitats

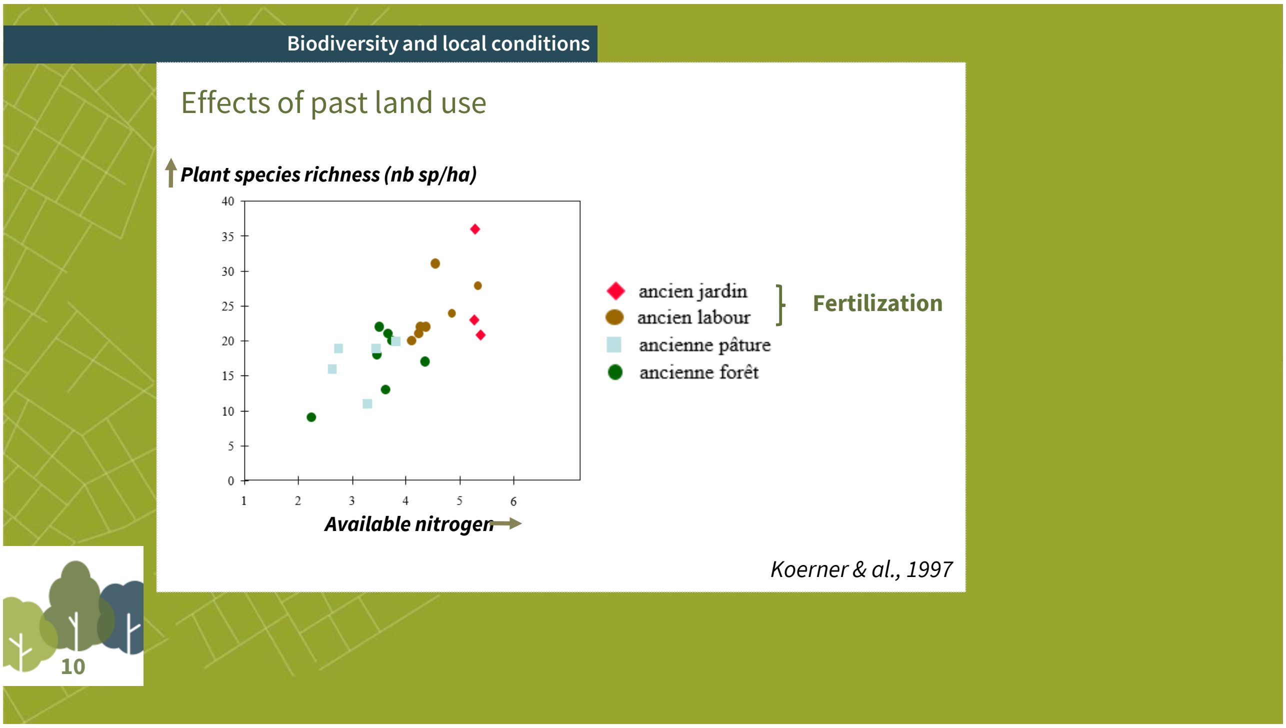
Stage of development
Management choices

Biodiversity also varies according to the stages of development (tree growth). The flora varies notably according to the light level of the forest. This quantity can vary strongly between a young very dense and dark forest and an old-growth forest beginning to open up and thus having much more light.

For example:

- a dense grove of young trees will provide shelter and refuge for wild boars
- while an old forest will have aging trees with cavities. These cavities will not only provide shelter to a whole fauna of insects that live in the decaying wood but also to birds and small mammals (bats) that find refuge there.

In the end, biodiversity can vary depending on the current and past management of the forest.



Biodiversity and local conditions

Effects of past land use

Koerner & al., 1997

Here is a graph from a study of plant diversity as a function of past soil use. The x-axis shows the amount of nitrogen available to plants and the y-axis is a measure of plant richness.

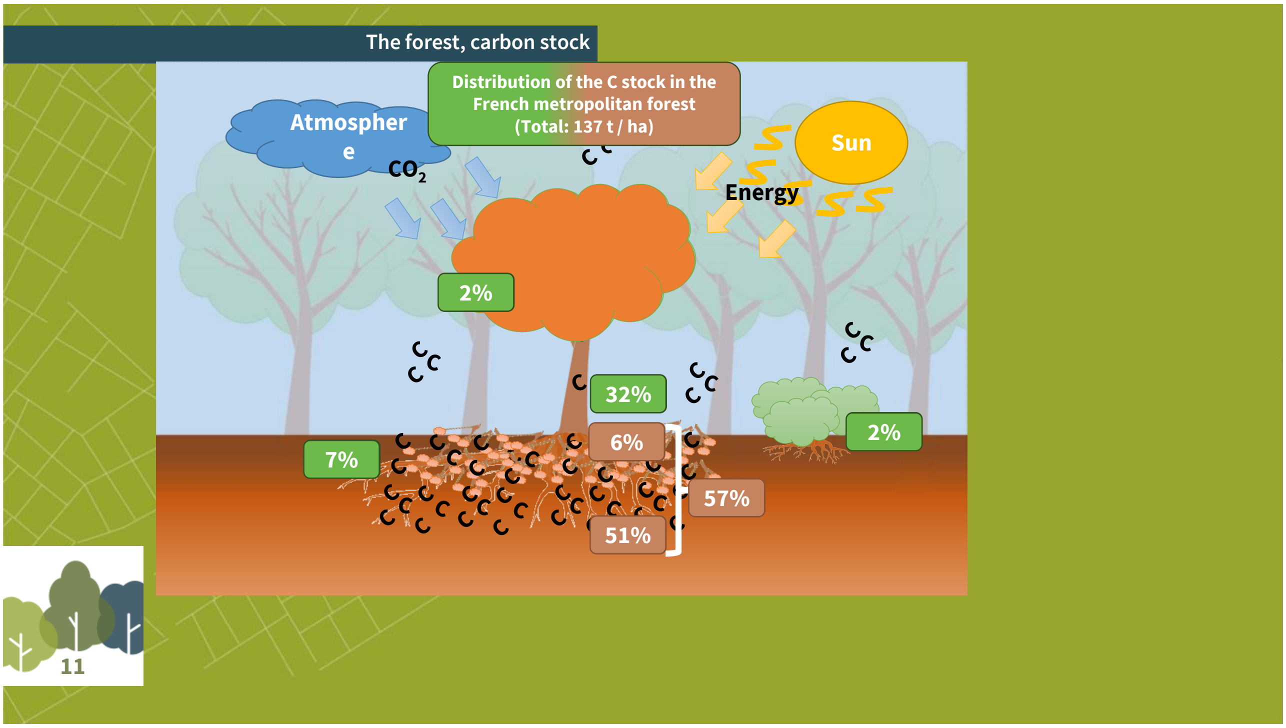
The color of the dots indicates past land use:

- Former forest
- Former rangeland
- Former cropland (plowing, tilling, digging, etc...)
- Old garden

We can see that from the old forest to the old garden, there is not only an increasing gradient of available nitrogen but also an increasing plant richness. This is related to the fertilization practices of these old farms that have permanently modified the flora.

Conversely, a forest that has not been cleared for several centuries may contain species that have generally been eliminated from a more recent forest, for example on former pastures.

The forest, carbon stock


Distribution of the C stock in the French metropolitan forest (Total: 137 t / ha)

Rich in biodiversity, the forest is also rich in carbon, one of the main chemical elements of living organisms.

Through photosynthesis, plants synthesize organic molecules using energy from the sun, carbon from carbon dioxide in the atmosphere, water, and minerals in the soil.
This carbon accumulates in the plant tissues (wood and leaves) as the trees grow and account for nearly half of their dry mass. When the leaves and dead wood fall, the carbon accumulates in the humus and then in the mineral horizons of the soil. This graph shows the distribution of this carbon stock, in the French metropolitan forests, according to its different compartments:

- Trunks and branches: 32%.
- Roots: 7
- Foliage: 2
- Low vegetation and dead wood: 2%.

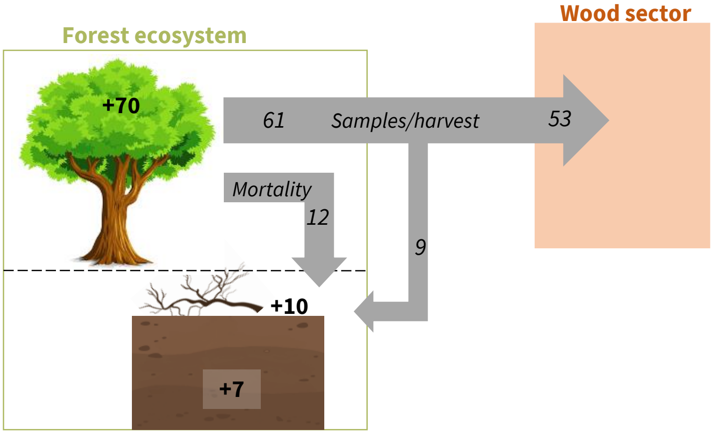
- The soil constitutes 57% of the forest carbon stock, including

- 6% in humus
- 51% in the first 30 centimeters of mineral horizons.

Conversely, carbon is released into the atmosphere by the respiration of living beings or by the decomposition or combustion of dead organisms.

On a global scale, forests represent 40 to 53% of the carbon of the continental biosphere, i.e. of all soils and land vegetation.

French forests, carbon sinks



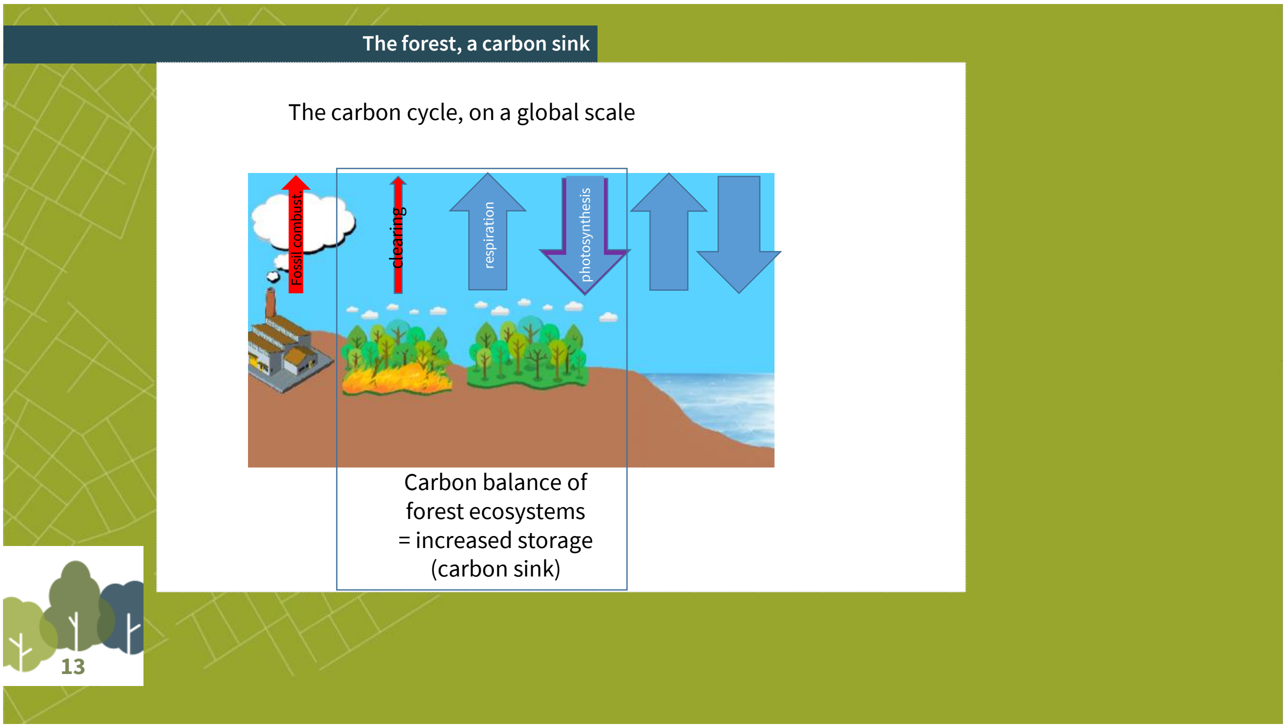
Annual variations in stocks of mainland French forests and *material flows*, in MtCO2eq / year

Not only are the quantities of carbon considerable, but in many contexts, they tend to increase over time. This is particularly the case in Europe, where forests are generally young and growing, both in area (expansion) and in volume (densification as trees mature).

The forest thus acts as a carbon sponge by absorbing and storing carbon in the trees and the soil.

Not only that, but the quantities of carbon stored in this way tend, in many contexts, to increase over time. This has been particularly the case in Europe for several decades, as forests are generally young and growing.

With climate change, we are more aware than ever of the importance of this regulating function of the forest. In fact, it is just as essential as the oceans.



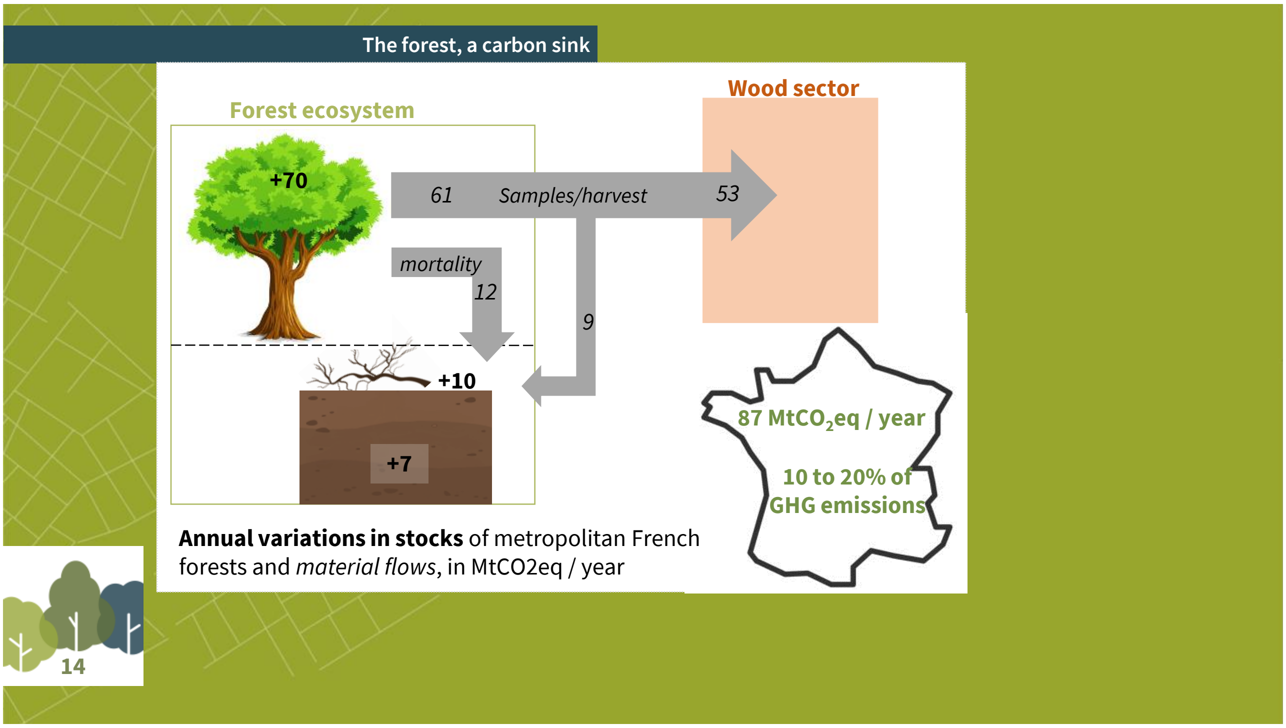
The forest, a carbon sink

The carbon cycle, on a global scale

Carbon balance of
forest ecosystems
= increased storage
(carbon sink)

When oil burning, for example, increases the CO2 content of the atmosphere, or when forest areas are cleared, forests tend to increase their photosynthetic activity and absorb more carbon. They therefore partly regulate - with a certain number of constraints to which we will return - the imbalance caused by human activity, and therefore global warming.

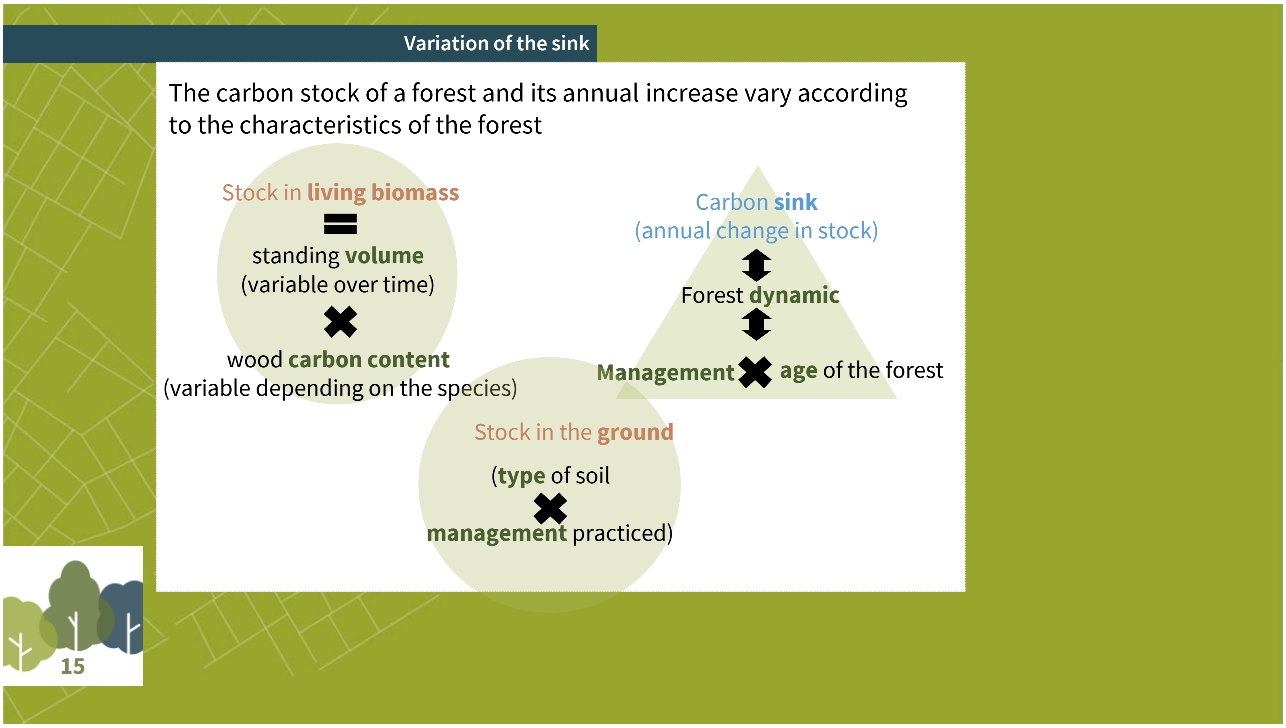
This is why the forest is considered and called "carbon sink".



The forest, a carbon sink

Annual variations in stocks of metropolitan French forests and *material flows*, in MtCO2eq / year

Generally speaking, each year in France, the forest increases its carbon stock by about 87 MtCO2eq / year, i.e. about 10% of human GHG emissions, while 53 MtCO2eq / year are exported from the forest in the form of timber.



Variation of the sink

The carbon stock of a forest and its annual increase vary according to the characteristics of the forest

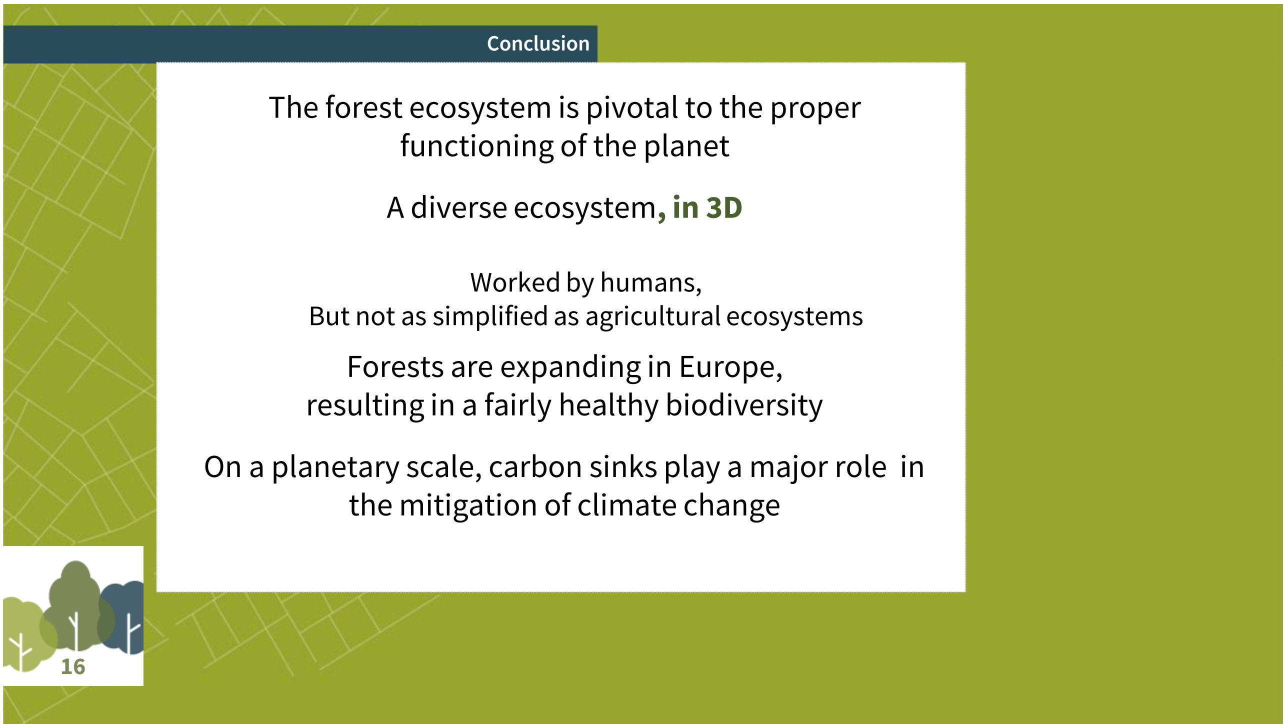
Stock in **living biomass**
=
standing **volume**
(variable over time)
✖
wood **carbon content**
(variable depending on the species)

Carbon **sink**
(annual change in stock)
↕
Forest **dynamic**
↕
Management ✖ **age** of the forest

Stock in the **ground**
(**type** of soil
✖
management practiced)

Again, both the carbon stock and the annual increase in that stock (i.e., the size of the carbon sink) vary greatly by forest.
-> The carbon stock in the living biomass varies particularly with not only standing volume, but also with the carbon content of the wood, which in turn varies with species.
-> The carbon stock in the soil varies according to the type of soil and the management practiced.

The carbon sink depends on the dynamics of the forest (is it maturing and thus increasing its standing volume?), which in turn depends on the age of the forest and the way it is managed.



Conclusion

The forest ecosystem is pivotal to the proper functioning of the planet

A diverse ecosystem**, in 3D**

Worked by humans,
But not as simplified as agricultural ecosystems

Forests are expanding in Europe,
resulting in a fairly healthy biodiversity

On a planetary scale, carbon sinks play a major role in the mitigation of climate change

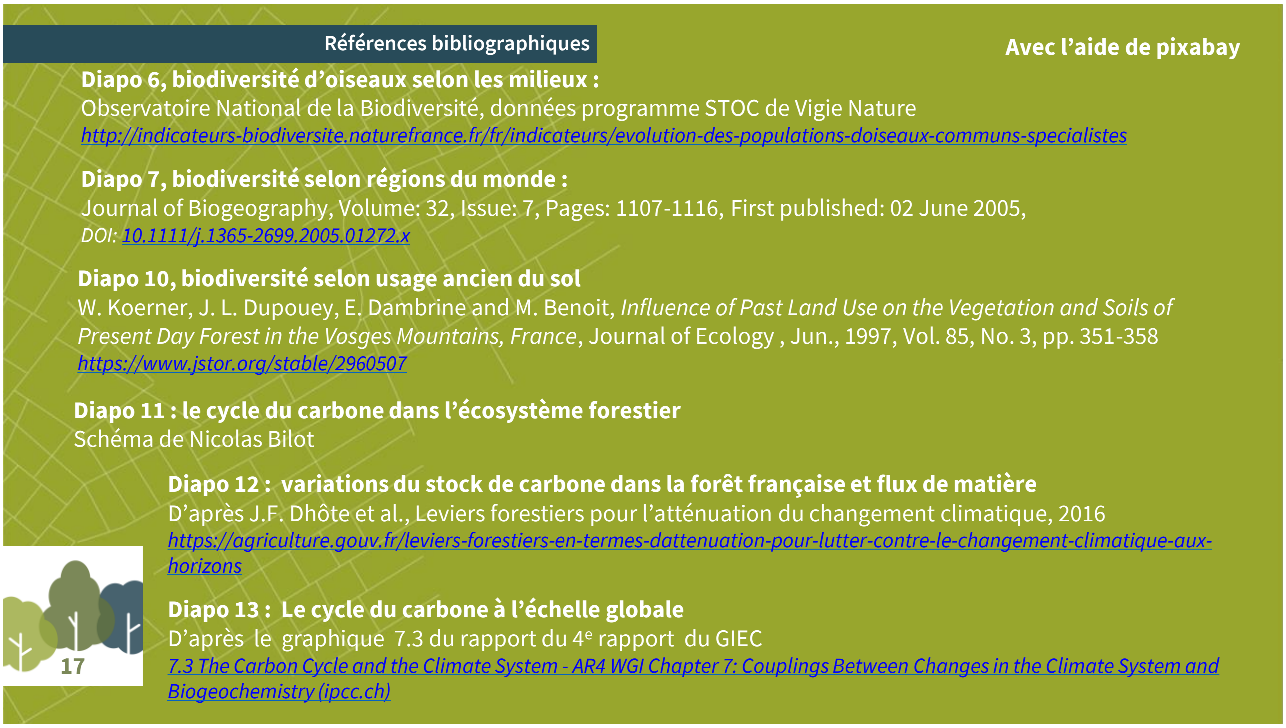
Beyond all the services it provides directly to humans, the forest is a pivotal factor in the proper functioning of the planet.

It is a diversified ecosystem, in all three dimensions.

Although man has been working the forest for thousands of years, even in unsuspected places like the so-called "virgin" forests of the Amazon, it is still considered less modified than agricultural or urban ecosystems.

In Europe, forests are expanding and biodiversity is doing quite well.

This expansion, observed on several continents, is also reflected in a significant increase in the global carbon reservoir, adding a new dimension to the role of forests in climate regulation by partially offsetting the greenhouse gas emissions caused by human activity.



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Week 2

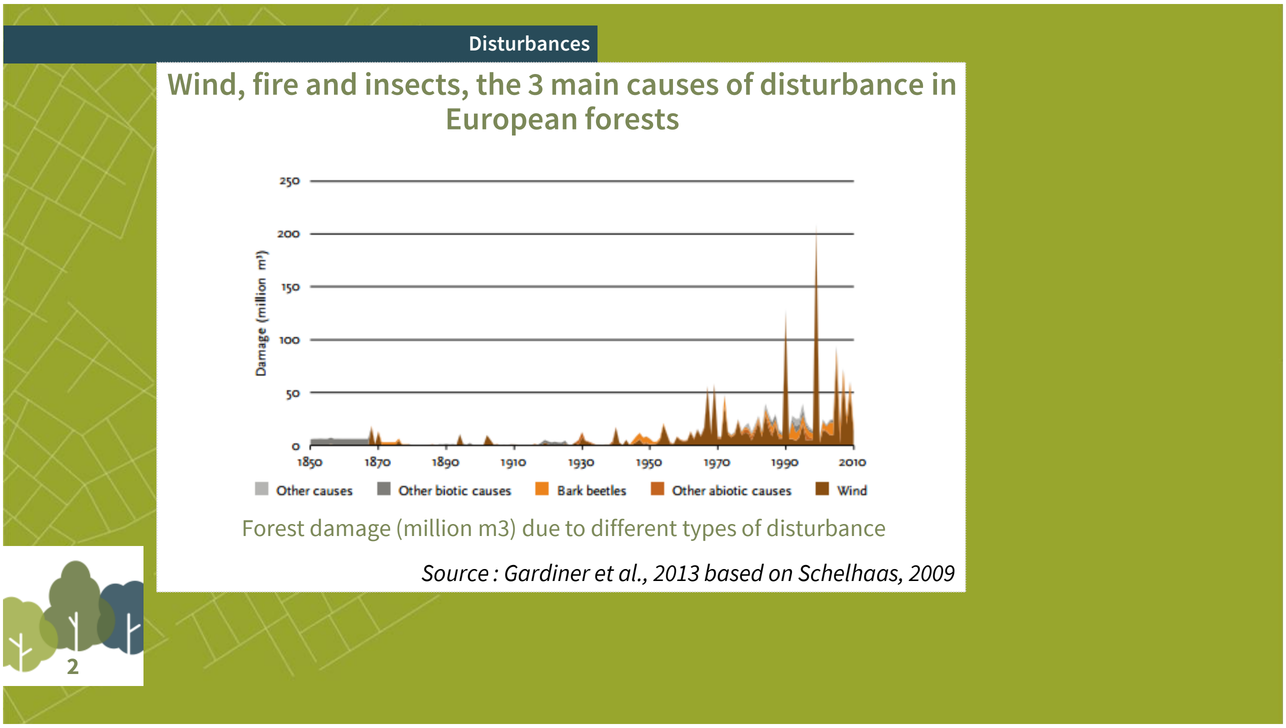
What is sustainable forest management?

Video 3

Threats to the forest: clearing and degradation

Now that we have a better understanding of the diversity and importance of the services that the forest provides to us, I suggest that we now think about the protection of this valuable resource.

To do so, we need to look at the various threats that forests face today.



Disturbances

Wind, fire and insects, the 3 main causes of disturbance in European forests

Forest damage (million m3) due to different types of disturbance

Source : Gardiner et al., 2013 based on Schelhaas, 2009

Wind, fire, insects: disturbances or threats?

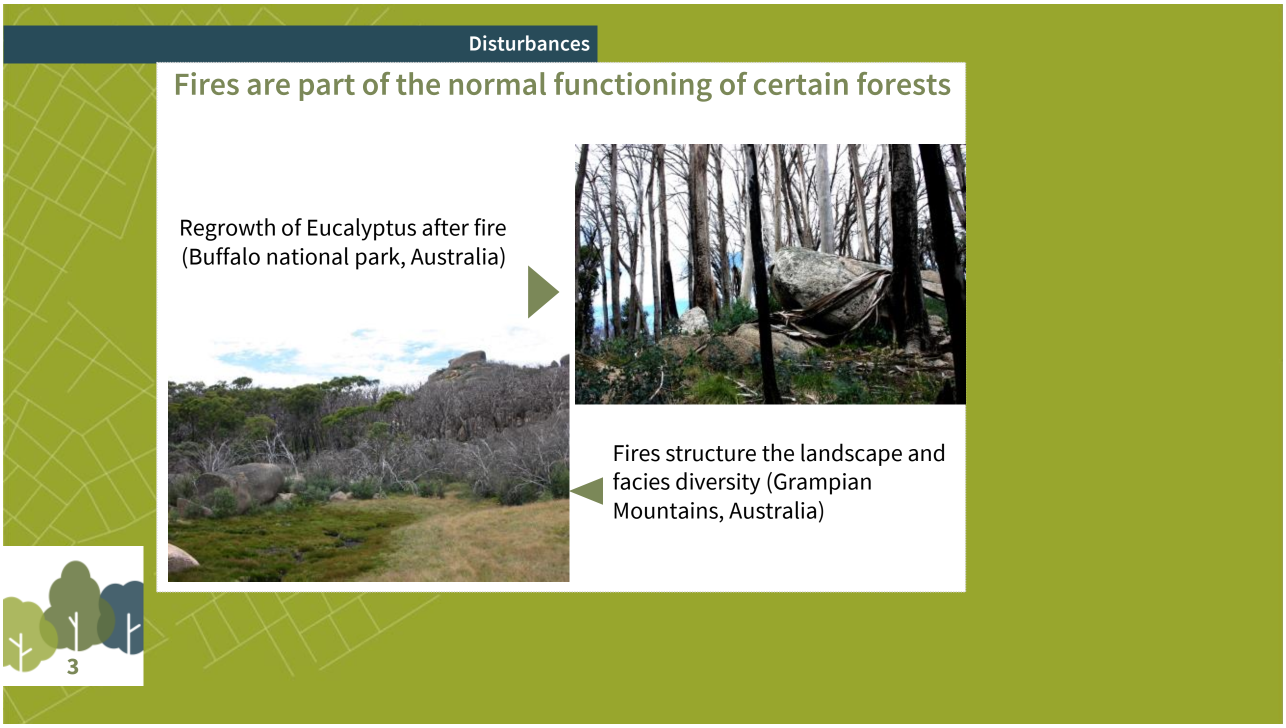
What threatens a forest?

I suppose that many of you will think first of forest fires - which lead to the sudden destruction of forest cover, in some cases over an area of thousands of hectares.

Similarly, a storm can also destroy whole sections of forest. We saw this in France in 1999 with the storms Lothar and Martin.

In fact, in Europe, fires, storms and insect infestations were the three main causes of forest damage over the last century. This is shown in the graph above.

But do these sudden events really destroy the forest? In general, no. The forest recovers on its own, in a variable timeframe, depending on the type of forest and the type of disturbance. In terms of time, it is generally of the order of a few decades.



Disturbances

Fires are part of the normal functioning of certain forests

Regrowth of Eucalyptus after fire (Buffalo national park, Australia)

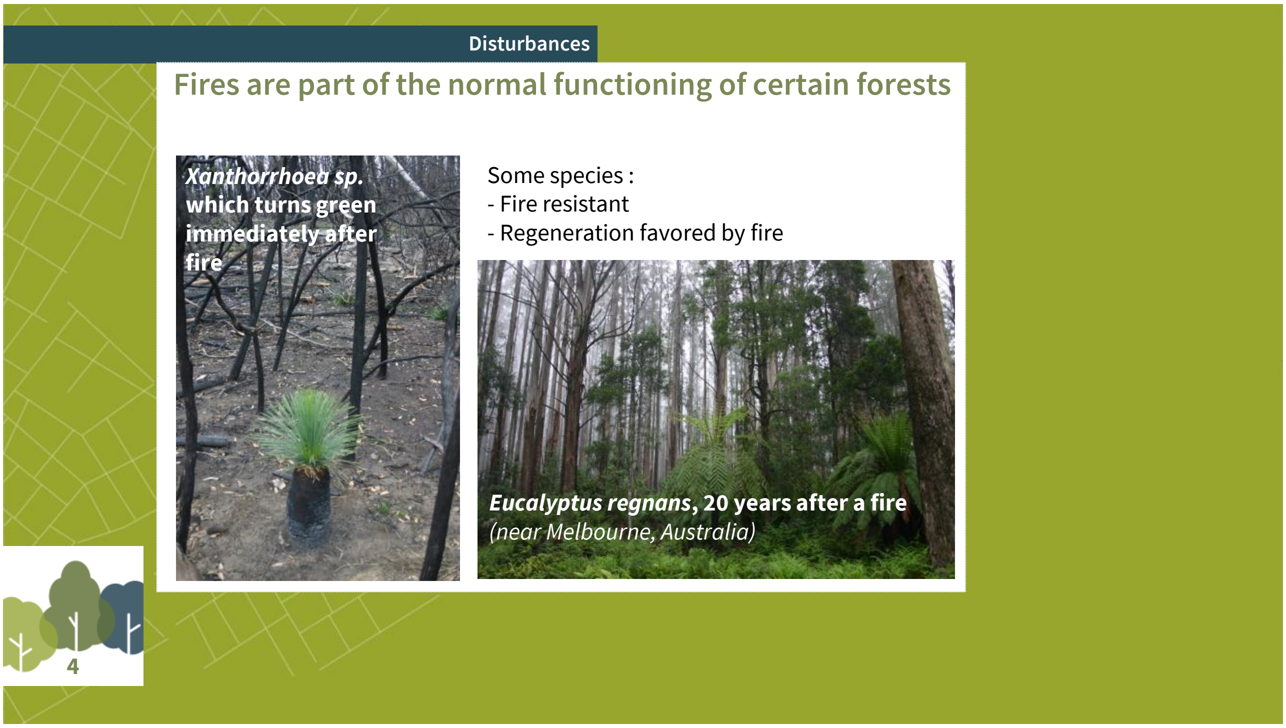
Fires structure the landscape and facies diversity (Grampian Mountains, Australia)

Examples of forests where fire plays a major ecological role: Forests in the region of Melbourne, Australia

In certain types of forests, fires play an integral role in the forest's life cycle. By destroying the old tree cover and eliminating competing species, fires make room for younger trees to thrive. The ecological role of fire has, for example, been widely studied in the United States, in the boreal forest or in Siberia, and as shown in the photos above, Australia.

Ecologists have thus demonstrated that the composition and structure of these forests were made possible through a natural fire regime, which has played a major role in the renewal of stands and the diversification of facies.

Here, you can see a recovery of Eucalyptus trees after a fire and a landscape made up of areas which have been more or less affected by the fire, in a facies mosaic.



Fires are part of the normal functioning of certain forests

Xanthorrhoea sp. **which turns green immediately after fire**

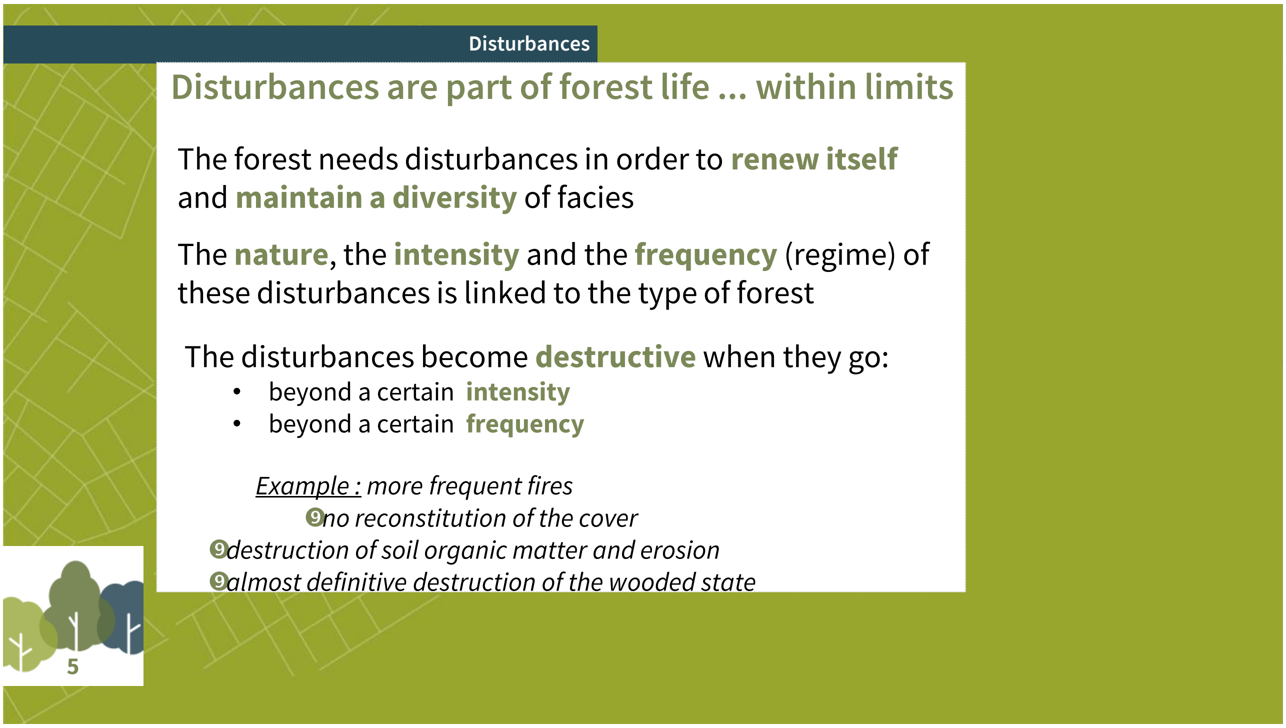
Some species :
- Fire resistant
- Regeneration favored by fire

Eucalyptus regnans**, 20 years after a fire**
(near Melbourne, Australia)

Some species of these forests can exhibit an adaptation to fire:

- Some trees resist fire better than others. Take for example the *Xanthorrhoea sp*. in the photo, on the left, thanks to its bark or thick tissue, it turns immediately back to green after a fire.

- Others, see their regeneration stimulated by fire. For example, some trees need heat to help open their fruit, or some simply thrive more in the open spaces that fires create. This is the case for *Eucalyptus regnans,* the impressive forest shown in the photo, on the left, naturally regenerated, 20 years after a fire.



Disturbances are part of forest life ... within limits

The forest needs disturbances in order to **renew itself** and **maintain a diversity** of facies

The **nature**, the **intensity** and the **frequency** (regime) of these disturbances is linked to the type of forest

The disturbances become **destructive** when they go:

- beyond a certain **intensity**
- beyond a certain **frequency**

Example : *more frequent fires*

❾*no reconstitution of the cover*

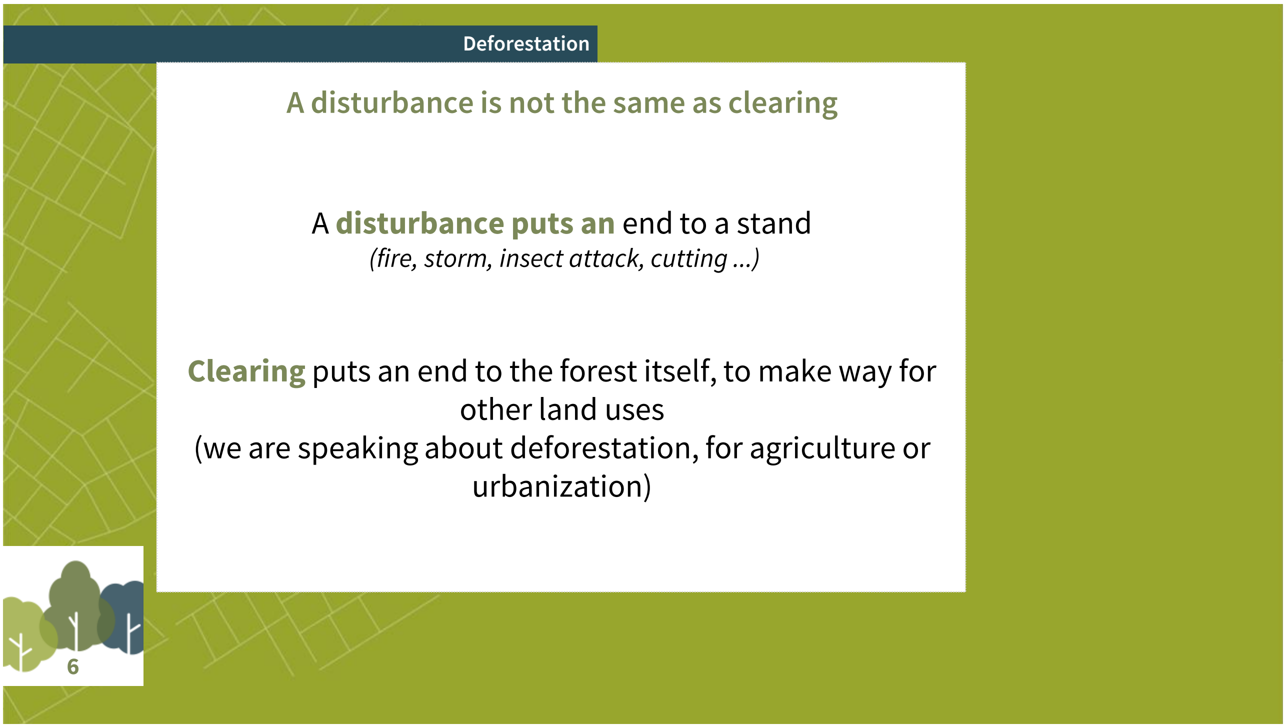
❾*destruction of soil organic matter and erosion*

❾*almost definitive destruction of the wooded state*

Disturbance is a part of forest life ... within limits

In general, contrary to what is often thought, forests need disturbances to renew themselves and maintain a diversity of facies, ecological conditions and species. These disturbances can be related to fires, storms, insect invasions, as well as to human interventions, such as logging. Depending on the nature and frequency of these disturbances, the forest can be significantly altered.

These disturbances become truly destructive to the forest when their frequency or intensity becomes excessive. Repeated fires destroy and prevent the reconstitution of the canopy, leading to the destruction of the soil's organic matter and exposing it to erosion, to the point of almost irreversible destruction of its wooded state.



Deforestation

A disturbance is not the same as clearing

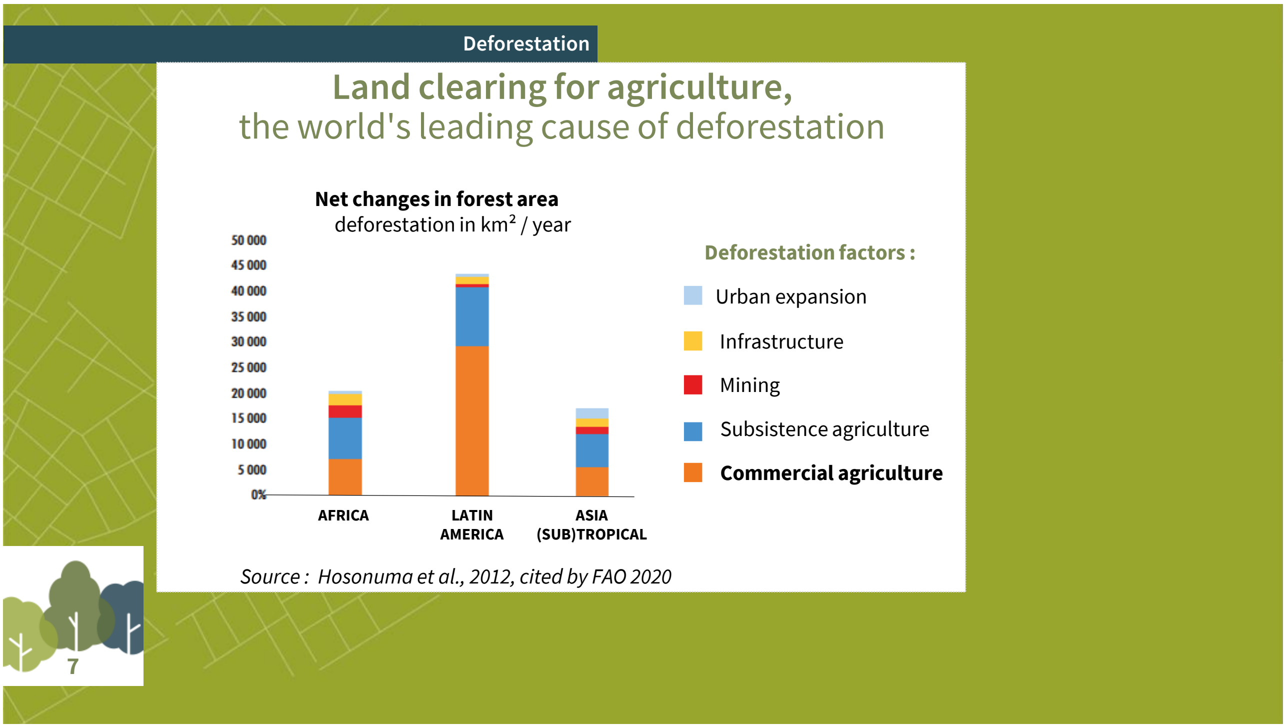
A **disturbance puts an** end to a stand
(fire, storm, insect attack, cutting …)

Clearing puts an end to the forest itself, to make way for other land uses
(we are speaking about deforestation, for agriculture or urbanization)

A disturbance is not the same as clearing!

Sometimes people also use fire to their advantage to replace the forest with crops or pasture. This leads us to the main threat to the forest: land clearing.

Clearing (or deforestation) is an act whereby trees are cut down with the aim of clearing the land for alternative use, other than a forest. It is important to distinguish between felling where the objective is to clear the land for reuse and felling where, although the trees are cut (harvested), the objective is for the land use to remain a forest. In the latter case, after the trees have been felled, the canopy will be reconstituted, either by planting or by natural regeneration.



Deforestation

Land clearing for agriculture, the world's leading cause of deforestation

Net changes in forest area
deforestation in km² / year

Deforestation factors :

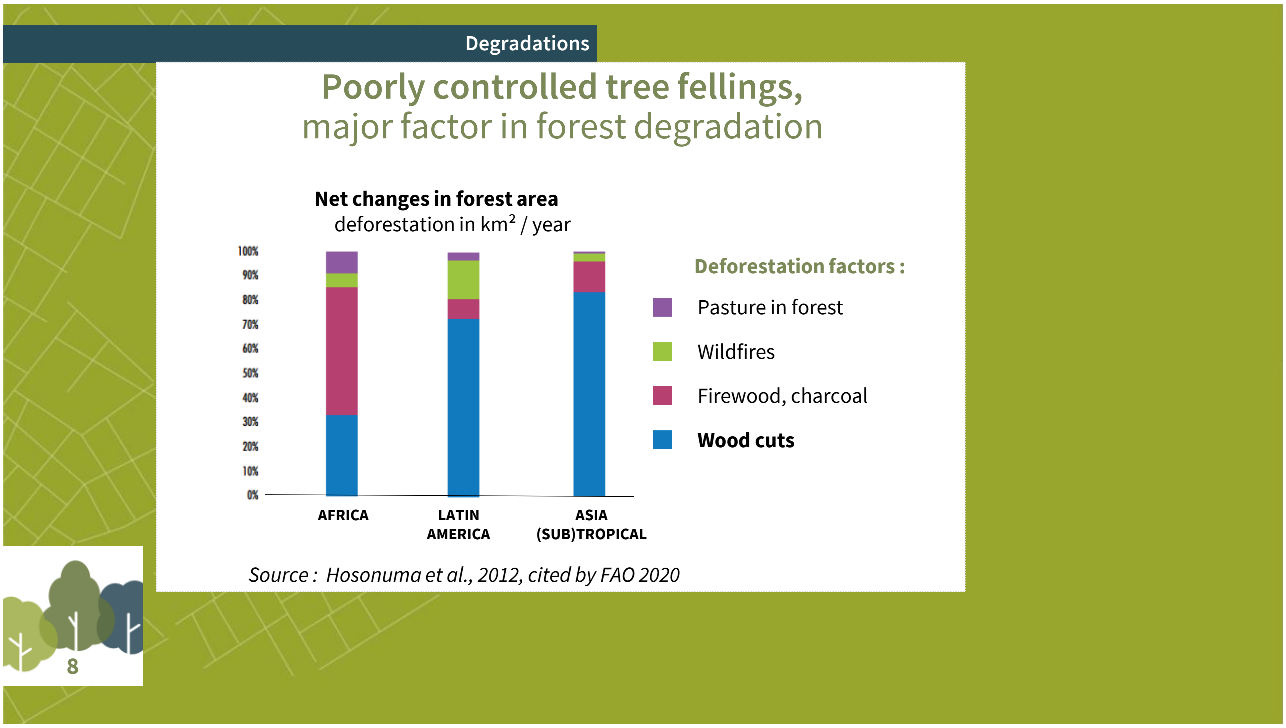
- Urban expansion
- Infrastructure
- Mining
- Subsistence agriculture
- **Commercial agriculture**

Source : Hosonuma et al., 2012, cited by FAO 2020

The main cause of forest destruction in the world: agricultural clearing

Historically in France, and in general, the world, the first cause of forest decline is clearing for the benefit of **agriculture.** Here, on this graph, deforested areas are shown in orange, in relation to the factors of deforestation on the 3 developing continents. By the way, this is an opportunity to stress that you are certainly more likely to promote the destruction of forests by buying beef fed on soybean meal or cookies made with palm oil than by using paper. This is called imported deforestation.

You may be surprised not to see tree cutting on this graph?



Degradations

Poorly controlled tree fellings,
major factor in forest degradation

Net changes in forest area
deforestation in km² / year

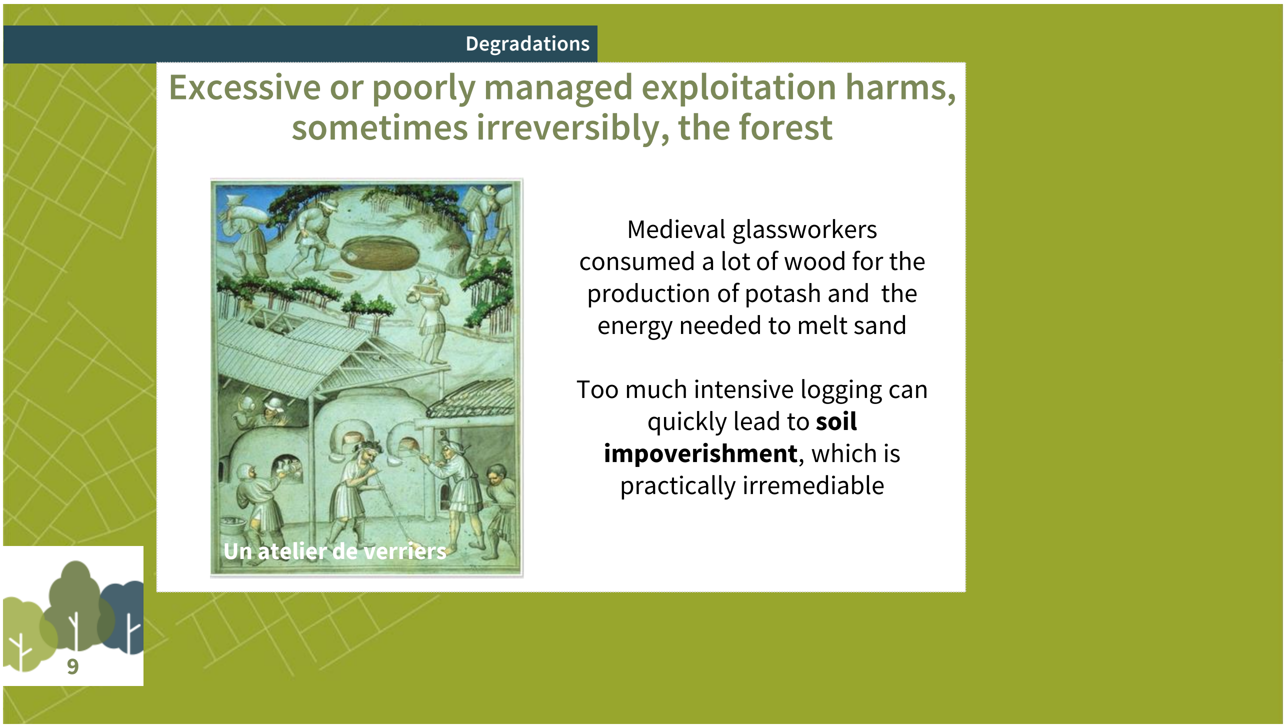
Deforestation factors :

🟪 Pasture in forest
🟩 Wildfires
🟥 Firewood, charcoal
🟦 **Wood cuts**

Source : Hosonuma et al., 2012, cited by FAO 2020

Poorly controlled felling, a major factor in forest degradation around the world

Logging itself is not a factor in the destruction of the forest, as it is self-regenerating. However, when it is practiced excessively, or without taking the necessary precautions, it becomes a major factor in the degradation of the state of the forest. This is illustrated on this graph, taken from the same source as the previous slide. Wood cutting , which appears in blue, is the most significant contributing factor when it comes to forest degradation in Latin America and Asia, and the second most contributing factor, after firewood and charcoal, in Africa.



Degradations

Excessive or poorly managed exploitation harms, sometimes irreversibly, the forest

Un atelier de verriers

Medieval glassworkers consumed a lot of wood for the production of potash and the energy needed to melt sand

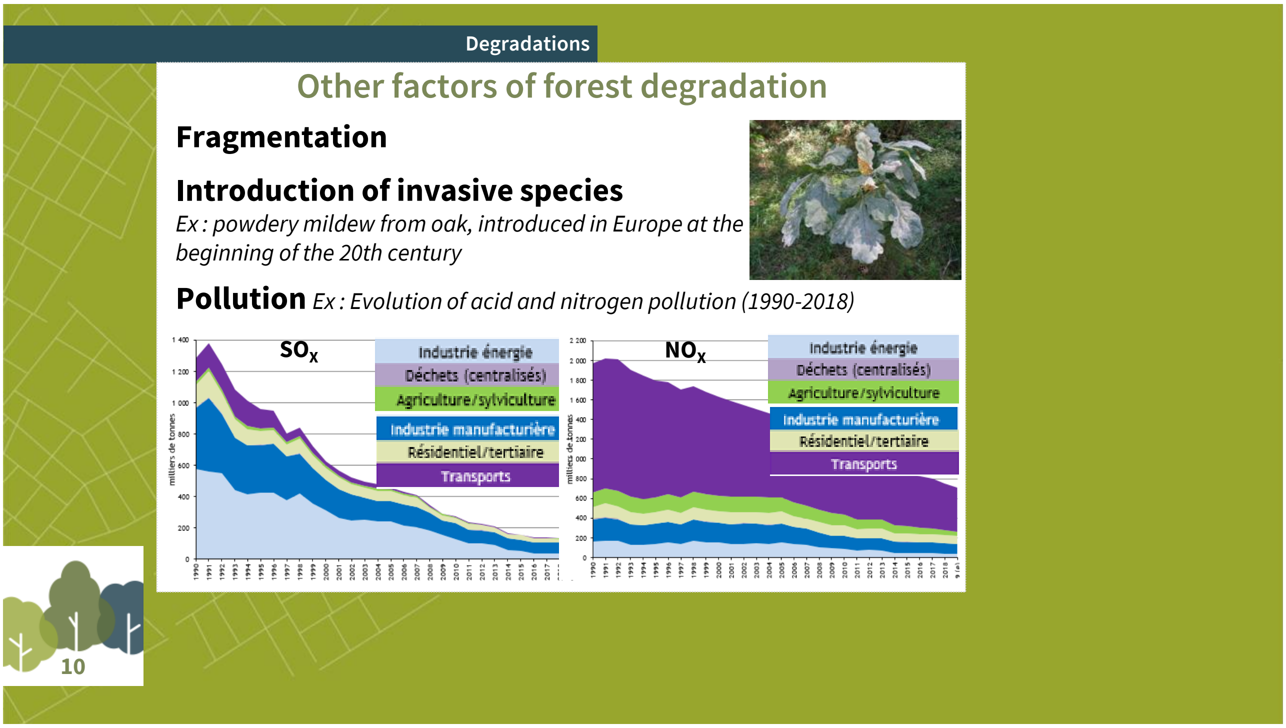
Too much intensive logging can quickly lead to **soil impoverishment**, which is practically irremediable

Excessive exploitation of the forest itself can cause damage, most often leading to soil impoverishment, rather than destruction.

A historical example in France is the medieval glass industry, which consumed a lot of wood. Not only was wood used to produce the energy needed to melt sand into glass, but it was also and above all used for the production of potash, which is contained in wood ash and is needed in the glass-making process.

Such intensive logging results in a massive loss of nutrients and can quickly lead to soil impoverishment.

Given the time it takes for the forest soil to recover, this consequence can be irreparable.



Other factors of forest degradation

Fragmentation

Introduction of invasive species

Ex : powdery mildew from oak, introduced in Europe at the beginning of the 20th century

Pollution *Ex : Evolution of acid and nitrogen pollution (1990-2018)*

Other factors of forest degradation

Of course, there are many factors associated with forest degradation. The fragmentation of forests into small, isolated stands, for example, weakens and reduces biodiversity. As the forest evolves, fragmentation not only limits the possibilities for some species to find areas with more favorable ecological conditions to migrate to, but it also condemns others, such as large predators, which need much more space to live. The introduction of new species can sometimes destabilize the local ecological balance when they become invasive. In our European forests, this phenomenon concerns very few plant species, and almost no tree species, but increasingly occurs with accidentally introduced insects or pathogenic tree fungi.

Here is an image you may have seen before: it is a photo of an oak branch affected by powdery mildew. It should be noted that powdery mildew was only introduced into France at the beginning of the 20th century and at that time foresters were very concerned about its possible impact on oak groves.

Atmospheric pollution can also alter the condition of forests and change their composition. Although acid rain, which was much talked about in the 1980s, has been greatly reduced, forests still suffer from the effects of nitrogen pollution.

Clearing for agriculture,
the main cause of **deforestation**

Disturbances contribute to **the life of a forest**

... as long as they don't become
too ***aggressive*** *or too* ***frequent***

Climate change
alters the **disturbance regime**

Many **degradation** factors:
fragmentation, excessive exploitation, invasive species, pollution

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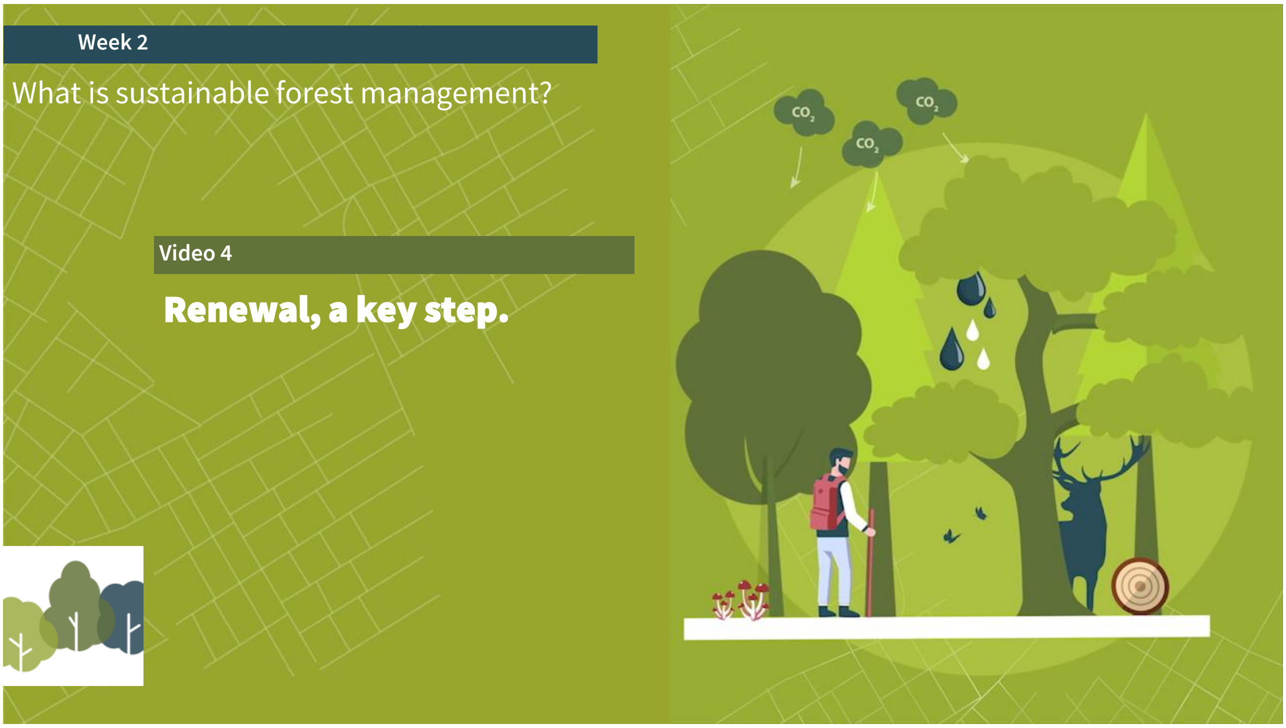


Week 2

What is sustainable forest management?

Video 4

Renewal, a key step.

The previous lesson reminded us that one of our first priorities to ensure the sustainability of the forest is to protect it from clearing.

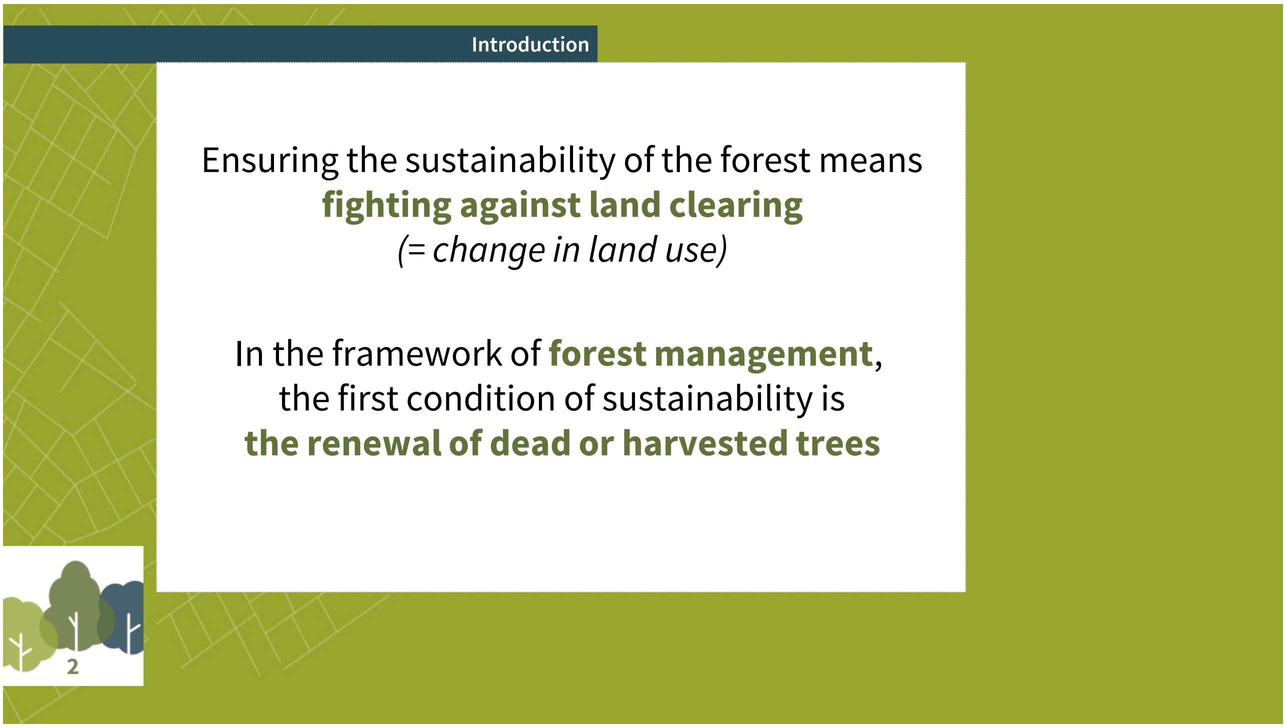
(The aim of clearing a forest area is to reuse the land for another purpose: agricultural development, infrastructure construction, mining, urbanization.)

Now that we have been reminded about this fundamental point, let us place ourselves within the framework of forest land use, whatever the objectives and management intensity.

In this context, the sustainability of the forest depends on , first and foremost, one key step:

RENEWAL

In fact, whether or not the forest is managed or natural, or the wood is harvested or not, the trees live, grow and die. In order for the forest to be maintained, the old trees which disappear, either by natural mortality or harvesting, need to be replaced by younger trees, capable of growing.



Ensuring the sustainability of the forest means
fighting against land clearing
(= change in land use)

In the framework of **forest management**,
the first condition of sustainability is
the renewal of dead or harvested trees

The process of renewal requires that the trees are able to flower, self-fertilize(selfing), that the seeds can germinate and develop.
Once in the ground, they need to be able to germinate, and then the seedlings need to be able to develop, receiving enough light to do so.

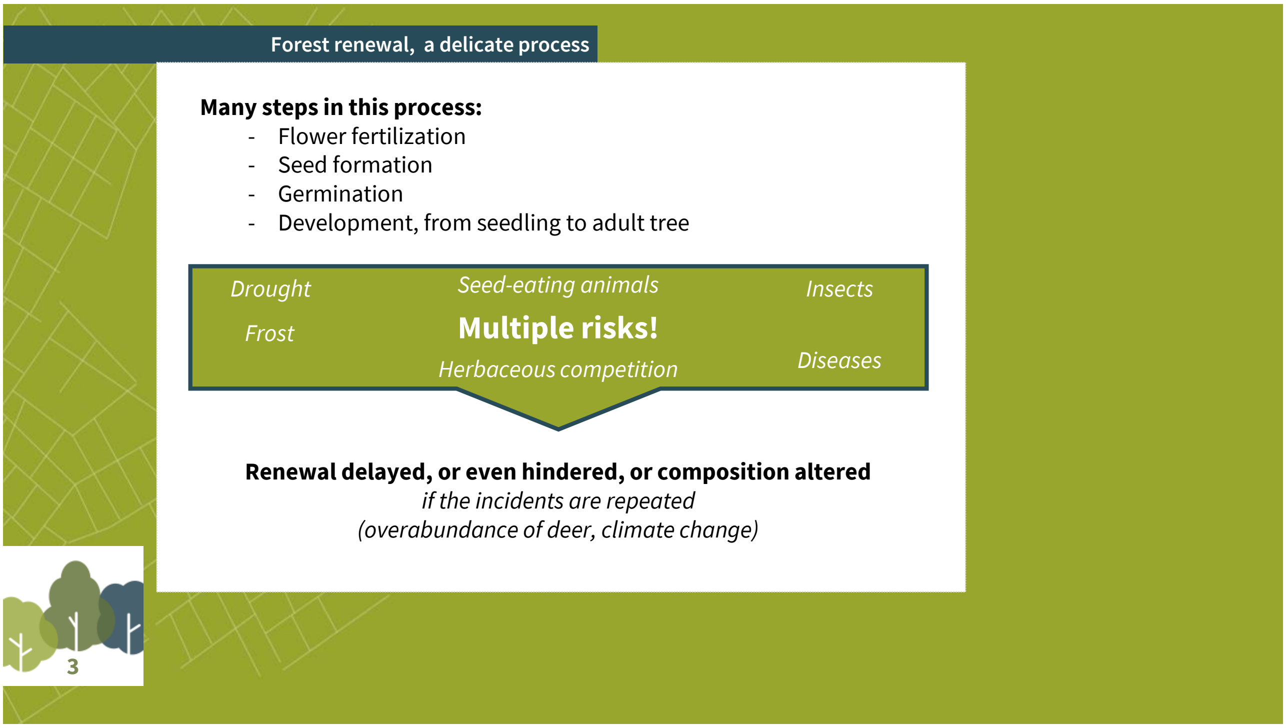
As the seedlings gradually develop, their numbers will decrease. The more vigorous ones gradually take up more space to the detriment of the others, eventually eliminating the competition.

MANY INCIDENTS COULD OCCUR DURING THIS COMPLEX PROCESS

Climatic events, i.e. extreme cold, droughts, can destroy the flowers, the seeds, or the seedlings. Damage caused by diseases, or insects can do the same.

These incidents which occur in managed forests as well as in natural forests, are generally transient, and only delay the establishment of the new stand.

The repetition of these incidents can nevertheless lead to obstacles.



Forest renewal, a delicate process

Many steps in this process:

- Flower fertilization
- Seed formation
- Germination
- Development, from seedling to adult tree

Drought

Seed-eating animals

Insects

Frost

Multiple risks!

Herbaceous competition

Diseases

Renewal delayed, or even hindered, or composition altered

if the incidents are repeated

(overabundance of deer, climate change)

SAME NOTES AS THE PREVIOUS SLIDE.

The process of renewal requires that the trees are able to flower, self-fertilize(selfing), that the seeds can germinate and develop.
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MANY INCIDENTS COULD OCCUR DURING THIS COMPLEX PROCESS

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These incidents which occur in managed forests as well as in natural forests, are generally transient, and only delay the establishment of the new stand.

The repetition of these incidents can nevertheless lead to obstacles.

Defoliation of mature seed trees by processionary caterpillars

Regeneration in the context of oak problems!

Forest animals feeding on young oaks

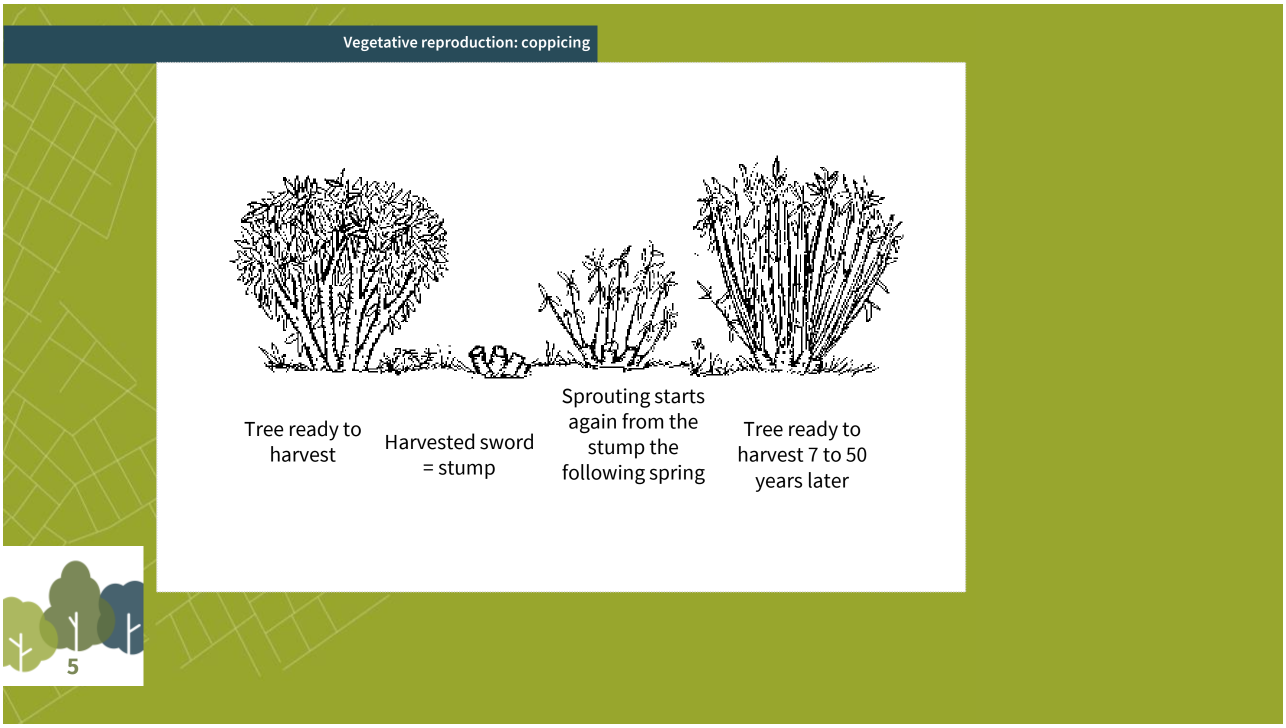
Sometimes, these incidents in the renewal of the forest locally favor the establishment of herbaceous flora, for example grasses, which hinders the establishment of tree seedlings. If this grass phase lasts a long time, the old trees could continue to disappear without being able to reproduce, thus creating a permanent clearing in the forest landscape.

What can also happen with the repetition of these incidents, is the permanent alteration of the forest cover. Frequent repetition of forest fires, for example, can push back the forest, and even destroy the soil. A very high density of herbivores (deer or roe deer), repeatedly herbivory on young shoots, can impede forest renewal.

With climate change, the repetition of climatically unfavorable years can also compromise or modify forest cover in the long term.

In managed forests, humans seek to limit these incidents by ensuring the renewal of the forest in a regular and continuous manner. They would like to continue to benefit from the services the forest provides to them, at the expected rate.

Knowing how to obtain the renewal of the forest in a reasonable amount of time, and examining its species composition is a key objective in the art of cultivating the forest: Silviculture



Vegetative reproduction: coppicing

Tree ready to harvest

Harvested sword = stump

Sprouting starts again from the stump the following spring

Tree ready to harvest 7 to 50 years later

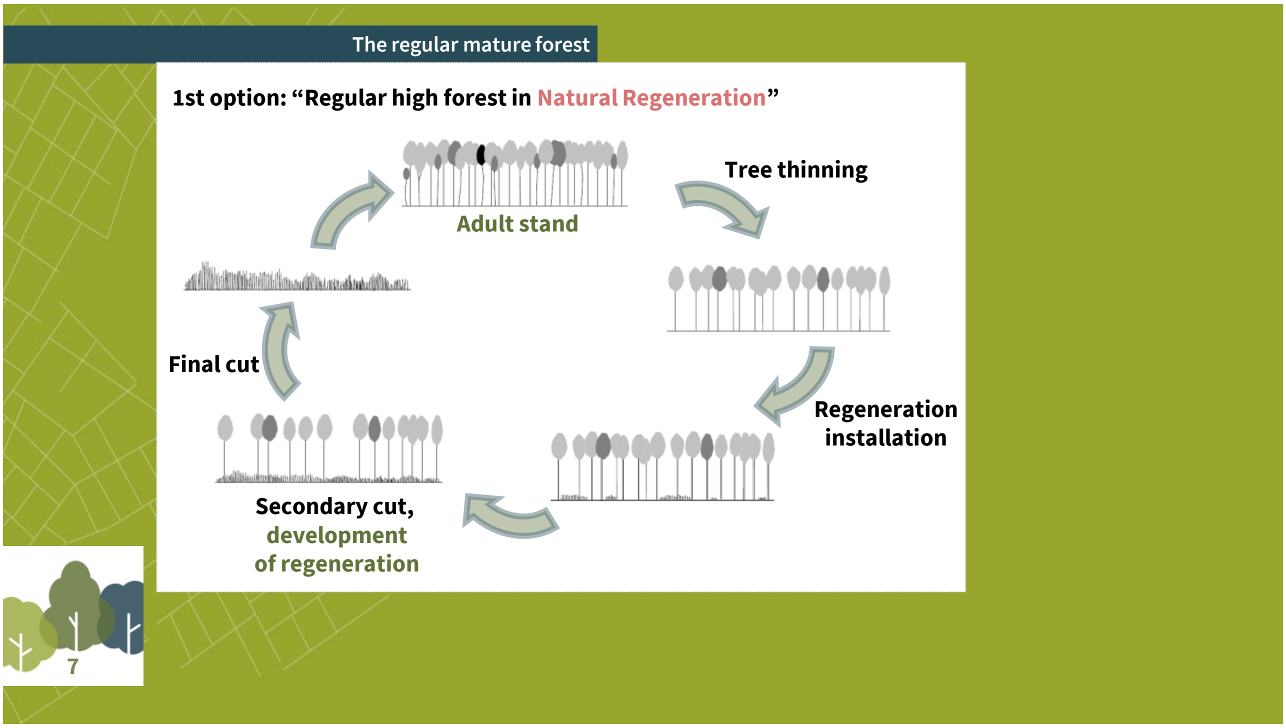
The simplest way to obtain an easy and regular renewal is to use vegetative reproduction : many broadleaf species have the ability to sprout from their stumps, from which a canopy can re grow.

Vegetative reproduction: coppicing

Example of coppicing :
chestnut coppice

Young trees benefit from an already established root system and exhibit **strong growth vigor.**

This is what is called the COPPICE REGIME. This was largely used in the whole of the Mediterranean basin, especially to provide firewood.



The regular mature forest

1st option: “Regular high forest in Natural Regeneration”

Adult stand

Tree thinning

Regeneration installation

Secondary cut, development of regeneration

Final cut

The forester can also favor and use the sexual reproduction of trees, practicing what is called "**NATURAL REGENERATION**".

Let us first consider the case where they want to obtain this renewal on a particular area of forest, let’s say a few hectares.

This management style is called **REGULAR HIGH FOREST** management.

They start with intense tree thinning, in order to keep the species they want to reproduce, keeping the most beautiful trees, and to highlight their crowns.

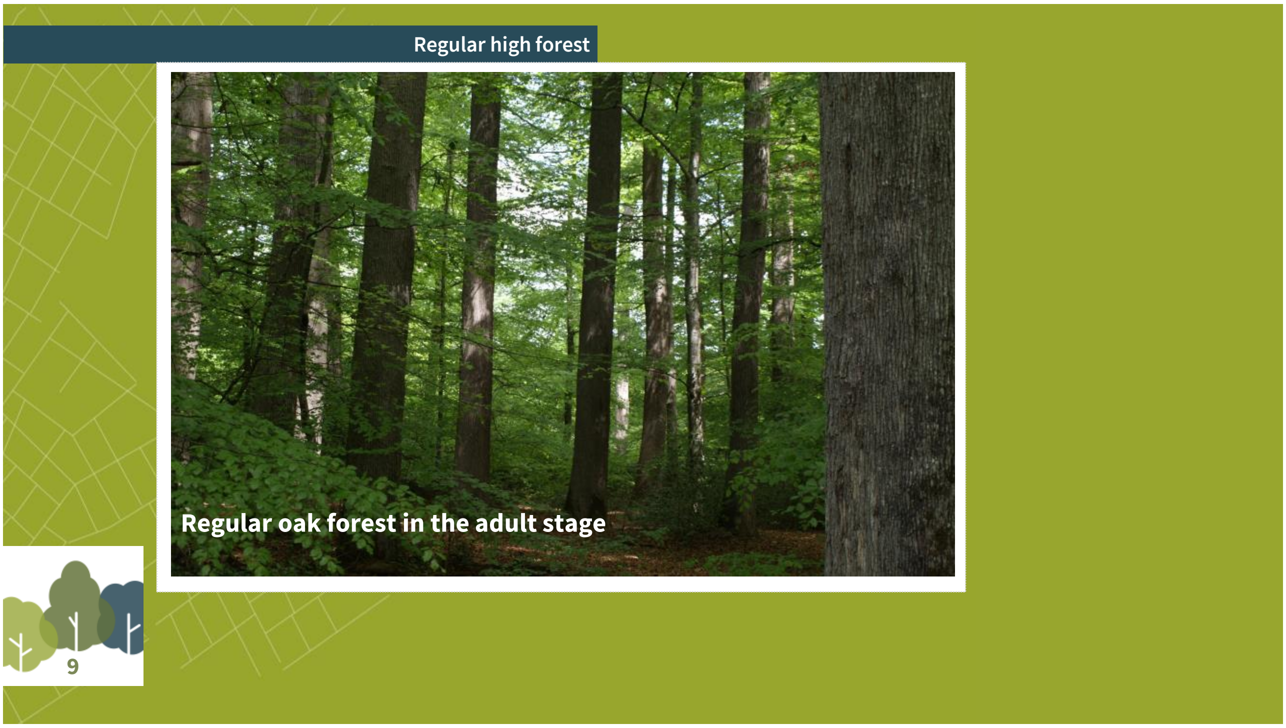
For several years, as seedlings settle under the mature trees, they are progressively cut, not only to be harvested later, but also, to provide the necessary amount of light for the development of other seedlings.

At the end of this seedling establishment and development process, the last of the remaining mature trees (Seed-trees) are removed during a practice called the final cut ,very different from clearcutting.

Oak forest at the secondary cutting stage
(FD Darney, Claudon, Vosges)

Here is an example of a forest in the process of **regeneration** : this an oak grove. We can see that this mature oak stand is, already, quite clear.

On the forest floor, we will find a certain number of **oak seedlings**, in sufficient density to obtain a new oak stand.



Regular high forest

Regular oak forest in the adult stage

Another example of a regular oak forest, this time at the adult stage, before regeneration cuts

High forest from plantation

Douglas-firs cleared of shrubs
(Millevaches plateau, Limousin)

You can also renew the stand by **direct seeding** or **seedling planting**. This is called **artificial regeneration**.

In the past, the entire adult stand was harvested by **clearcutting**.

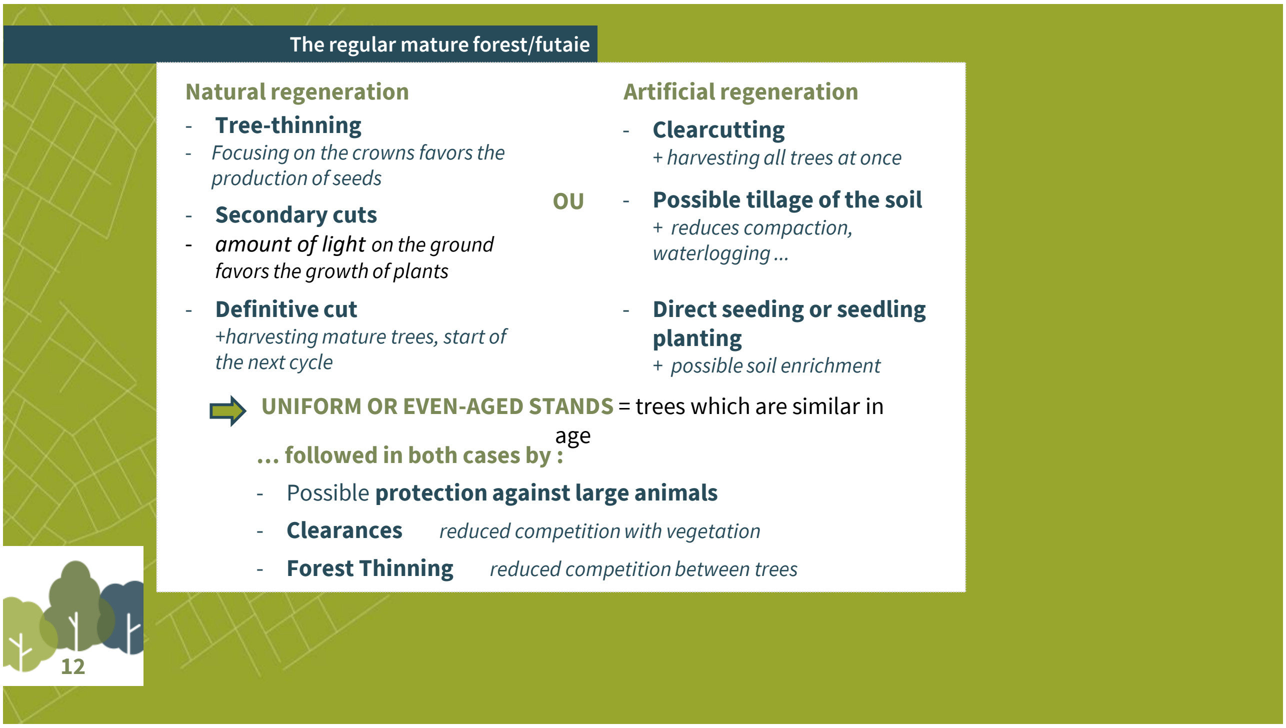
Here, young Douglas-fir trees face strong **competition** from surrounding shrubs (*Genista* plants).

The forester, in this case, has intervened to clear the surrounding shrubs (*Genista* plants) : we are talking about **clearing** vegetation, which is done by clearing brush.

High forest from plantation

Landes pine grove
(Landes de Gascogne massif)

Another example which we have already seen, the Landes pine grove



The regular mature forest/futaie

Natural regeneration

- **Tree-thinning**
- *Focusing on the crowns favors the production of seeds*
- **Secondary cuts**
- *amount of light on the ground favors the growth of plants*
- **Definitive cut**
  +harvesting mature trees, start of the next cycle

OU

Artificial regeneration

- **Clearcutting**
  + harvesting all trees at once
- **Possible tillage of the soil**
  + reduces compaction, waterlogging ...
- **Direct seeding or seedling planting**
  + possible soil enrichment

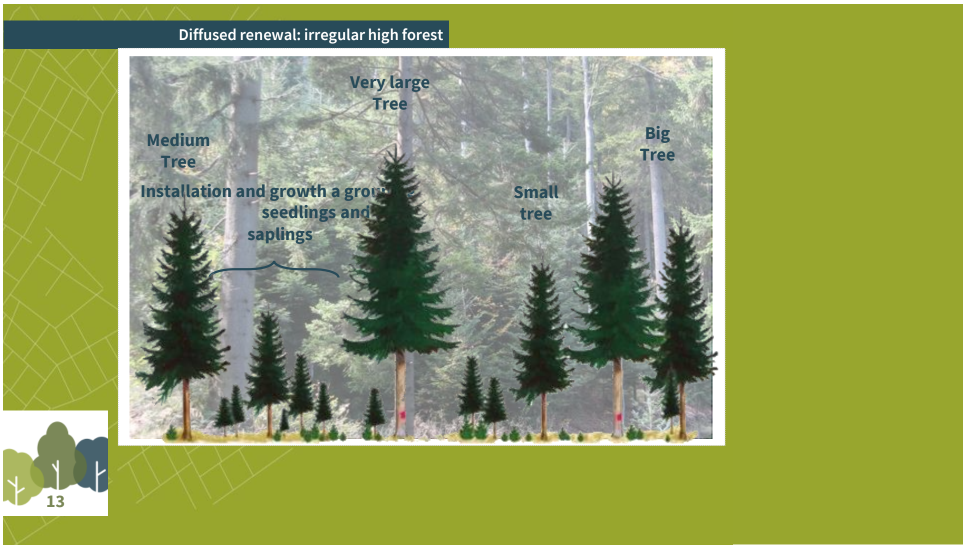
⇨ **UNIFORM OR EVEN-AGED STANDS** = trees which are similar in age

... followed in both cases by :

- Possible **protection against large animals**
- **Clearances** *reduced competition with vegetation*
- **Forest Thinning** *reduced competition between trees*

In both of these cases, whether through natural regeneration or planting, the result is a stand with trees which are approximately the same age.

We are within the framework of the regular high forest/mature forest.

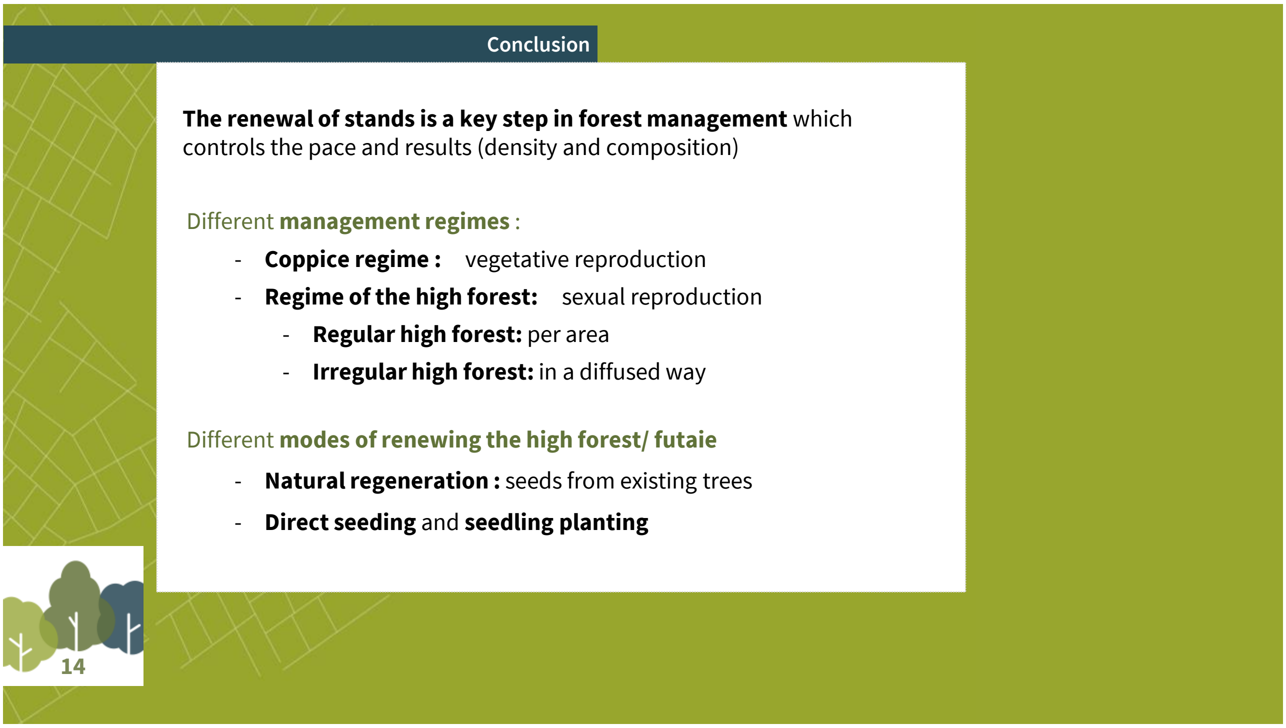


Diffused renewal: irregular high forest

This renewal process can also be undertaken on forest surfaces varying in size, or even in a disorganized fashion within the adult stand, as in the case of the **irregular high forest**.

The seeds settle in the gaps of the soil created by the previous harvest of one or more large trees. The seedlings then develop in small groupings, from which one or more large trees will eventually emerge.

Ex : context from where regeneration is traditionally obtained in a diffused way : **the Jura fir forest**



Conclusion

The renewal of stands is a key step in forest management which controls the pace and results (density and composition)

Different **management regimes** :

- **Coppice regime :** vegetative reproduction
- **Regime of the high forest:** sexual reproduction
  - **Regular high forest:** per area
  - **Irregular high forest:** in a diffused way

Different **modes of renewing the high forest/ futaie**

- **Natural regeneration :** seeds from existing trees
- **Direct seeding** and **seedling planting**

Depending on the context and the characteristics of the species, this or that modality dominates, without being exclusive.

The way in which renewal is carried out is closely linked to the way in which the entire forest cycle is managed.

Photographic credits

Jean François HAMARD

Léo-Pol JACQUOT

Nicolas BILOT

Yves EHRHART

+Wikimedia Commons

Schematics

From Yves BASTIEN ' s forestry course, ENGREF, 2001

Wikimedia Commons

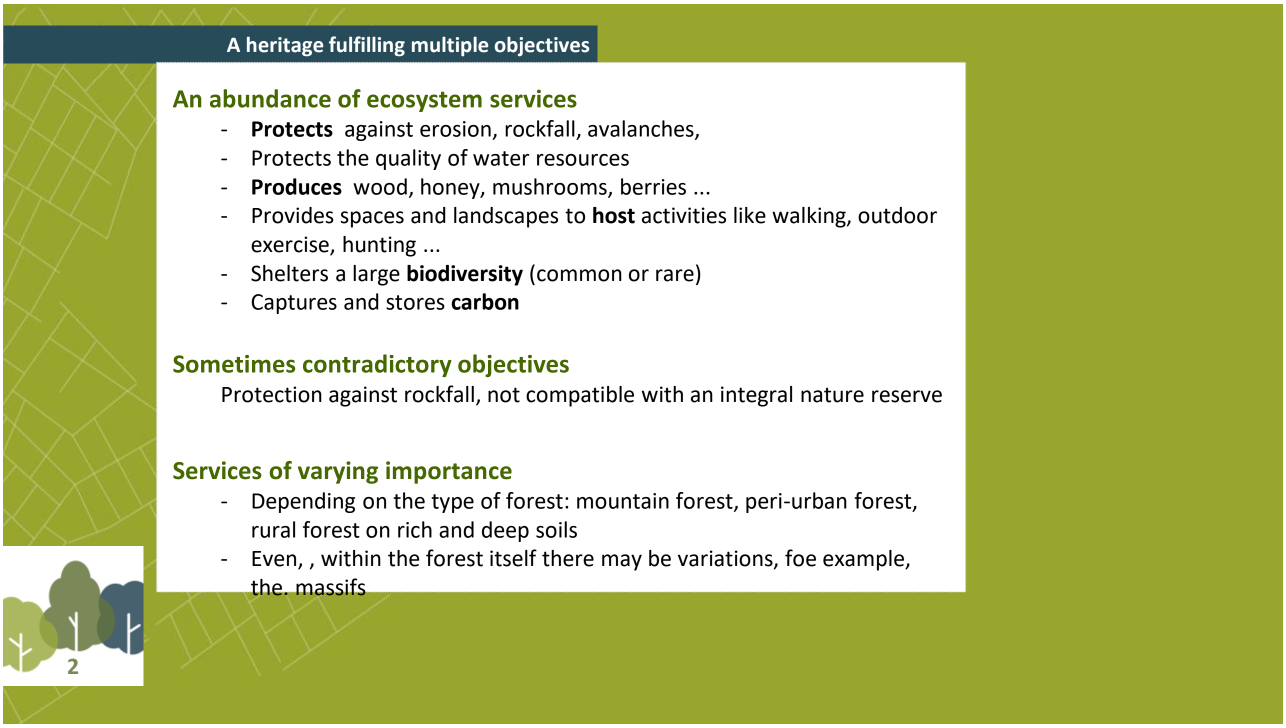
Coppice scheme : https://commons.wikimedia.org/wiki/File:Taillis.png

Week 2

What is sustainable forest management?

Video 5

Forest planning, at the heart of sustainable management



A heritage fulfilling multiple objectives

An abundance of ecosystem services

- **Protects** against erosion, rockfall, avalanches,
- Protects the quality of water resources
- **Produces** wood, honey, mushrooms, berries ...
- Provides spaces and landscapes to **host** activities like walking, outdoor exercise, hunting ...
- Shelters a large **biodiversity** (common or rare)
- Captures and stores **carbon**

Sometimes contradictory objectives

Protection against rockfall, not compatible with an integral nature reserve

Services of varying importance

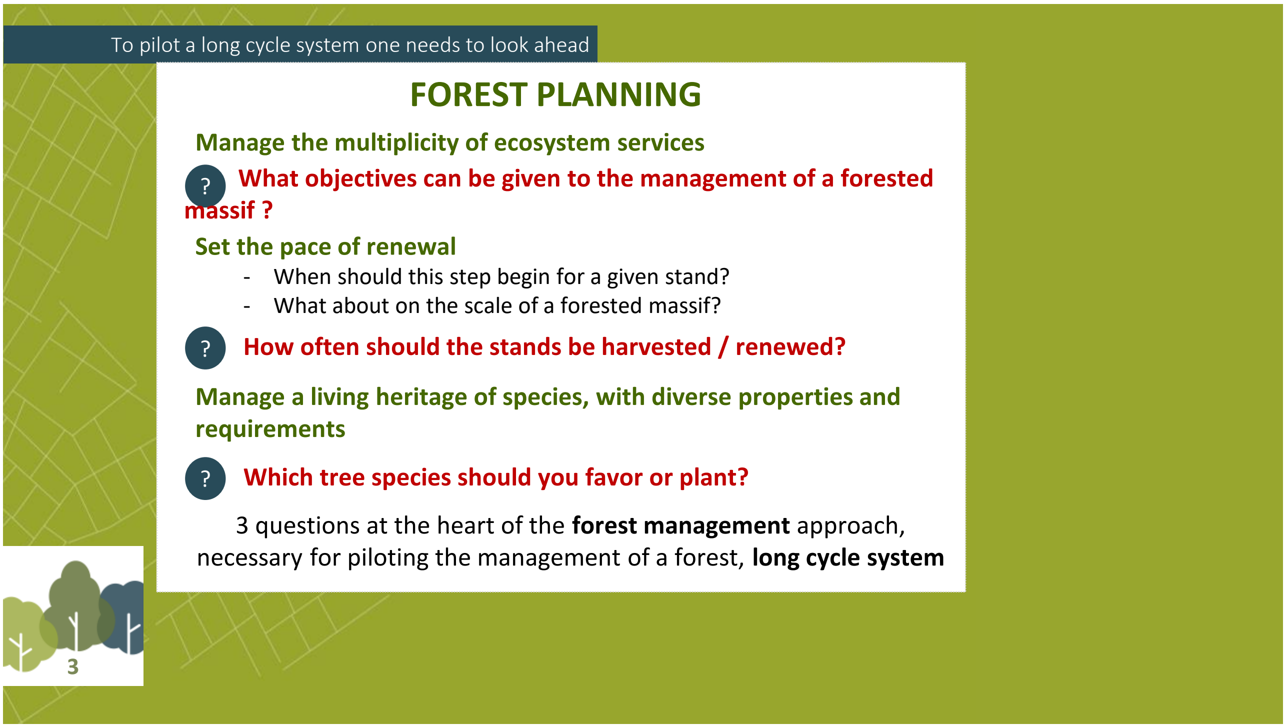
- Depending on the type of forest: mountain forest, peri-urban forest, rural forest on rich and deep soils
- Even, , within the forest itself there may be variations, foe example, the. massifs

Forest management is central when it comes to the sustainability of the forest. The word ‘development’ has a particular meaning in forestry, very different from urban planning.

Forests have multiple objectives and offers an abundance of services (see slide).

The objectives are sometimes contradictory, for example, if your stand provides protection to villages from rockfall , it cannot , at the same time, be classified as an integral natural reserve for the purpose of studying and protecting biodiversity. The two would be incompatible as the latter demands a certain guarantee that the stand maintains certain dendrometric characteristics.

Therefore, the importance of services provided varies depending :
- on the type forest (we do not have the same expectations of a mountain forest, a peri-urban forest, or a rural forest on rich soils)
or even within the forest itself, i.e. a small area that is home to remarkable biodiversity, a large area of production (timber), or an area that is in close proximity to a city.



To pilot a long cycle system one needs to look ahead

FOREST PLANNING

Manage the multiplicity of ecosystem services

? **What objectives can be given to the management of a forested massif ?**

Set the pace of renewal

- When should this step begin for a given stand?
- What about on the scale of a forested massif?

? **How often should the stands be harvested / renewed?**

Manage a living heritage of species, with diverse properties and requirements

? **Which tree species should you favor or plant?**

3 questions at the heart of the **forest management** approach, necessary for piloting the management of a forest, **long cycle system**

Before managing this multiplicity of ecosystem services, 3 questions need to be asked:

1. First question: what are the objectives? When should renewal begin?
2. Second question: at what rate, I.e. how often?
3. Third question: which tree species should be favored or planted?

These 3 questions are at the heart of the **forest management** process, necessary for piloting the management of a forest, **long cycle system**

Respond to a requirement: sustainable management

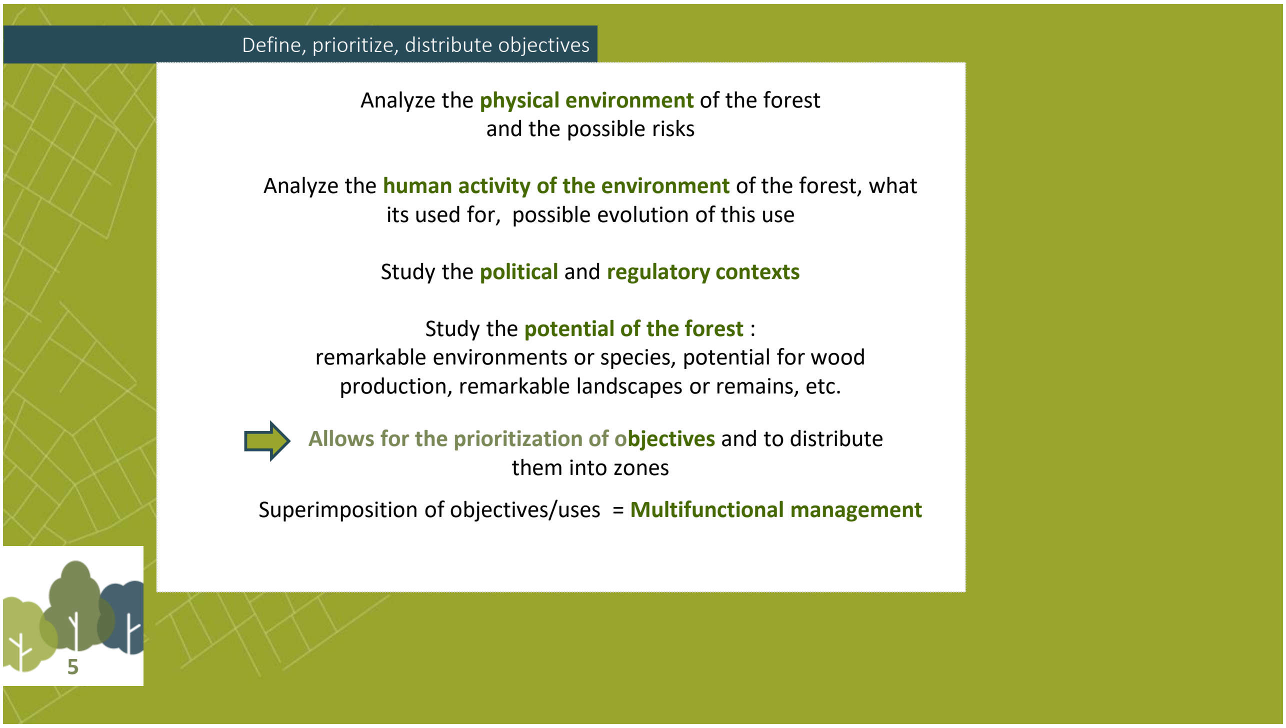
A concept emerged in the 14th century in the management of French forests, with the ‘Ordinance of Brunoy’ :

> ***"The masters of water and forests […] will visit all the forests and woods, make the sales therein, so that this said forest could perpetually be sustained in good condition "***

... extended and enriched today (1993) to all ecosystem services
(Helsinki Interministerial Conference on the Protection of European Forests)

> ***“Sustainable forest management means the management and use of forests […] such that they maintain their biological diversity, their productivity, their capacity for regeneration, their vitality and their capacity to satisfy, now and in the future, the relevant ecological, economic and social functions at local, national and global levels […] "***

An extract of the Ordinance of Brunoy , France, 14th century, one of the first documents to mention the concept of sustainable forest management.
This concept was extended to all forest services and upgraded more recently (Helsinki conference in 1993) = Roadmap for sustainable forest management



Define, prioritize, distribute objectives

Analyze the **physical environment** of the forest
and the possible risks

Analyze the **human activity of the environment** of the forest, what
its used for, possible evolution of this use

Study the **political** and **regulatory contexts**

Study the **potential of the forest** :
remarkable environments or species, potential for wood
production, remarkable landscapes or remains, etc.

➡ **Allows for the prioritization of objectives** and to distribute
them into zones

Superimposition of objectives/uses = **Multifunctional management**

Now we have to define, prioritize and distribute objections. How is this done?

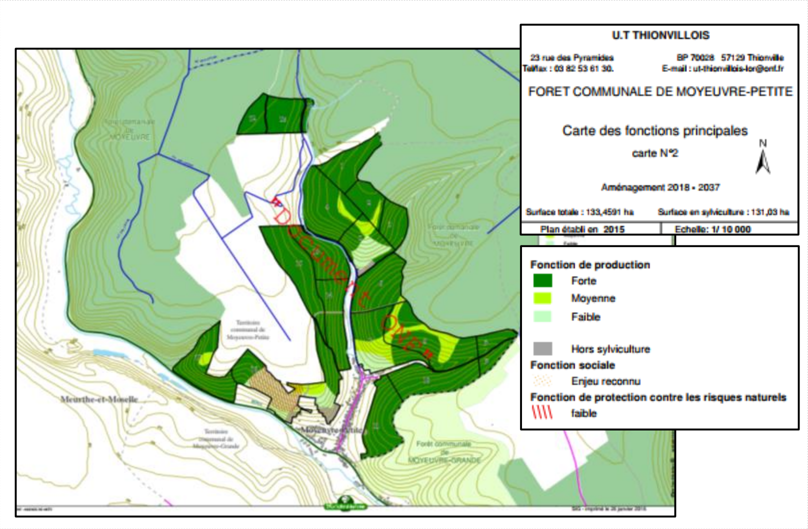
Analysis of: physical and human environment, political and regulatory context, forest potential

All of this, allows us to prioritize these objectives and to eventually organize them into different zones/sectors.

In general, In France, like in Europe, this zoning is limited . Very often, most territories meet more than one objective, very rarely , except in areas with smaller surfaces, do they specialize in only one.

This superimposition of objectives is what is called, multifunctional management.

Define, prioritize, distribute objectives



Here’s a first example:

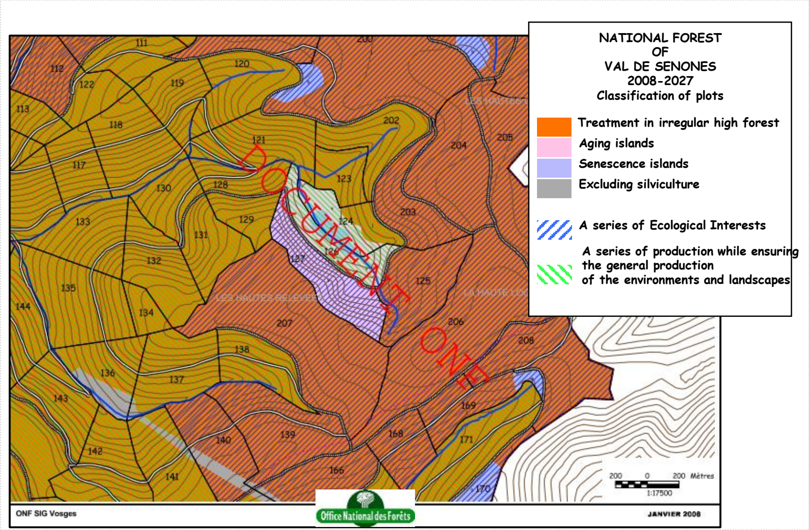
A small communal forest in Lorraine whose main activity is the production of wood.

This is illustrated with various shades of green: dark green representing high a fertilization rate to very light green representing a low fertilization rate.

We can also see:

- A small grey area near the village, which is excluded from production targets.
- A hatched area representing a steep slope, on a limited surface, serves as protection against natural risks. Natural risks remain low as we are not in a mountain area.

Define, prioritize, distribute objectives

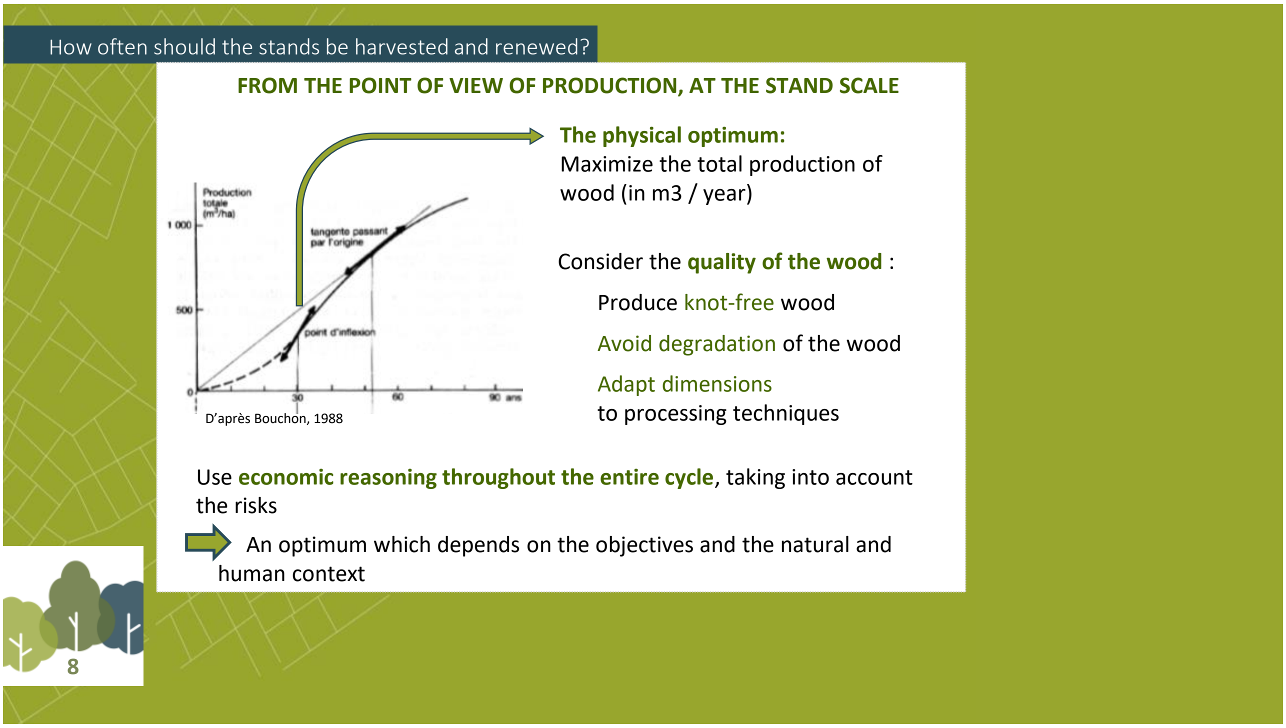


A second example, a sector of a national forest in the Vosges.

Hatched in green on red (= orange), an area where the primary objective is production

Hatched in blue on red (= dark red), an area where the primary objective is protection.

In the middle, in purple, is an area called a senescence island. We will come back to this later on.



How often should the stands be harvested and renewed?

FROM THE POINT OF VIEW OF PRODUCTION, AT THE STAND SCALE

D'après Bouchon, 1988

The physical optimum:
Maximize the total production of wood (in m3 / year)

Consider the **quality of the wood** :

- Produce knot-free wood
- Avoid degradation of the wood
- Adapt dimensions to processing techniques

Use **economic reasoning throughout the entire cycle**, taking into account the risks

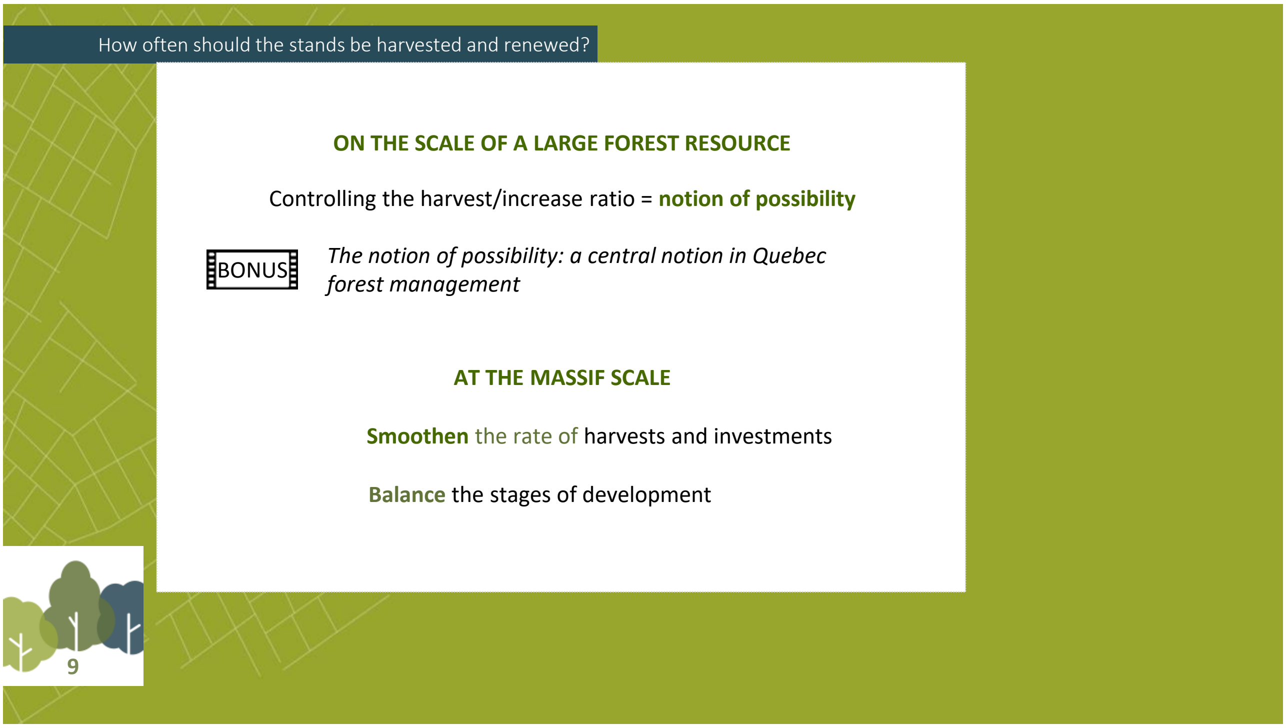
➡ An optimum which depends on the objectives and the natural and human context

Another question is: **How often should the stands be harvested and renewed ?**

In terms of timber production, at the stand scale :
On this graph, we can see the evolution in the increase of the volume of wood (m3/hectare) over the course of a stand's lifetime. The curve goes through an inflection point. Compared to the straight line on the graph, we can ,therefore, define the maximum total of production by looking at the highest point of the curve before it starts leveling off and decreasing again. This helps us to better understand that in the life of a forest stand there is an optimum physical point of production - if the stand is harvested too soon before this optimum would be like 'spending one's money before one gets it'.

Other considerations: notably, the quality of the wood produced (proportion of knots, damage if we wait too long, dimensions adapted to demand and processing techniques, etc.) depends on what stage the stand is harvested. Waiting too long to harvest could contribute to the degradation of the wood resulting from the aging trees. Therefore, the dimensions of the trees at the time of harvest should be adapted to wood processing techniques.

To sum up, we should take **economic reasoning into account throughout the entire cycle,** taking into consideration the initial investments, the total duration of the cycle, the harvests, and the end of cycle. It is through this economic reasoning that we are capable of defining, in the context of the human and natural objectives, this optimum point.



How often should the stands be harvested and renewed?

ON THE SCALE OF A LARGE FOREST RESOURCE

Controlling the harvest/increase ratio = **notion of possibility**

BONUS *The notion of possibility: a central notion in Quebec forest management*

AT THE MASSIF SCALE

Smoothen the rate of harvests and investments

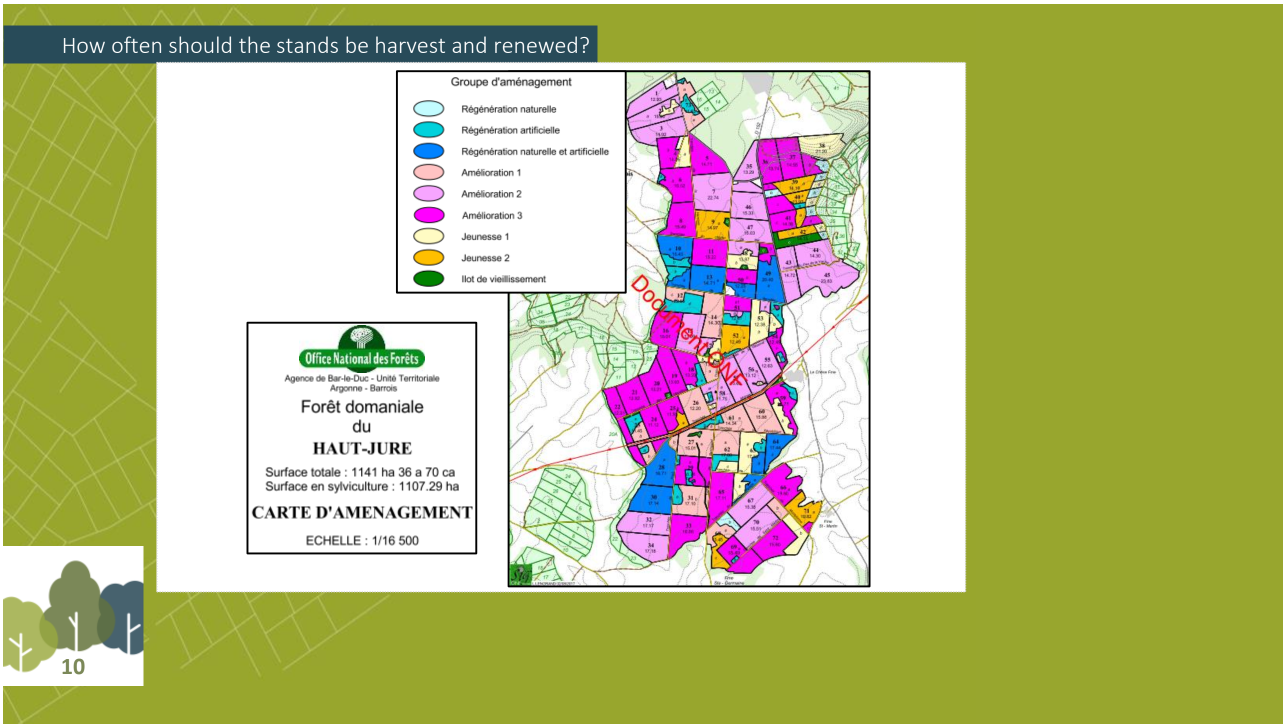
Balance the stages of development

Now we are going to look at the other extreme, a very large forest resource - the massifs. At this scale, we can consider that productivity is constant, moderate and representative of its capacity. In this case, it is necessary to monitor the ratio between harvest and growth. This will gives us, what is called, the notion of possibility. For more information on this, check out the bonus, in the additional resources, for a video from Quebec. It explains the importance of this notion in the management of the extensive forests of Quebec. : https://youtu.be/-4twge9Ubzg

After having looked at forest planning in terms of the stands and resource at the scale of the massifs, something else needs to be taken into consideration. That is, the importance of smoothening the rates of harvests and investments in order to maintain, over time, approximately the same proportion of revenues (from harvests) and the investments going towards the renewal of the stands.

Balancing the stages of development is not only valid for production, but also for other ecosystem services such a biodiversity.

The biodiversity in the early stages of stand development is not the same as the biodiversity found in the later stages of stand development. Not only is balancing the different stages important to biodiversity, it is also important in terms of landscape. A forest composed of only young stands is not as captivating, from a landscape point of view. The same is true for a forest composed of only aging stands, that will eventually be harvested and renewed leaving only small young trees. In sum, balancing the stages of development is important for all the services provided by the forest.



How often should the stands be harvest and renewed?

Groupe d'aménagement

- ● Régénération naturelle
- ● Régénération artificielle
- ● Régénération naturelle et artificielle
- ● Amélioration 1
- ● Amélioration 2
- ● Amélioration 3
- ● Jeunesse 1
- ● Jeunesse 2
- ● Ilot de vieillissement

Office National des Forêts
Agence de Bar-le-Duc - Unité Territoriale
Argonne - Barrois

Forêt domaniale
du
HAUT-JURE

Surface totale : 1141 ha 36 a 70 ca
Surface en sylviculture : 1107.29 ha

CARTE D'AMENAGEMENT

ECHELLE : 1/16 500

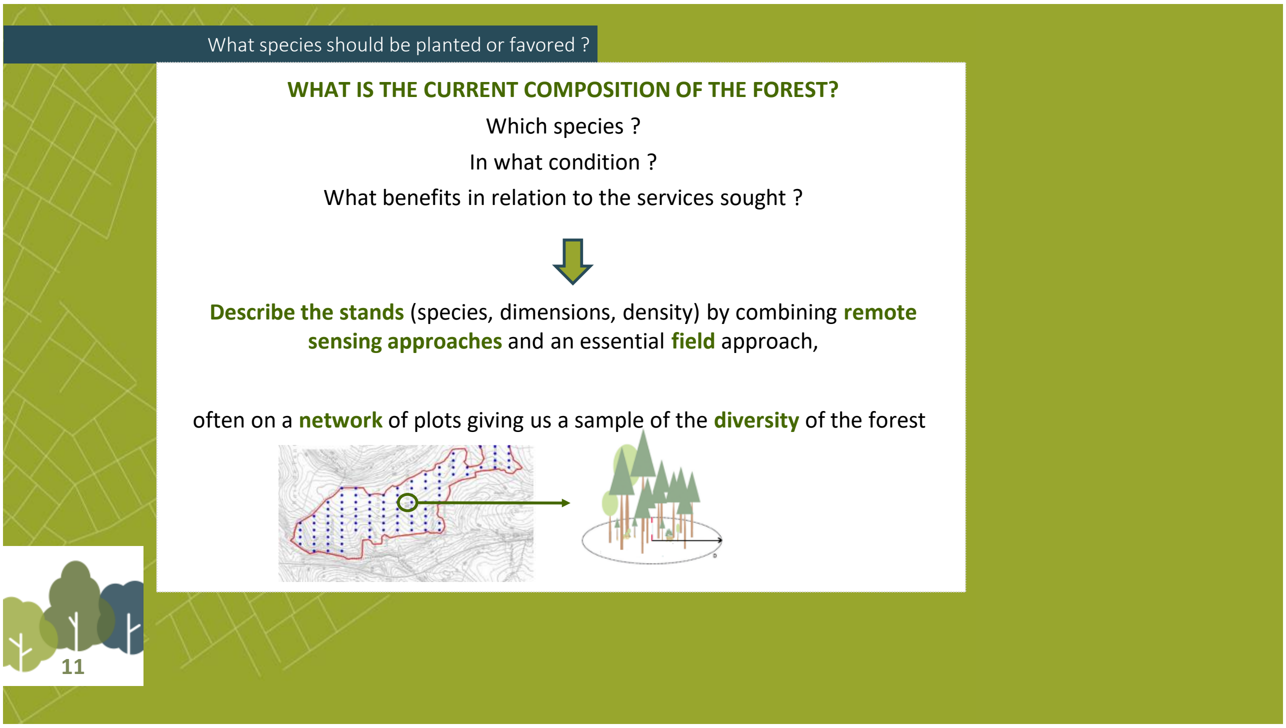
Here is a another example, this time using a map of a national forest in Lorraine:

In blue, the plots which will be renewed.

In yellow, plots which were renewed in the previous forest planning layout, hence young trees which need to be invested in and taken care

In pink , plots, composed of mostly adult stands , which will be thinned to create clearer stands allowing room for other younger trees to grow.

In dark green, an aging island. Earlier, we saw a senescence island. Although there is a small difference between the two, both serve to ensure the presence of very old stage stands which are usually removed by forest management before reaching this stage. Here, because of their importance to biodiversity, forest managers are given the means and space to maintain them.



What species should be planted or favored ?

WHAT IS THE CURRENT COMPOSITION OF THE FOREST?

Which species ?

In what condition ?

What benefits in relation to the services sought ?

⇩

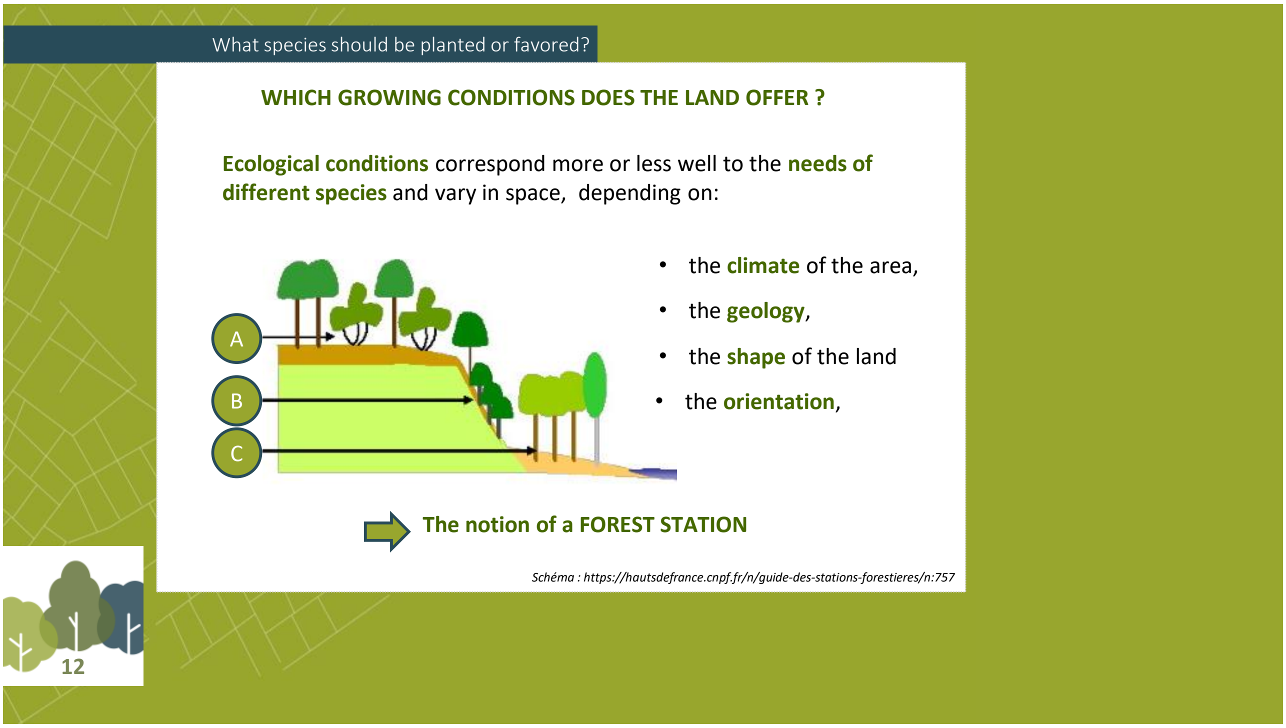
Describe the stands (species, dimensions, density) by combining **remote sensing approaches** and an essential **field** approach,

often on a **network** of plots giving us a sample of the **diversity** of the forest

The third and final question: Which species should be planted or favored?

To address this question we have to first look at the current composition of the forest: what species are present? In what condition are its stands it? What are the benefits it provides in relation to the services expected from it?

For this, it is necessary to describe the stands in terms of species, dimension and density. In general, this is done by combining remote sensing (aerial photos) and an essential terrain approach, which often consists in charting a network of plots, giving us a sample of the trees observed.



What species should be planted or favored?

WHICH GROWING CONDITIONS DOES THE LAND OFFER ?

Ecological conditions correspond more or less well to the **needs of different species** and vary in space, depending on:

- the **climate** of the area,
- the **geology**,
- the **shape** of the land
- the **orientation**,

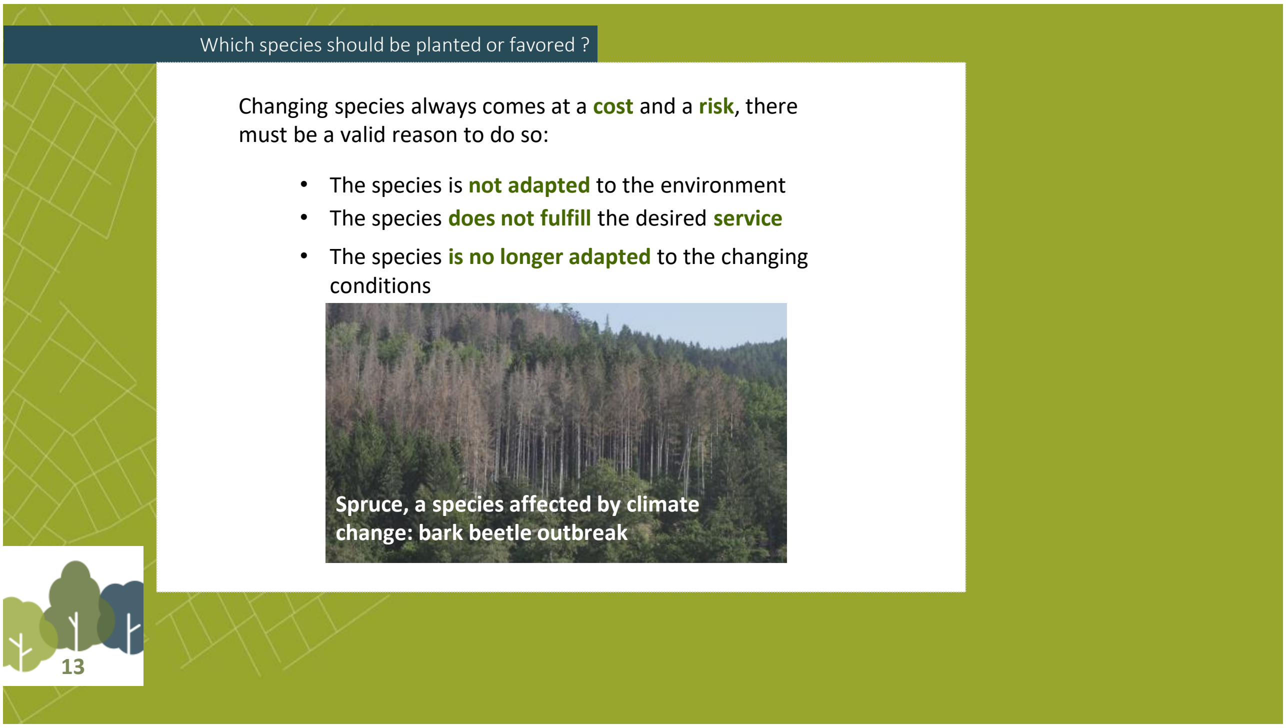
➡ **The notion of a FOREST STATION**

Schéma : https://hautsdefrance.cnpf.fr/n/guide-des-stations-forestieres/n:757

Now that we’ve described the stand, our next question is this: what are the growing conditions offered by the land?

This diagram illustrates, in terms of climate, soil, topography, aspect, etc., that depending on these factors the ecological conditions change, thereby making the different zones of the forest more or less adapted to the ecological needs of the different species found there.

The general description of these conditions is called a forest station.



Which species should be planted or favored ?

Changing species always comes at a **cost** and a **risk**, there must be a valid reason to do so:

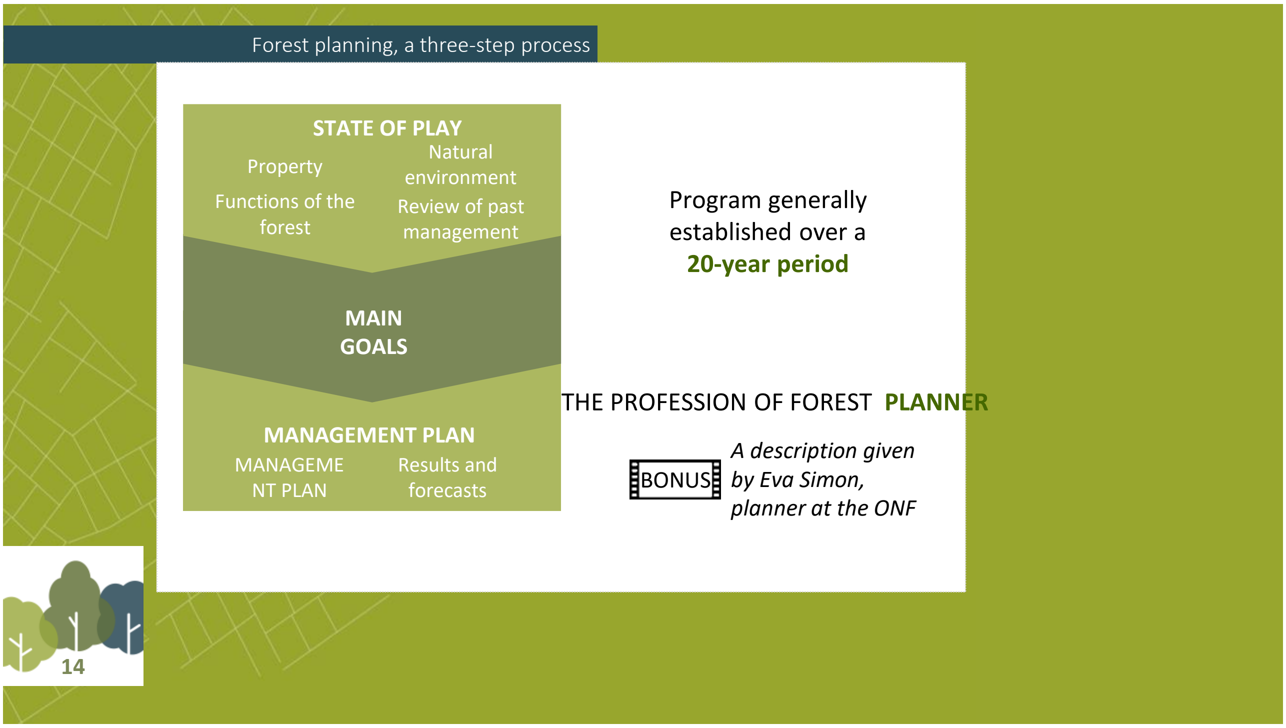
- The species is **not adapted** to the environment
- The species **does not fulfill** the desired **service**
- The species **is no longer adapted** to the changing conditions

Spruce, a species affected by climate change: bark beetle outbreak

Now, we have to ask ourselves: which species should be planted or favored?

Changing species always comes at a **cost** and a **risk for the forest manager** , and therefore they must have a good reason for doing it.
Reasons include:

- The species is **not adapted** to the environment because the predecessor made a mistake by introducing a new species (it happens, forestry is not an exact science)
- The species **does not adequately perform the service** sought after and feel that another species would do better in its place. For example, in the case of a poorly developed stand where you believe another species would do better in terms of production or landscape.
- The species **is no longer adapted** to the changing conditions. Unfortunately, this is becoming a lot more frequent due to climate change. In the photo, we can see a spruce stand with an outbreak of bark beetle. Due to global warming the spruce has weakened considerably while there has been an acceleration in the dynamics of the beetle population. Thus, making the spruce no longer suitable in some areas.



Forest planning, a three-step process

STATE OF PLAY

Property

Natural environment

Functions of the forest

Review of past management

MAIN GOALS

MANAGEMENT PLAN

MANAGEMENT PLAN

Results and forecasts

Program generally established over a **20-year period**

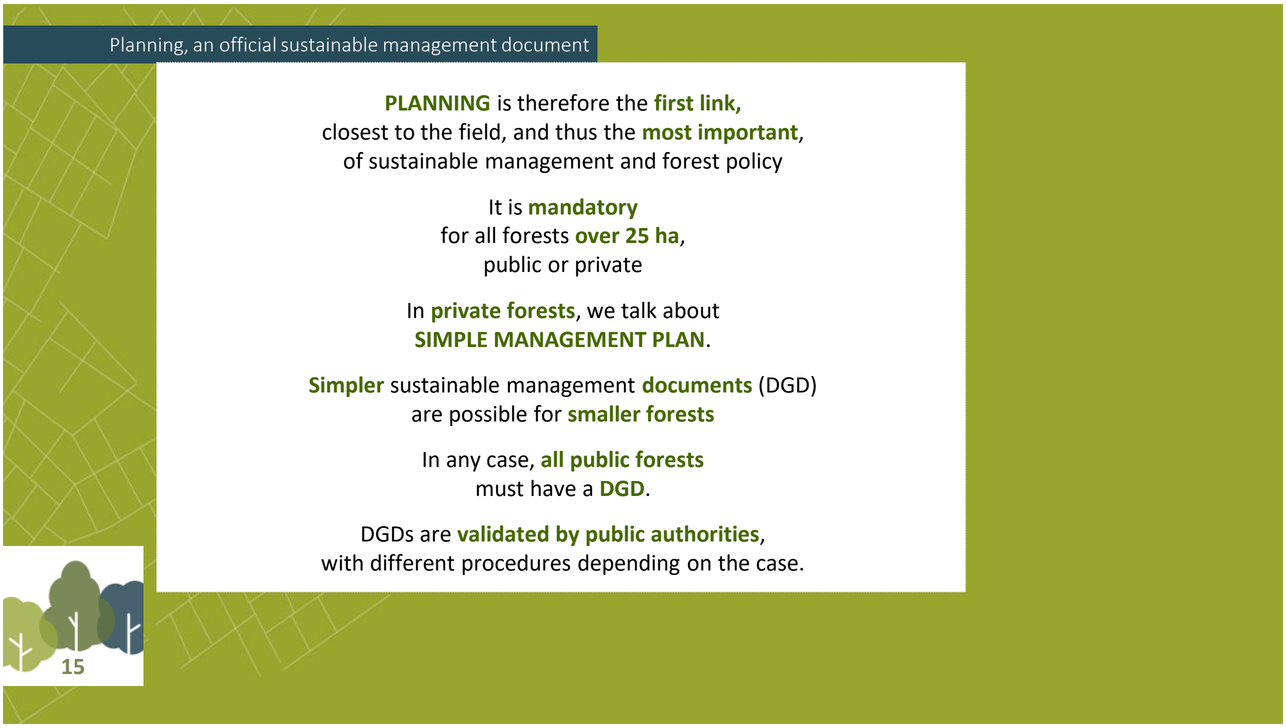
THE PROFESSION OF FOREST **PLANNER**

BONUS *A description given by Eva Simon, planner at the ONF*

A three-step process:

1. Make an inventory of all aspects of forest management, both human and natural aspects and a report of the function of the forest from the previous few years.
2. From this, it’s necessary to set objectives and make important decisions based on the questions we have just looked at.
3. These decisions are then deployed in the form of a management plan which lays out an action program, in particular for forestry work, and a projection of the expected results. This program should last for about 20 years, which is the right length of time for forest management to make sense in the long term. Although, this duration could be called into question today with the rapid evolution of climate change, it would still be very important to look ahead . In taking the analogy of a cruise liner, you have to look far ahead to be able to anticipate and see where you’re going.

This type of planning is also a career - it is the job of a forest planner.
Another bonus, the description given by Eva Simon, a planner at the ONF.
https://youtu.be/xbodz-APHVQ



Planning, an official sustainable management document

PLANNING is therefore the **first link,**
closest to the field, and thus the **most important**,
of sustainable management and forest policy

It is **mandatory**
for all forests **over 25 ha**,
public or private

In **private forests**, we talk about
SIMPLE MANAGEMENT PLAN.

Simpler sustainable management **documents** (DGD)
are possible for **smaller forests**

In any case, **all public forests**
must have a **DGD**.

DGDs are **validated by public authorities**,
with different procedures depending on the case.

DGD(document de gestion durable) = sustainable management document

Although, we talk about a SIMPLE MANAGEMENT PLAN when it comes to private forests , the steps are the same.

Simpler sustainable management documents (DGD - documents de Gestion durable) are possible for smaller forests.

It is imperative for all public forests to have a DGD.

DGDs are validated by the public authority, with different procedures depending on the case.

Conclusion

The length of forest cycles and the multiplicity of functions
associated with the forest require a long-term vision
to ensure a coherent and sustainable management.

The **FOREST PLANNING** approach responds to this requirement by answering these 3 main questions :

1. What **objectives** should be given to the management of this forest?
2. How **often should** you harvest and renew the stands?
3. Which **tree species** should be planted or favored?

The process is carried out in 3 stages:

1. **Analysis of the massif** in all its dimensions, and its environment
2. **Setting goals** and major decisions
3. **Management plan**

Forest planning is also a passionate job,
One that is essential to forest management.

Bibliographical references

Slide 6, 7 and 10: cartographic extracts from forest management documents
http://www1.onf.fr/lire_voir_ecouter/sommaire/amenagements/@@index.html

Slide 8: Evolution of the current growth of a stand over time and maximum total production, according to J. Bouchon, 1988
https://infodoc.agroparistech.fr/index.php?lvl=cmspage&pageid=26&id_article=93

Slide 11: Inventory diagram by sampling,
Based on illustrations borrowed from the following documents :
https://www.gembloux.ulg.ac.be/gestion-des-ressources-forestieres/upload/Notes%20techniques/ntfg_08.pdf
http://documents.irevues.inist.fr/bitstream/handle/2042/29200/145_154_BERGEOT_BD.pdf?sequence=1

Slide 12: Concept of forest station,
Diagram taken from the CRPF Hauts de France website
https://hautsdefrance.cnpf.fr/n/guide-des-stations-forestieres/n:757

Photographs

Léo-Pol JACQUOT

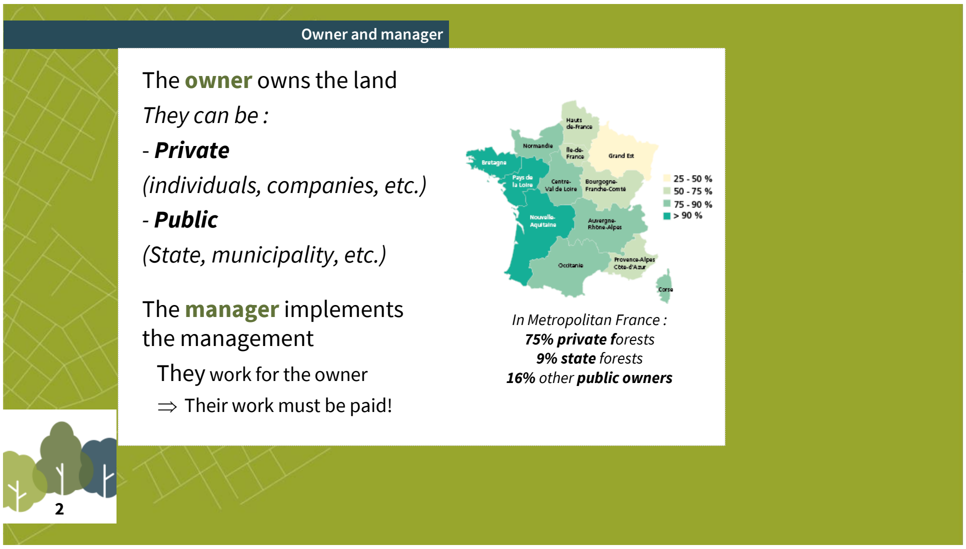
Week 2

What is sustainable forest management?

Video 6

Sustainable Forest Management: the stakeholders

In this video we will take a look at all those who play a role in the services provided by the forest.



Owner and manager

The **owner** owns the land

They can be :

- ***Private***

(individuals, companies, etc.)

- ***Public***

(State, municipality, etc.)

The **manager** implements the management

They work for the owner

⇒ Their work must be paid!

In Metropolitan France :
75% private f*orests*
9% state *forests*
16% *other* ***public owners***

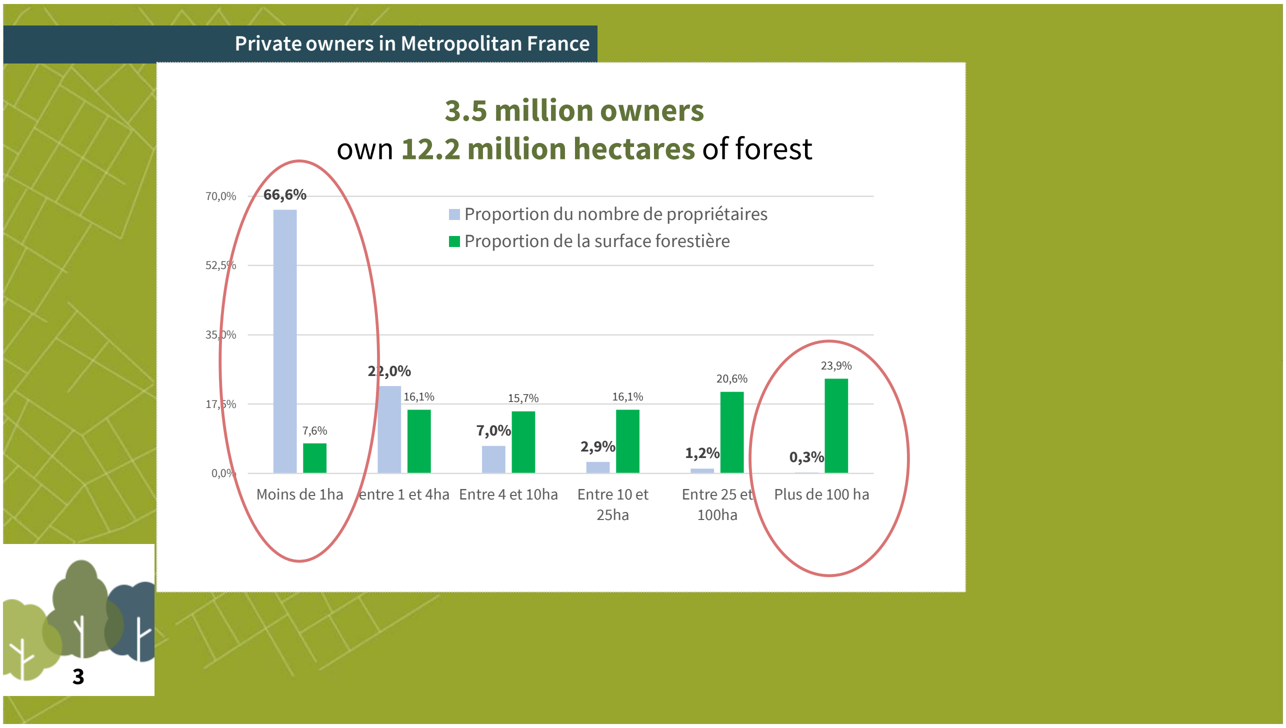
Owner: The one who owns the land

Remember that in metropolitan France, 75% of the forest area is private ... with great disparities depending on the region, between :

- the West, where more than 90% of the surface is private
- the Grand Est , where private forests only represent 44% of the surface.

The manager, works for the owner!
The owner is not a forest professional, the manager is: their work must be paid.

Up until recently, the services of sustainable forest management have almost always been paid for exclusively from sales of timber.



Private owners in Metropolitan France

3.5 million owners
own **12.2 million hectares** of forest

There are **3.5 million private owners in France**, with great diversity within the same forest property itself :

0.3% or **9000 owners** have forests of more than 100ha and own **24% or nearly a quarter of private forests**. Among them are some very large forest growers :

- ⇒ Wealthy, powerful families of French capitalism.
- ⇒ Investors like banks or insurance companies. *For example, the Caisse des Dépôts owns nearly 150,000 ha*.

In contrast, **two-thirds, 67% have only own a very small forest of less than 1 ha**.

These owners could be you or I, who often inherit a portion of the family forest, and are sometimes completely unaware of it.

FRANSYLVA

The federation of private forest owners

⇒ Informs, represents and defends values :

⇒ **Economic**
Produce and transform French wood.

⇒ **Environmental**
Respect natural balances, sustainable and responsible management.

⇒ **Social**
Create jobs, an integrated forest in its territory

⇒ **15 regional unions**, and departmental unions
⇒ **41,000 members** possessing **2 million hectares**
⇒ A bimonthly “**Forêts de France**” review

The private owners have a federation, Fransylva.
It provides information, for example, through their bi-monthly review, « Forets de France. »

Fransylva also wants to, ultimately, become a brand with
- 41,000 members
- 2 million hectares.

On the one hand it has quite a large membership, but on the other hand there are still a lot of private owners that Fransylva has not yet reached .

The managers of the private forest

Several types of managers :

⇒ **Experts**

EXPERTS FORESTIERS DE FRANCE

⇒ **Freelance technicians**

⇒ **Cooperatives** of owners

UCFF Les Coopératives Forestières

Get together to manage your forest :

- ⇒ Free trade union associations for forest management (**ASLGF**)
- ⇒ Forest Economic and Environmental Interest Group (**GIEEF)**

Several types of managers, experts, freelancers, owners.
There are also associations of owners who meet and manage their forests together.

The private owner is not a forestry professional.
As soon as we take interest in our forest, there are decisions which need to be made in order to have a forest that provides the services that we expect of it.
You have to know what to invest in or not, to take risks or not.

Managing a forest requires both time and skill.
A private owner can have recourse to professional forest management: cooperatives, experts, independent managers...
Several associations also allow owners to share the management.

We will go into more detail about this.

Forest cooperatives

⇒ **Bring together forest owners**
with a view to :

UCFF
Les Coopératives Forestières

⇒ **ensure and improve the management and value**
of the forests of their cooperative members.

⇒ **supply local industries**
with wood products from cooperators' forests,
managed sustainably.

110 000 sylviculteurs regroupés

2 000 000 d'hectares de forêts gérées

1 200 salariés au sein des coopératives

In the territories, Forest Cooperatives are created and managed by forest owners.

They ensure :

- Forest management of members (owners)
- the supply to local industries.

Nationally, forestry cooperatives are grouped into :

- A cooperative : the **GCF** (Forest Cooperatives Group) which provides transversal services such as group PEFC certification, training or certain research and development activities.

- A union: **UCFF (**Les Coopératives Forestières), which represents the interests of cooperative members to the administration, and also provides information and communication , on a national level, to cooperative owners, in particular.

The forest expert

⇒ **An entrepreneur**

their clients are private owners

EXPERTS FORESTIERS DE FRANCE

⇒ **A regulated profession**

level of training and experience, training obligation, rules of independence (eg: no timber trade nor forestry work)

⇒ **All aspects of management**

log marking, drafting of management plans, third-party relations (hunters, administration, neighborhood, etc.)

⇒ **Diversification**

research office activity (environmental or wood industry), training, international consultancy, legal expertise, etc.

⇒ **1 million hectares** managed by **166 experts** in France

Experts are independent contractors, their clients are private owners.
It is a regulated profession which requires a level of training and experience, an obligation of training, and strong ethics in terms of independent rules (for example, an expert cannot sell wood or carry out forestry work themself).

An expert addresses all aspects of management for their owner, in a relationship of trust

Experts are independent entrepreneurs who, like cooperatives, carry out several different jobs for their **client-owners :**

- Designing and project managing
- marking of cuts and bringing the timber to market,
- drafting of management plans,
- putting together files for grants
- Helping with recruit and managing forestry staff,
- relations with third parties (hunters, administrations, communities, associations)
- resolving conflicts between neighbors,
- forest insurance advice

There also seems to be a **diversification of activities and customers :**

- Consulting firms,
- international consulting ,
- Legal expert,
- ...

The forestry company of Caisse des Dépôts

⇒ **A subsidiary of the CDC**

⇒ **Manages 307 000 ha** of forests

Société Forestière
Faire de la nature une valeur sûre

⇒ **Several trades**

- **Support for** Sustainable Forest **Management**
- Wood **trading** / Wood energy activities
- Forest **transaction**
- **Marketing** and management of forest investment products
- **Forest Based Solutions :**
  - "carbon" projects,
  - production of indicators or management of actions in favor of the preservation of biodiversity

Société Forestière is an example a large owner which internalizes the management of its forests, that is to say it recruits its own employees, then creates a subsidiary to provide services to the owners.

Société Forestière is a **subsidiary of Caisse des Dépôts et Consignation** (which is considered a private owner like other businesses, banks or insurance companies that own forests).

Like most independent expert firms, Société Forestière has expertise in various trades and **offers various services.**

The National Forest Property Center

A public stakeholder of private forest development

⇒ **Support of public policies** for better management of private forests

- ⇒ **Approves simple management plans**
- ⇒ **Advises and trains owners,** carries out studies and Research and Development
- ⇒ **Support the regrouping of owners** to carry out service projects, mobilize wood, regroup worksites, pool the costs of forestry work, etc.

⇒ **11 CRPFs** as close as possible to the field (Regional Centers)

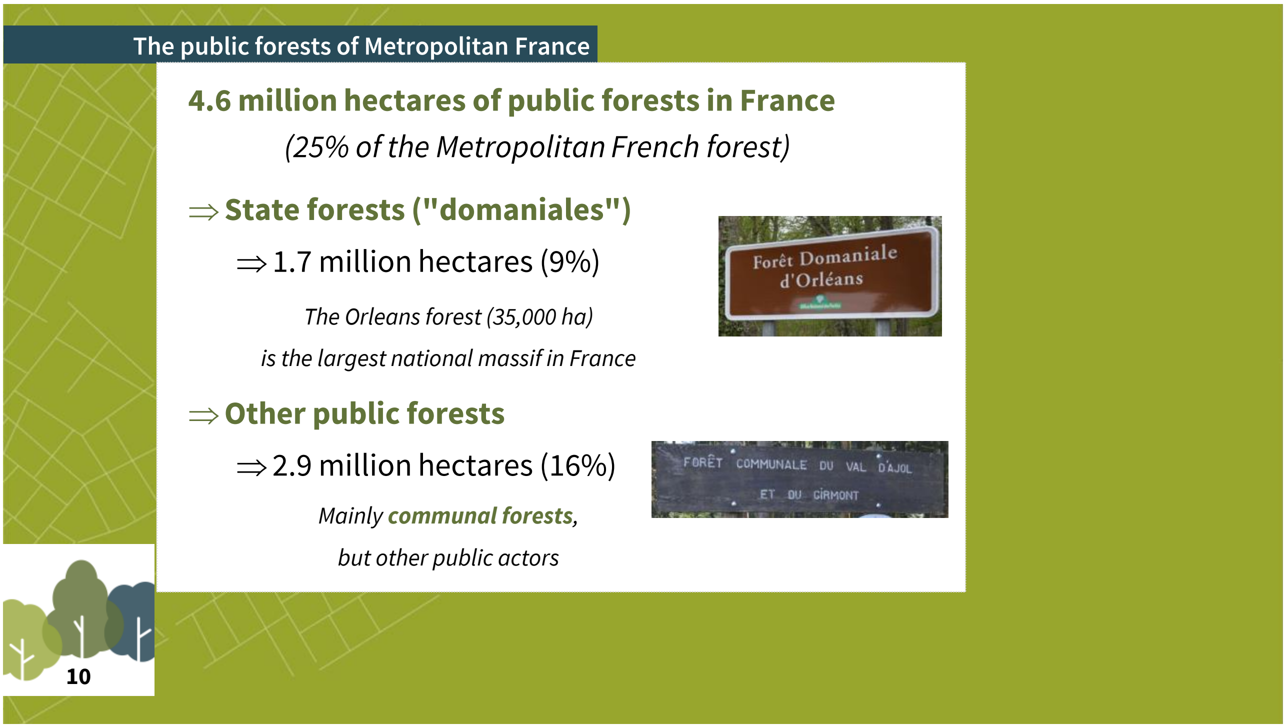
Here is a public establishment in charge of the management of private forests.

The CNPF is not like the Société Forestière or the Experts a company hires out to a client owner. It is a **public establishment under the supervision of the State,** more specifically of the **Ministry of Agriculture** in charge of forests.

It should be noted that these public bodies, like the chamber of agriculture, dedicated to private property do not offer forest management services: they do not designate which trees to harvest or to conserve, they do not manage the forest labour, nor market the products: **they do compete with the various actors of forest management, i.e. cooperatives, independent technicians and hired experts.**

They approve simple management plans (PSG). They offer advice, training, studies and research and development. They support the grouping of owners to pool management activities.

National and territorial organization as close as possible to the field.



The public forests of Metropolitan France

4.6 million hectares of public forests in France

(25% of the Metropolitan French forest)

⇒ **State forests ("domaniales")**

⇒ 1.7 million hectares (9%)

The Orleans forest (35,000 ha)
is the largest national massif in France

⇒ **Other public forests**

⇒ 2.9 million hectares (16%)

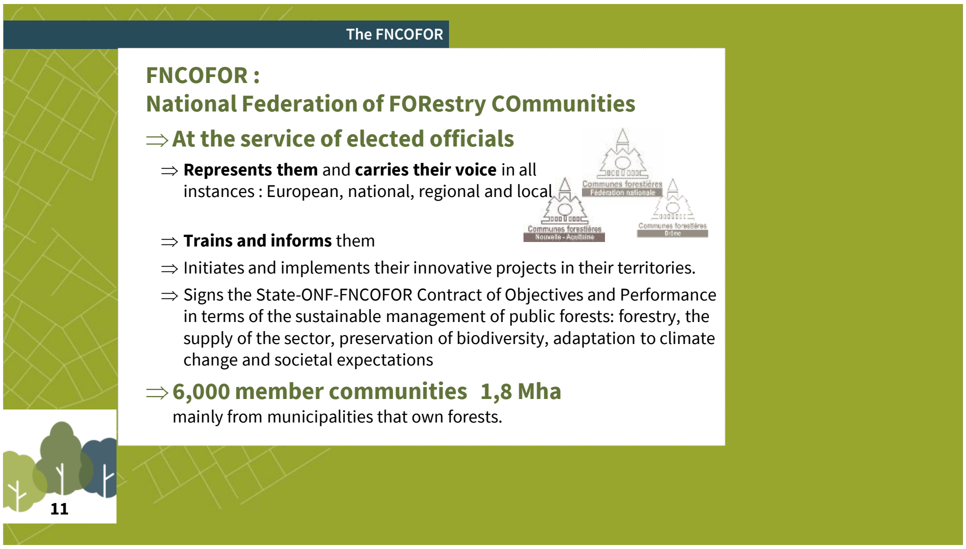
*Mainly **communal forests**,*
but other public actors

State forests and other public forests.

Overall in France :- 4.6 million ha, 25% of the forest is public *(with big differences depending on the region)*

And of this 25%:
- Only 1.7 million hectares (9%) are national forests, belonging to the State. These are generally large forests, especially from royal domains. The Orleans forest, 35,000 ha, is the largest national massif in France.
- 2.9 million hectares belong to other communes, mainly municipalities.

(but AgroParisTech, which offers you this MOOC, is a public owner of the forest it manages as heritage and as a school used in the service of the training of forest engineers)



The FNCOFOR

FNCOFOR :
National Federation of FORestry COmmunities

⇒ **At the service of elected officials**

- ⇒ **Represents them** and **carries their voice** in all instances : European, national, regional and local
- ⇒ **Trains and informs** them
- ⇒ Initiates and implements their innovative projects in their territories.
- ⇒ Signs the State-ONF-FNCOFOR Contract of Objectives and Performance in terms of the sustainable management of public forests: forestry, the supply of the sector, preservation of biodiversity, adaptation to climate change and societal expectations

⇒ **6,000 member communities 1,8 Mha**
mainly from municipalities that own forests.

As private forest owners have their Fransylva federation, the forest communities have their own federation: the **National Federation of Forest Communes FNCOFOR**.

FNCOFOR is at the service of elected officials with various missions, in particular it signs the COP between the State, ONF and FNCOFOR in the area of sustainable management of public forests.
It is a national organization broken down into **regional unions** and **departmental associations**.

Its members include mainly municipalities , but also forest management unions, inter-municipal authorities, departments and regions.

The ONF, manager of public forests

ONF: National Forestry Office

⇒ **Public industrial and commercial establishment**
(**EPIC**, created in 1964),

⇒ **Manager of public forests**

⇒ **4 missions** (and many professions)

1. **Sustainable management** of **state** forests
2. **Sustainable management** of **community** forests
3. Implementation of **general interest missions**
4. Implementation of **services**.

ONF is an EPIC placed under the supervision of the Ministry of Agriculture and Food and the Ministry of Ecological and Inclusive Transition. This is an EPIC and not an administration, with the obligation to balance its budget.

The ONF is in charge of the management of public forests, and this is enshrined in law.

The ONF's missions are associated with many professions and can be grouped into four activities:

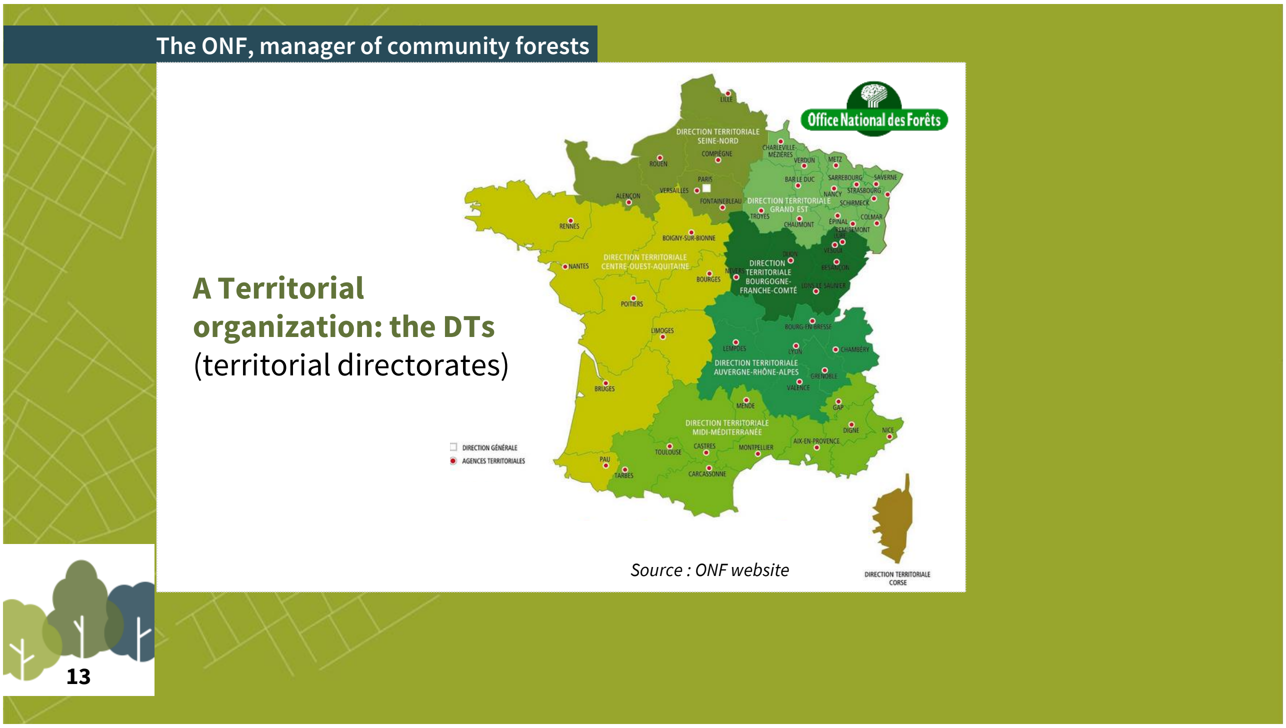
The sustainable management of state forests, the sustainable management of community forests, missions that legitimize the institution.

The implementation of MIG(general interest missions) which are missions entrusted by the State or communities, which they pay the full cost for.
⇒ for example, the restoration of land in the mountains or the protection against forest fires;

Local projects like work related to tourism done in national forests
The delivery of services where the ONF offers their know-how as a paid service:
⇒ forestry-related work activities

⇒ wood energy supply,
⇒ advice on arboriculture
⇒ international advice ...

For this, the ONF has subsidiaries ONF Energy, ONF International, Arbre conseil.



The ONF, manager of community forests

A Territorial organization: the DTs
(territorial directorates)

Source : ONF website

The ONF - a territorial organization which is not as present in areas where public forests are the minority.

Another key player, ETF

Forestry Contractor ETF
⇒The backbone of the forest

Entrepreneurs des Territoires
FNEDT

- ⇒ Provides services to the forest manager or owner
- ⇒ Silviculture work
- ⇒ Felling and skidding (See S4)

Felling a beech tree

Forestry work: uprooting blueberry bushes blocking the natural regeneration of trees

Here is another key player.

The forestry contractor (ETF) whose know-how is forestry work, particularly in felling and skidding. (We will take a closer look at this in week 4.)

They are independent contractors, who we don't see much of but without them, forest management would remain at the concept stage. They are the ones who ensure the services and makes sure the work is done.

ETFs also have their own federation: the FNEDT, which they share with agricultural contractors.

Other stakeholders, forest users

Forest users

⇒ Wood sector

⇒ Hunters

⇒ Environmentalist associations

⇒ Hikers, various uses ...

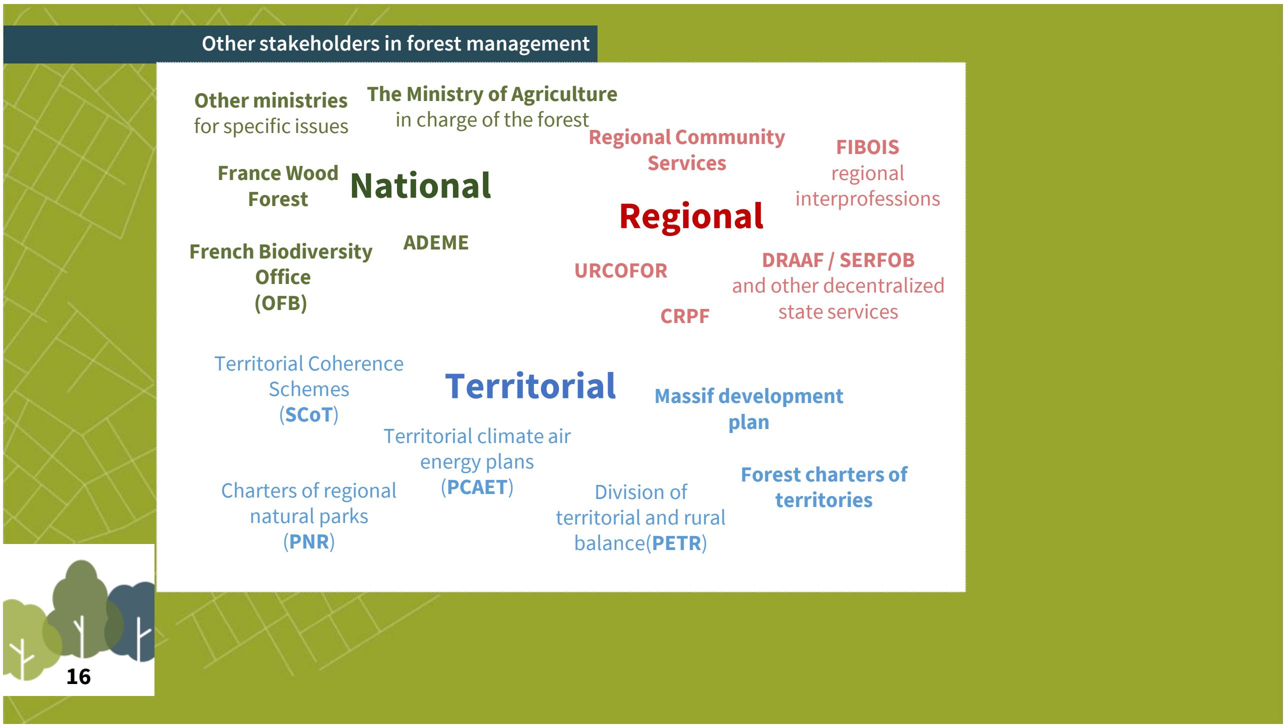
Do you find all these people who take care of and manage the forests, complicated?

It is not over, there are still important players in forest management: **forest users**. Users of the forest also have their own federations or associations which inform and defend them.

Along with larger federations which draw in many users, particularly the ones for the wood sector, environmentalists and hunters , there are also plenty of smaller associations for hikers, forest lovers , sportspeople , like mountain bikers. Not to forget the even smaller associations which are still considered quite anecdotal by forest managers and owners, such as silvicultural therapists and forest eaters.

The diverse activities of all these users are not always easy to reconcile, but the demand is in line with the current expectations of urban society.

In this context of these growing, organized and sometimes divergent interests in the forest, one of the major challenges today for those in forest management is to continue to promote their various professions and the services they provided, and learning to work together in order to achieve their objectives.



Other stakeholders in forest management

National

Other ministries for specific issues

The Ministry of Agriculture in charge of the forest

France Wood Forest

French Biodiversity Office (OFB)

ADEME

Regional

Regional Community Services

FIBOIS regional interprofessions

URCOFOR

DRAAF / SERFOB and other decentralized state services

CRPF

Territorial

Territorial Coherence Schemes (**SCoT**)

Territorial climate air energy plans (**PCAET**)

Massif development plan

Charters of regional natural parks (**PNR**)

Division of territorial and rural balance(**PETR**)

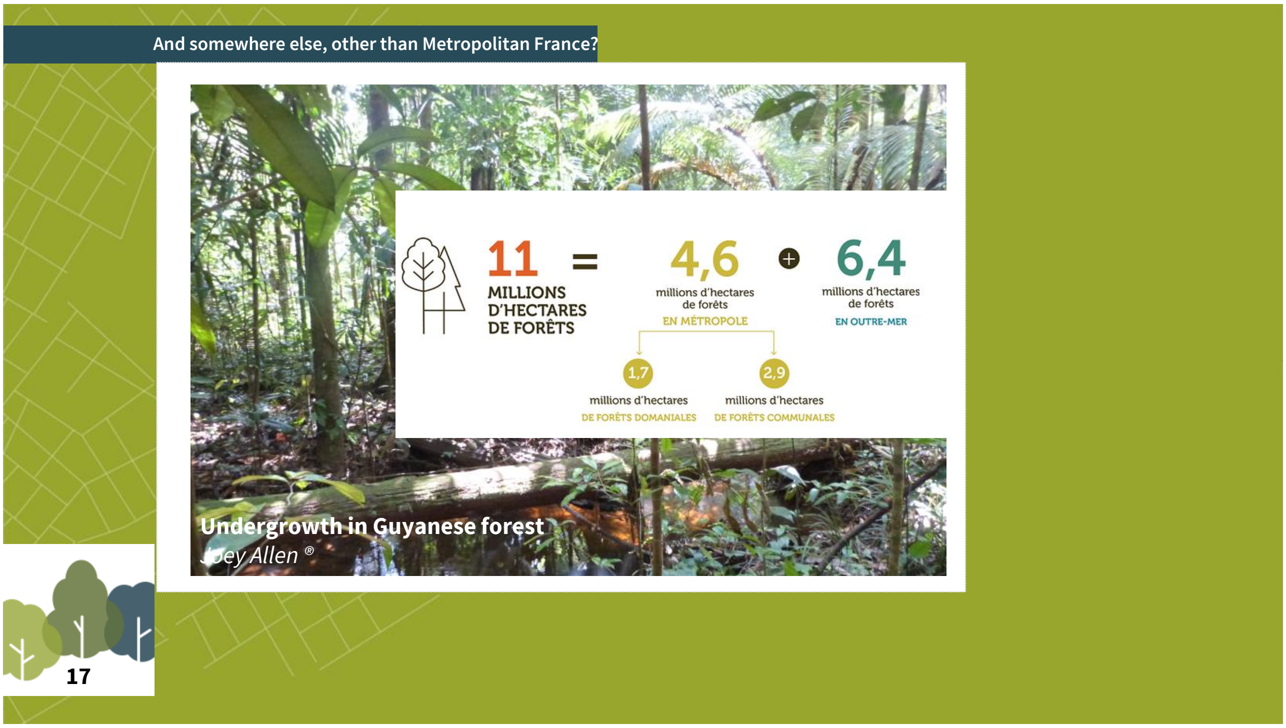
Forest charters of territories

And it's not over ! There are many other stakeholders at different scales, from the national to territorial level.

At the national level, there is the Inter-professional Nationale France Foret Bois, and then there are state bodies such as the OFB which deal with biodiversity. There is also the ADEME which deals with making ecological transition a success, since this transition obviously concerns the forest.
In week 4, we will also talk about the certification of wood from sustainably managed forests, PEFC and FSC.

At the Regional level, there are the CRPF Regional Centers for Forest Property, the URCoFor Regional Unions of Forest Municipalities which we have already mentioned, and also FIBOIS Inter-professionals and dedicated systems within communities or decentralized State services.

At the territorial level, there are still many other things, the forest charters of CFT territories, the development plans of PDM massif which are specific to forestry development but also other territorial development tools : PNR, PETR, PCAET, SCoTs who may be interested in and have an impact on forest management.



And somewhere else, other than Metropolitan France?

Undergrowth in Guyanese forest
Joey Allen ®

How about elsewhere?
Obviously, sustainable forest management is not an issue which is specific to Metropolitan France.

It is difficult to have a comprehensive discussion as long as the organizations are specific and dependent on the history of their own territory, the proportion of public/private forests on the territory and what the forest represents in strategic terms for the territory.

But now that you understand that there are public and private forests, owners and managers, organizations that represent forest users or support forest development policies, you will be able to work out the organization of any territory.

I encourage you to go and see what is happening in the overseas territories. Note that the ONF also manages 6.4 million hectares of forest in these territories, much more than in the metropolitan territory of France. You will not find the same stake holders there, for example the communities of forest peoples or the first nations peoples in Guyana.

Conclusion

Owners

private

public

Managers

private

public

Forest development stakeholders

Other stakeholders (users)

In conclusion, I hope you now know how to find your way through this myriad of forest management stakeholders, at least in the case of Metropolitan France.

I hope that you now have a better understating of who does what, with a certain number of questions and maybe the desire to engage with some of them.

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To go further

CNPF "I train for my woods" www.jemeformepourmesbois.fr

⇒ *Portraits of owners* ⇒ *www.jemeformepourmesbois.fr/n/portraits-de-proprietaires/n:1877*

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Photographs

Forest operators *(S14)* AgroParisTech image center
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Guyanese undergrowth *(S17)* Wikimedia Commons
http://commons.wikimedia.org/wiki/File:For%C3%AAt_tropicale_1.JPG

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PHOTOGRAPHS

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  ⇒ http://poleimage.agroparistech.fr/ajaris/media/60323
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- **Guyanese undergrowth (S18)**
  ⇒ http://commons.wikimedia.org/wiki/File:For%C3%AAt_tropicale_1.JPG

Week 3

What is silviculture?

Video 1

The growth of trees in a stand

REMINDER: WHAT IS A FOREST

As we saw in the first week (in video S1V3), a forest consists of a stand of trees of varying size and density, up to very closed canopies. In these closed canopies, little light penetrates to the forest floor.

At the same time, the trees live and grow through photosynthesis, which requires light. This search for light concerns all chlorophyllous plant species in the forest, from the ground to the canopy, and structures any forest and conditions the growth of trees in stands - our focus today.

Forest layers and access to light

Tropical rainforest
Guyana

Let's start with a quick tour in primary rainforest.

These forests have very little human impact (remember the definition of a primary forest in week 1) but above all the canopies can be quite closed, even if these forests don't hold world records for basal area, with so little light on the forest floor (only 2% of incident light) that almost no herbaceous plants can grow.

Under these conditions, the growth of trees that do not emerge from the canopy is very slow, barring a disturbance that suddenly brings a lot of light into a clearing.

Forest layers and access to light

Closed beech forest
Saint Helene, Vosges

« Closed stand»
few herbaceous plants on the ground, presence of an understory layer, crowns in contact and competing for light

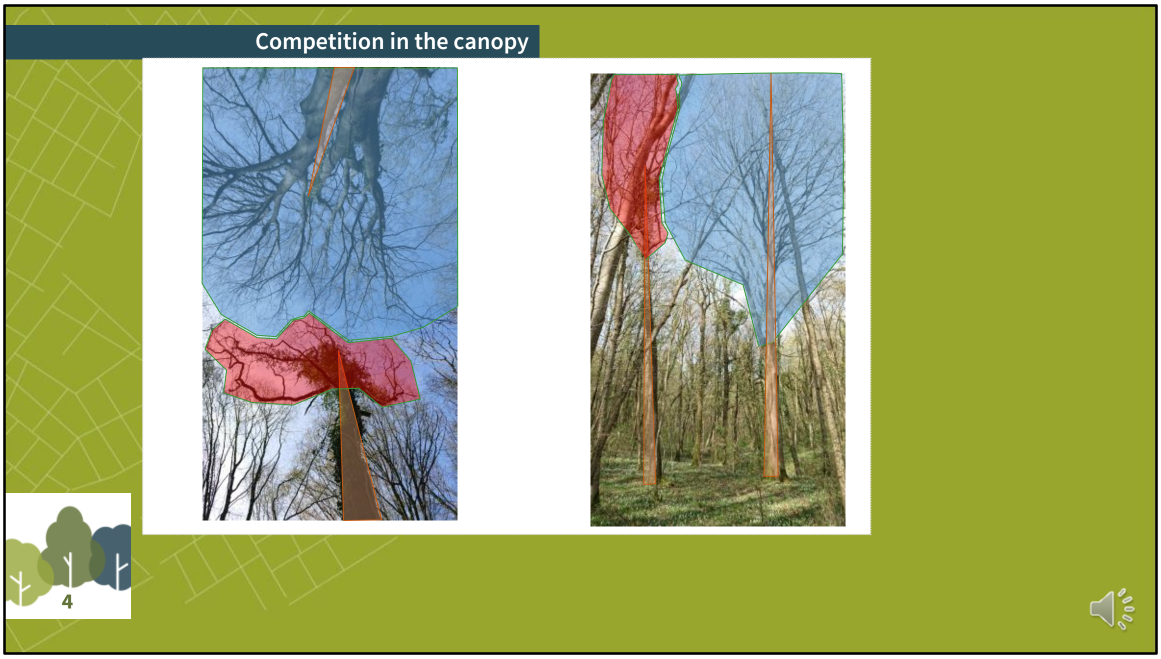
3

Moving back to the temperate zone, in a **closed mature forest**. The term "**closed**" here means that the crowns of large trees (i.e. all their branches) **cover almost the entire forest floor**: there is no clearing or space larger than the crown of a large tree.

On the forest floor, there are small plants, shrubs, or non-woody plants (ferns and some grass), which are called the **herbaceous layer**. Sometimes a **moss layer** can be seen at the forest floor level.

Just above this, small trees, often spindly and leaning, can be seen, which constitute the so-called **understory**.

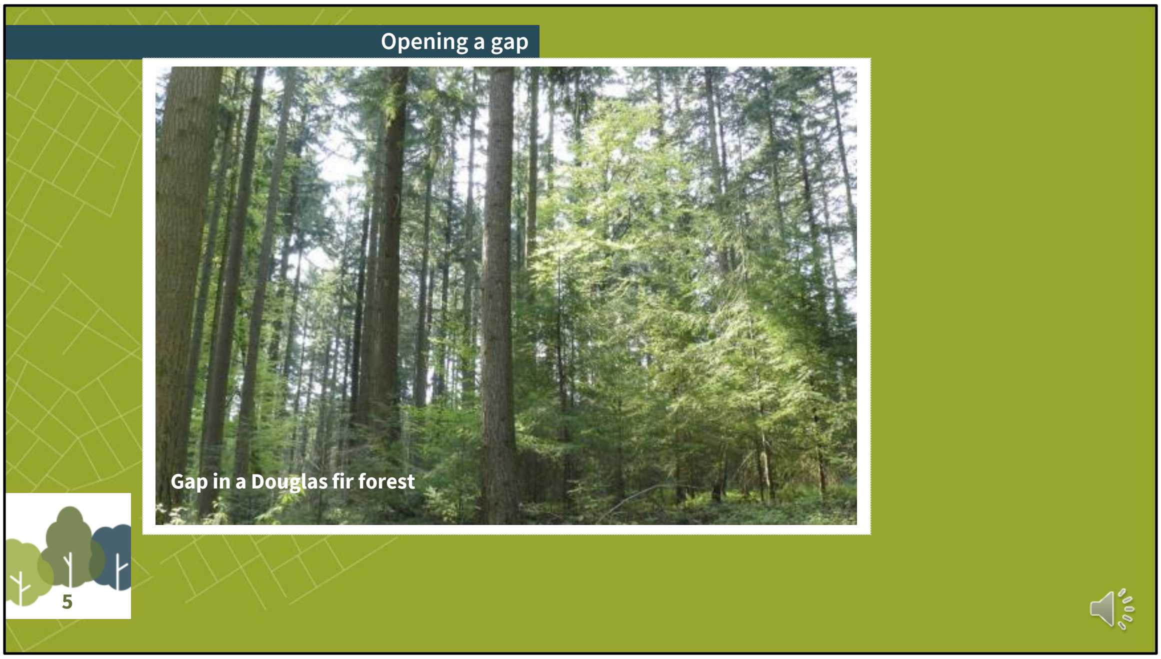
Looking upwards, the crowns of the larger trees are almost in contact with each other. They form the so-called **overstory**, which is the sun-exposed canopy.



Competition in the canopy

Looking again at the crowns of the overstory, you can see that some of the larger trees have wider, rounder crowns, like the tree highlighted in blue here, and others have very small crowns, like the one highlighted in red, which seems to be flattened between the crowns of its neighbors.

This tree loses the battle for light and is eliminated from the dominant tier. A tree's place in a particular layer is technically referred to as its "social status". Of course, any parallel with human society is meaningless.



Opening a gap

Gap in a Douglas fir forest

Now imagine that a disturbance of some kind, such as a storm, creates a gap in this stand, eliminating several large neighboring trees. The influx of light to the forest floor will be sufficient for the young shoots to develop. In both temperate and tropical forests, the development of vegetation when the fall or felling of one or a few large trees allows light to reach the ground shows at a glance the importance of competition for light and its structuring effect on the vegetation.

If the gap is large enough, in the long run, two different generations of trees can coexist locally, and the stand can be said to have become locally irregular.

This unevenness can also be caused by the forester, and be a management choice, as we saw in lesson S2V4 on forest renewal.

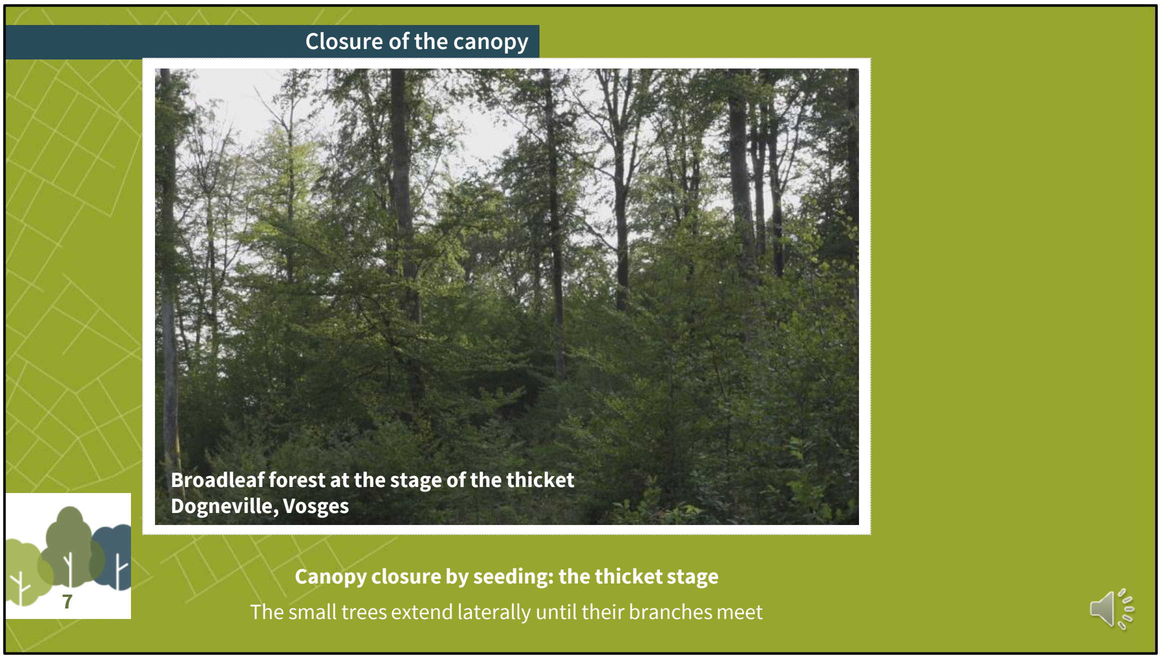
Open regular high forest in regeneration

Oak forest in natural regeneration
Saint Hélène, Vosges

Opening of the forest by progressive harvesting: Seedlings grow by tens of thousands under the seed banks

Let's now consider a regular forest, at the very last stage of its development, in which we start the process of natural regeneration (a renewal method often practiced in our forests, as we saw in S1V4, in particular in deciduous beech or oak forests).

In a regular mature forest at the stage of natural regeneration, the young seedlings are present by thousands on a single hectare, by tens of thousands on a plot. On this picture, the seedlings are still covered by the trees that gave birth to them and that will soon be harvested.



Closure of the canopy

Broadleaf forest at the stage of the thicket
Dogneville, Vosges

Canopy closure by seeding: the thicket stage

The small trees extend laterally until their branches meet

As the seedlings grow in height, they spread their branches laterally until they come into contact with each other. **The competition for light begins.**

Competing and reaching for the light

Broadleaf forest at the stage of the perch
Dogneville, Vosges

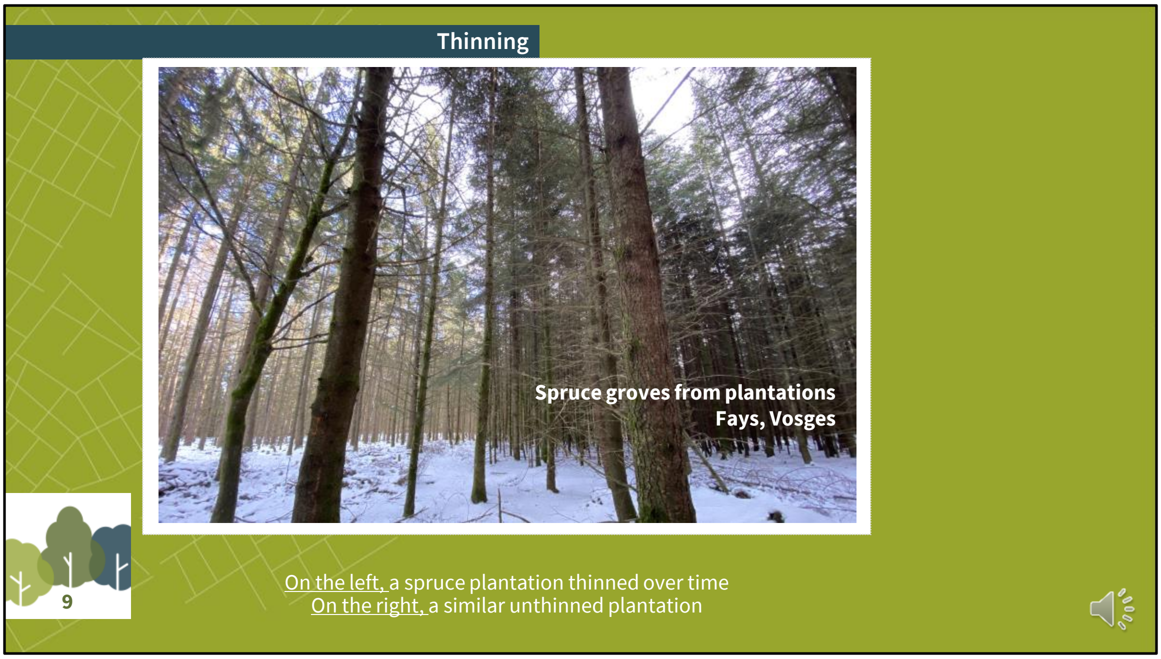
The perch stage

The trees rush towards the light, and lose their low branches, insufficiently lit

On the one hand, the low branches that find themselves in the shade, wither, and die. This is called **natural pruning**, which gives forest trees a slender silhouette that is very different from the shape of trees that grow isolated in parks or in fields.

On the other hand, some stems, less vigorous, do not manage to grow high enough to keep a sufficient access to light. They thus enter a loop of reduction of their growth speed and their access to light and they can no longer maintain themselves in the dominant stage.

How they respond to this drop in the dominant storey depends very much on the species - we'll see that next time: either they **dieback** or they take their place in the **understory.**



Thinning

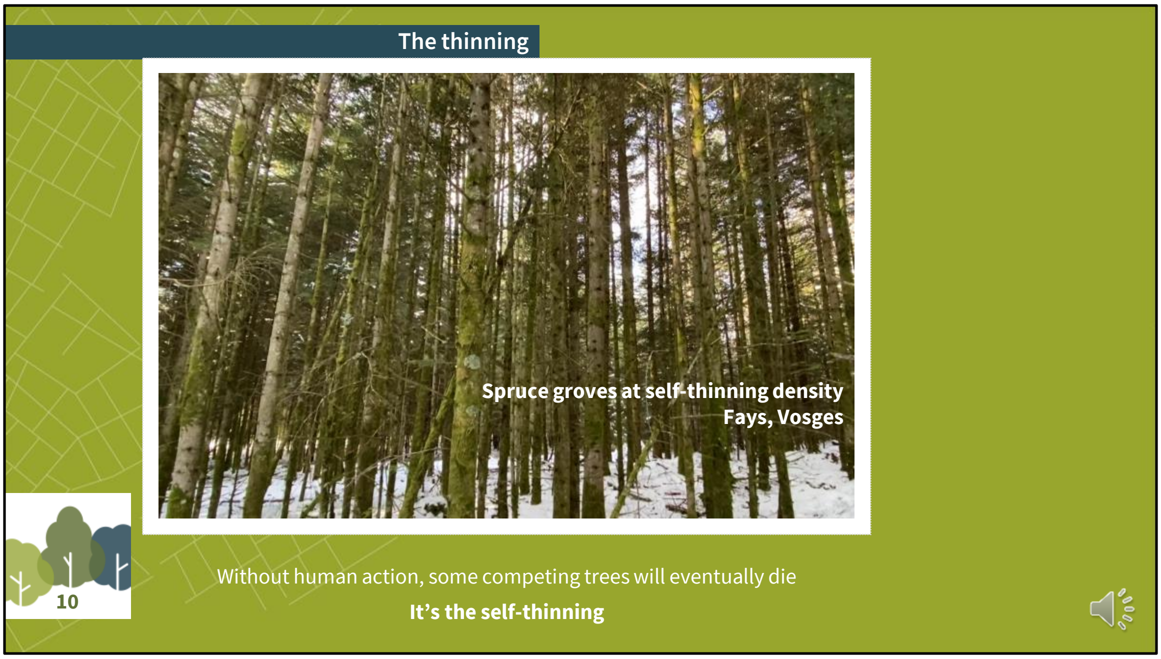
Spruce groves from plantations
Fays, Vosges

On the left, a spruce plantation thinned over time
On the right, a similar unthinned plantation

In a managed forest, the forest manager intervenes to choose himself the trees to be removed, and favour the most promising individuals.

This is called **thinning** (we will see this in more detail later)

Of course the rhythm and the modalities of this elimination depend a lot on the type of forest, the environmental conditions and the species composition.



The thinning

Spruce groves at self-thinning density
Fays, Vosges

Without human action, some competing trees will eventually die

It's the self-thinning

As the population increases, it changes and the conditions for growth change. The temperaments of the individuals and the competition that arises lead to the death of some in favor of others.

The **natural death** of individuals in an unfavorable situation is called **self-thinning**.

In a regular forest that has not been logged recently, if you look up, you can see this self-thinning at work in the shape of the crowns of the dominant stratum:

- some large trees have a wider, rounder crown,
- others have a very narrow crown, flattened out between those of their neighbors. These latter trees are being eliminated from the dominant layer.

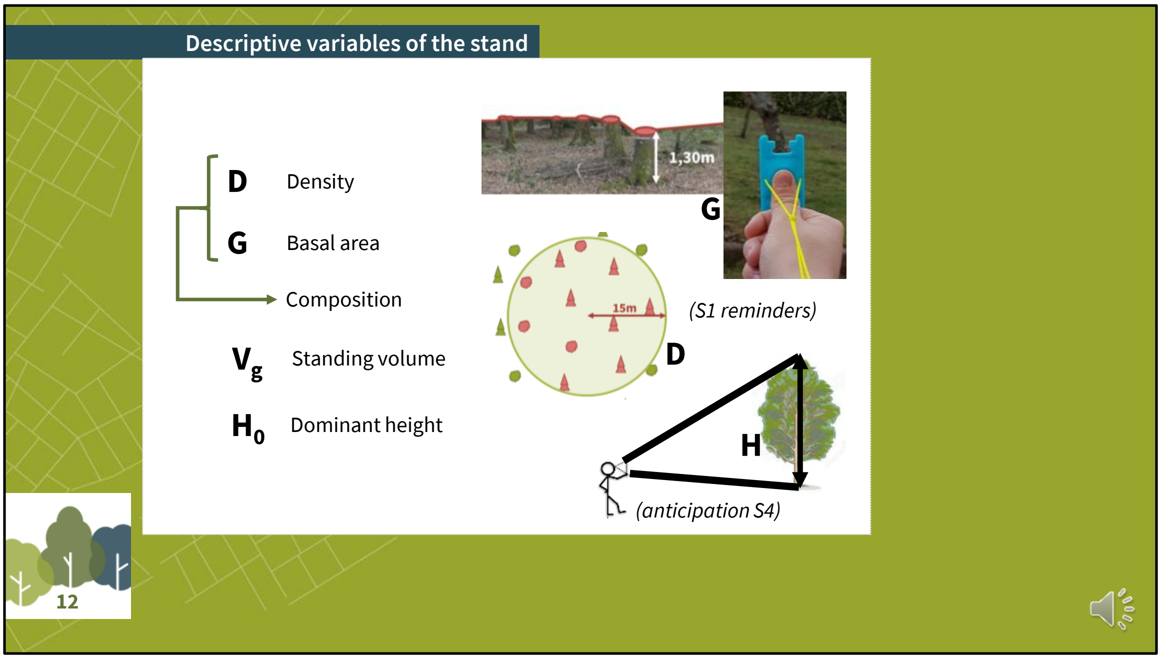
As we have seen before, whether a tree belongs to a certain layer is technically called its "social status".

From tree to stand

The simplest forests, or at least the best known, are stands :

- of **temperate environments**
- **Monospecific,** i.e. made up of a single species
- **Regular,** i.e. where all the trees belong to the same generation with approximately the same age

Their silviculture, formalized in the 19th and 20th centuries, led foresters to no longer consider lists of trees, but a new object which is the stand itself.



Descriptive variables of the stand

D Density

G Basal area

Composition

V_g Standing volume

H_0 Dominant height

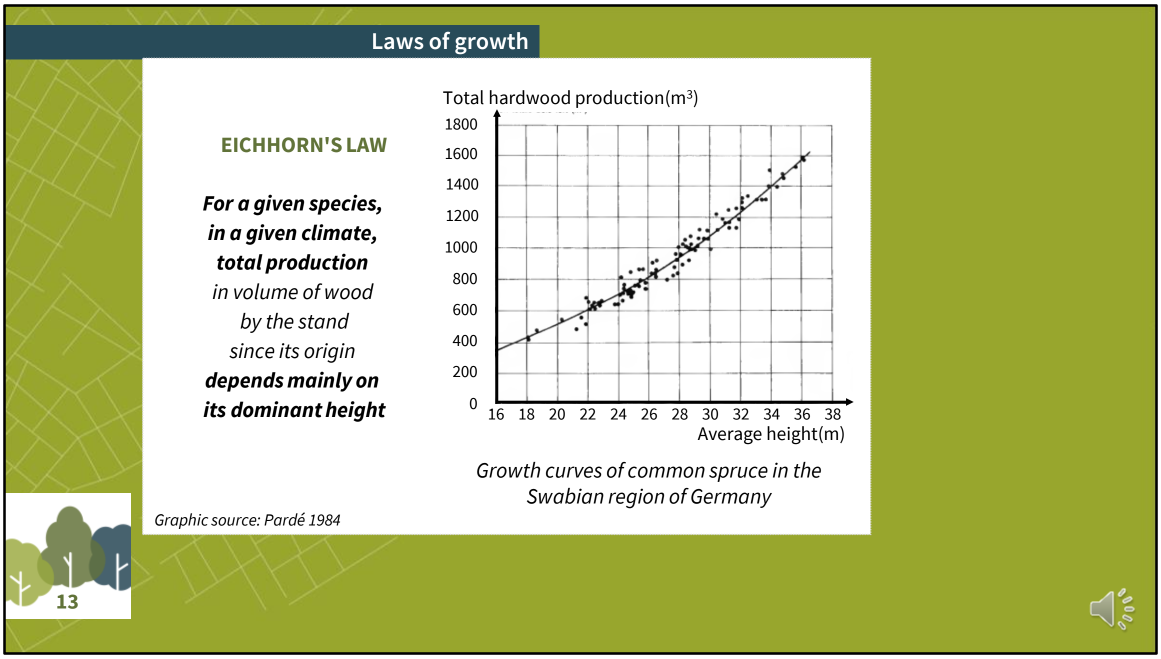
(S1 reminders)

(anticipation S4)

As seen in week 1, this stand can be described by variables such as;

-**density**, defined as the number of trees above a certain diameter per hectare
-**basal area**, defined as the cumulative area of the sections of these stems at 1.30 m
-**standing volume**, defined as the cumulative volume of trunks and branches up to a certain diameter
-**the dominant height**, defined as the average height of the 100 largest trees per hectare.

The first two variables make it possible to determine **the composition**, defined by the respective proportion of the various species, in basal area or in number of stems, because even a stand said to be "monospecific" often contains other species than the dominant one, especially if it comes from natural regeneration!



Laws of growth

EICHHORN'S LAW

For a given species,
in a given climate,
total production
in volume of wood
by the stand
since its origin
depends mainly on
its dominant height

Growth curves of common spruce in the Swabian region of Germany

Graphic source: Pardé 1984

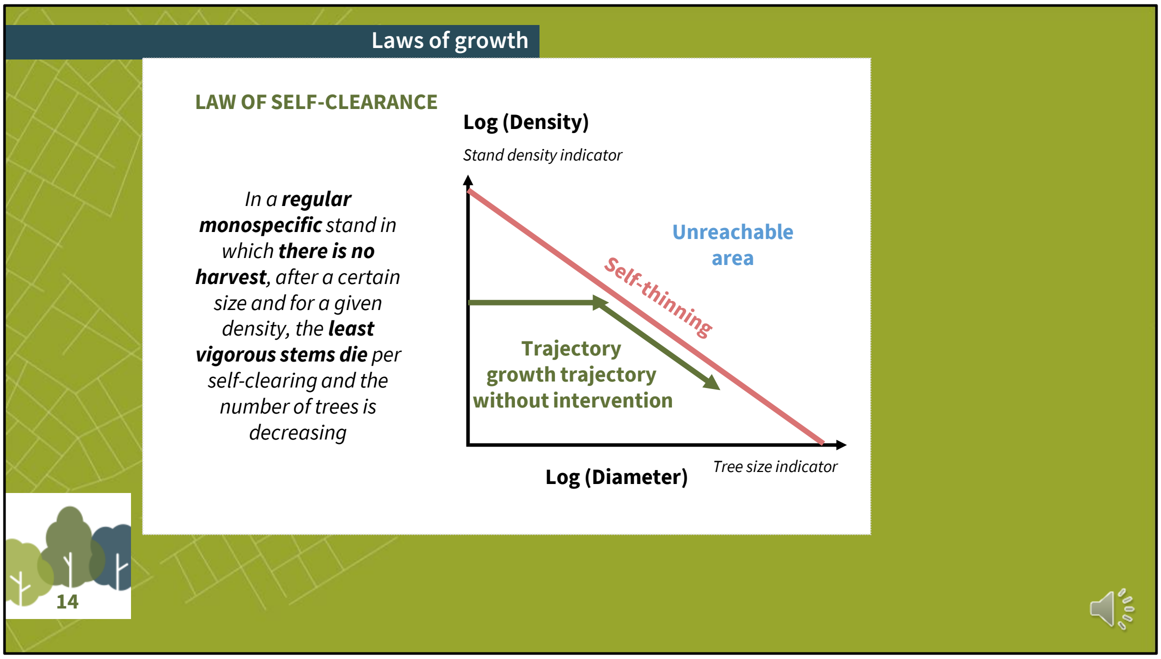
The study of the growth of regular monospecific stands has made it possible to identify some major general laws. One of them, highlighted by **Fritz Eichhorn at the beginning of the 20th century**, shows that for a given species, under a given climate :

- **the total volume of wood produced** by the stand since its origin **depends essentially on its dominant height**, independently of the treatment of the stand by the forester and the fertility of the soil
- **the height** reached at a given age expresses **the fertility of the site.**

This graph shows the growth curves of the common spruce in the Swabian region of Germany. The fertility in this representation is expressed by the speed at which a given stand moves from left to right along the curve.

If this law does not seem obvious to you, that is normal! Nevertheless, knowing it is not without interest for the informed citizen that we all wish to be. In particular, it means that **the thinning carried out by the silviculturist, as long as it remains within a correct range of intensity, does not reduce the wood production capacity of the stand**.

We will see in the video on carbon inventory in week 4 that understanding this is essential to reasoning about the effect of forest management on the carbon balance.



Laws of growth

LAW OF SELF-CLEARANCE

In a ***regular monospecific*** *stand in which* ***there is no harvest****, after a certain size and for a given density, the* ***least vigorous stems die*** *per self-clearing and the number of trees is decreasing*

Log (Density)

Stand density indicator

Unreachable area

Self-thinning

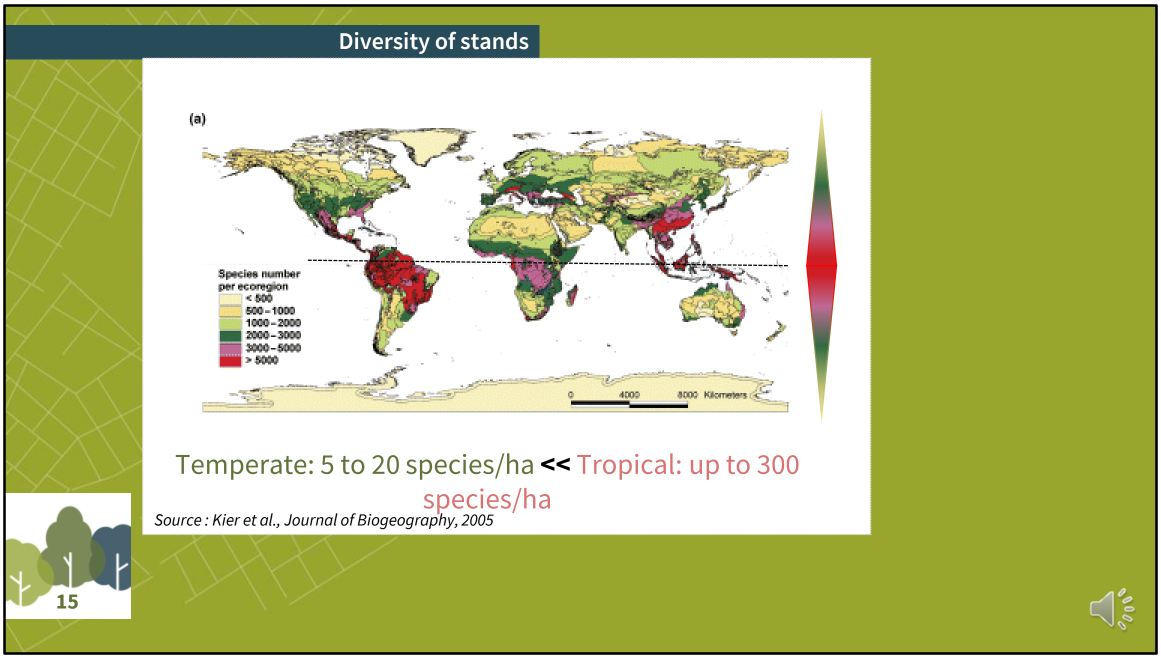
Trajectory growth trajectory without intervention

Log (Diameter)

Tree size indicator

Other laws can be demonstrated by studying these regular monospecific stands.

Thus, the study of **self-thinning** processes has shown that in a regular monospecific stand in which no harvesting is done, after a certain size and for a given density, the least vigorous stems die by self-thinning and the number of trees decreases. This self-thinning law takes a particular form, evoked by this diagram, in which the logarithm of the maximum density reached as a function of the logarithm of the dominant diameter of the stand takes the form of a straight line with a negative slope.



Diversity of stands

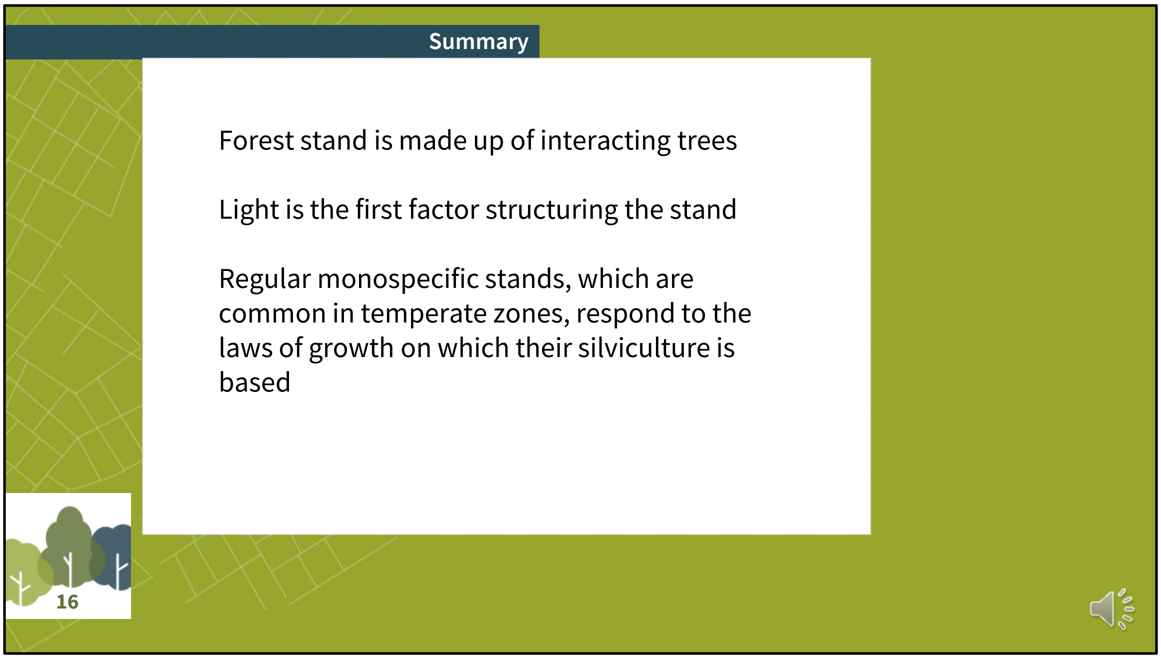
Temperate: 5 to 20 species/ha **<<** Tropical: up to 300 species/ha

Source : Kier et al., Journal of Biogeography, 2005

We have discussed regular monospecific stands. In our temperate European contexts, forests left to evolve freely often tend towards a dominant species (mainly beech in France, spruce or pine in Scandinavia...). Regular monospecific stands, therefore, represent an interesting study model for a large proportion of forests, whether planted or naturally regenerated.

Breaks in the cover of the dominant species during natural accidents or management operations then create disturbances that cause biodiversity to change, as we saw in S2V3 with regard to threats to forests.

In other climatic domains, the diversity of tree species in mixtures is much higher, with the extreme of local diversity being reached in tropical rainforests. As we saw in S2V2, these forests contain considerable species diversity, very often more than 250 different tree species in 600-1000 stems in a hectare (looking around, you are unlikely to see two trees of the same species).



Summary

Forest stand is made up of interacting trees

Light is the first factor structuring the stand

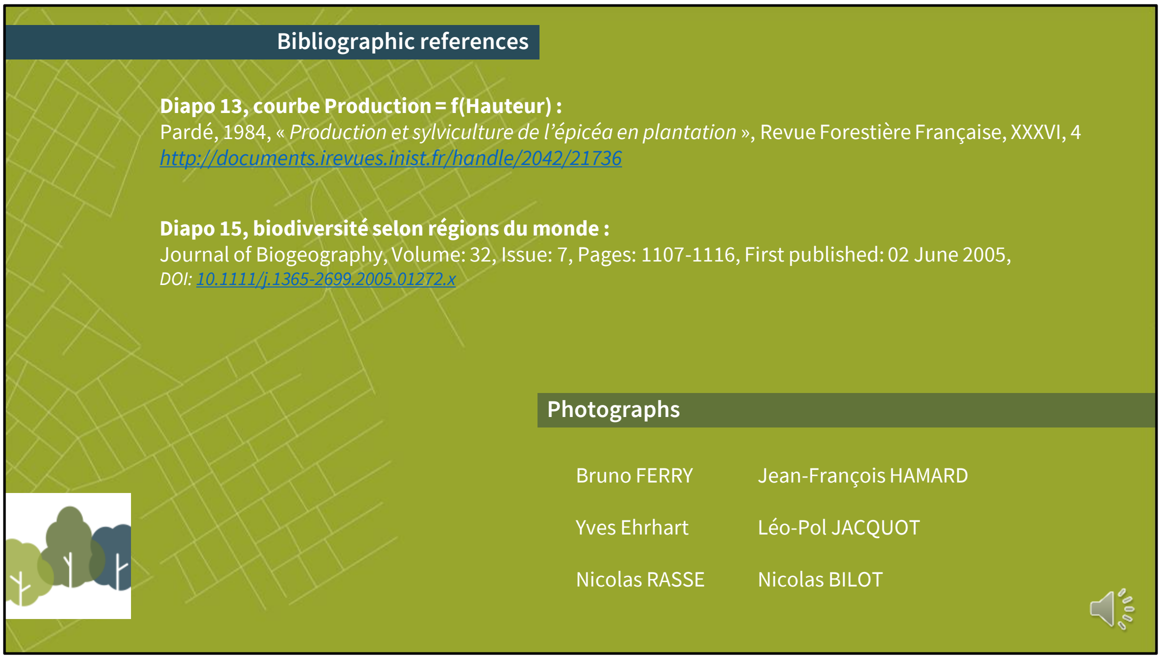
Regular monospecific stands, which are common in temperate zones, respond to the laws of growth on which their silviculture is based

- **Trees in a forest** are not a simple collection of juxtaposed individuals: they interact with each other and form a whole**, the stand**, which can be studied as a whole.

- Within this stand, the search for **light structures** to a large extent the growth of stems and the interactions between species.

- The study of regular monospecific stands, the simplest case, has thus made it possible to identify **growth laws** that can be formalised mathematically, and **on which their silviculture is based.**

- These regular monospecific stands are the **simplest case**, whose functioning is best known, and at the same time they represent a **valid model** for many stands **in temperate zones**, including natural stands, because **in a temperate context, forests left to evolve freely generally tend towards a dominant species.**



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Journal of Biogeography, Volume: 32, Issue: 7, Pages: 1107-1116, First published: 02 June 2005,
DOI: 10.1111/j.1365-2699.2005.01272.x

Photographs

Bruno FERRY	Jean-François HAMARD
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Nicolas RASSE	Nicolas BILOT

Courbe Production = f(Hauteur) :
Pardé, 1984, « *Production et sylviculture de l'épicéa en plantation* », Revue Forestière Française, XXXVI, 4
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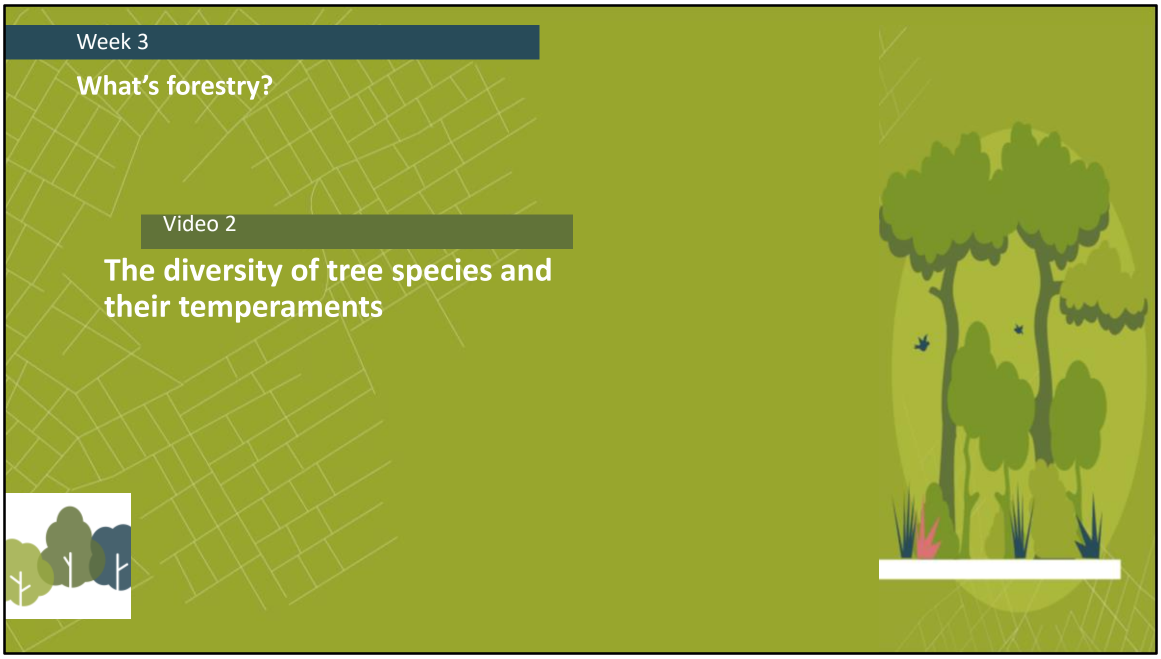


Week 3

What’s forestry?

Video 2

The diversity of tree species and their temperaments

Trees in their environment

2

We last saw the growth of trees in a stand was accompanied by a strong competition for light.

During week one, we also saw that the characteristics of a forest, its composition and structure are strongly conditioned by the soil and the climate in which it grows.

Today, we will see that different / each tree species respond(s) differently to these growing conditions, and that all aspects of this response draw up a kind of ecological profile for each species, which is very useful to know.

The need for light

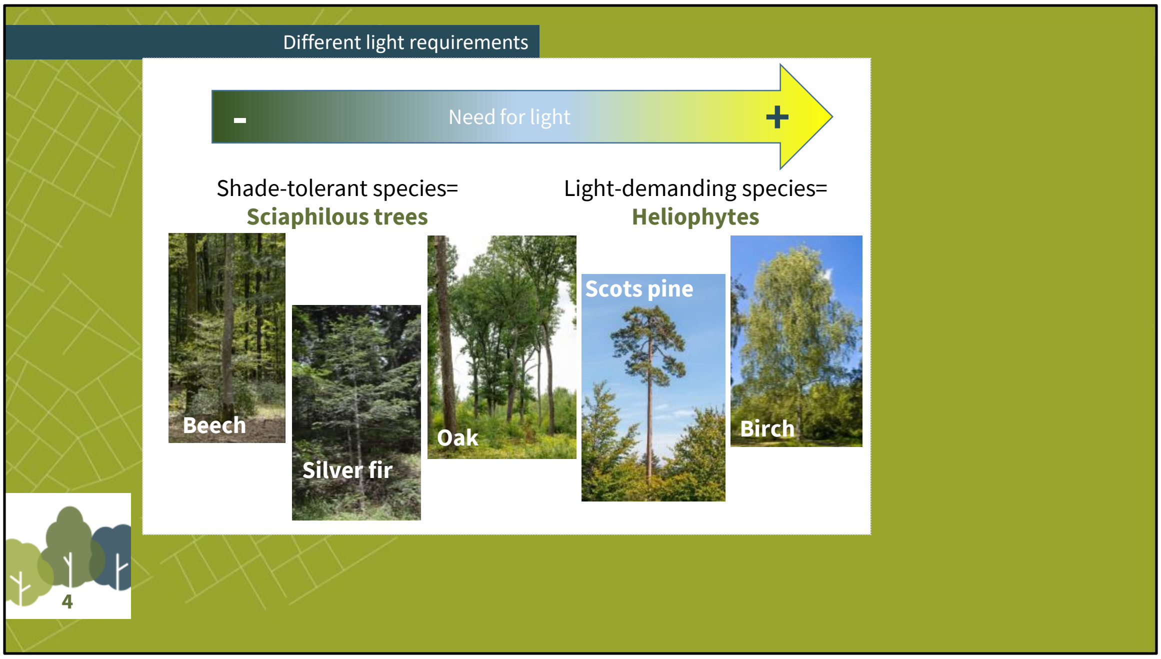
Some species tolerate cover, they make up the understorey

Let's start with light. As we saw earlier, light is very important for the growth of trees in a stand. Photosynthesis is the engine of their growth and all chlorophyllous plant species need it to thrive.

However, some species tolerate a certain amount of cover, with reduced growth. Some species can remain under a canopy all their life, with limited development and often a tendency to bend or spread out.

In our hardwood forests, hornbeam or beech often form a layer under the canopy of the larger trees, called an understory* - a term we learned in the previous lesson.

Thus, while some stems remain in the understory all their lives, other young stems of these shade-tolerant species can gain access to light fairly quickly, and thus fully develop their growth potential by becoming canopy trees.



Different light requirements

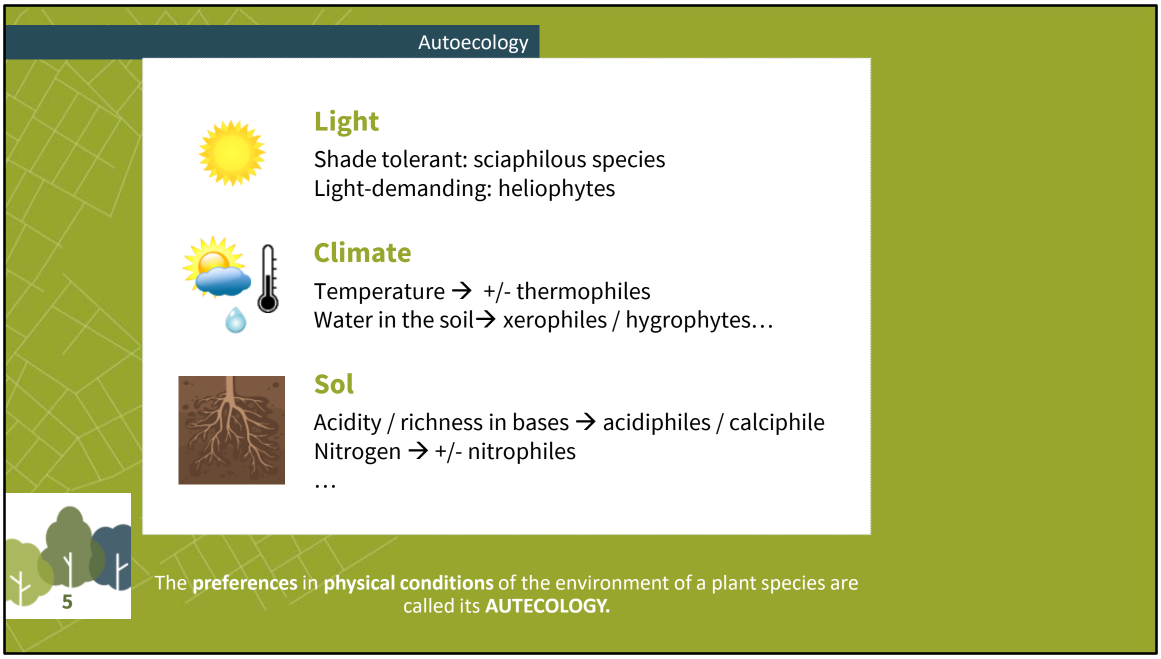
- Need for light +

Shade-tolerant species=
Sciaphilous trees

Light-demanding species=
Heliophytes

These species such as hornbeam, beech, fir, holly, yew, which tolerate canopy by adopting reduced growth with little light are called shade tolerant species or ***sciaphilous species***.

Conversely, species such as oak, birch or cherry will not be able to remain under canopy cover for more than a few years. They are called shade-intolerant species, or ***heliophytes***.



Autoecology

Light

Shade tolerant: sciaphilous species
Light-demanding: heliophytes

Climate

Temperature → +/- thermophiles
Water in the soil→ xerophiles / hygrophytes…

Sol

Acidity / richness in bases → acidiphiles / calciphile
Nitrogen → +/- nitrophiles
…

The **preferences** in **physical conditions** of the environment of a plant species are called its **AUTECOLOGY.**

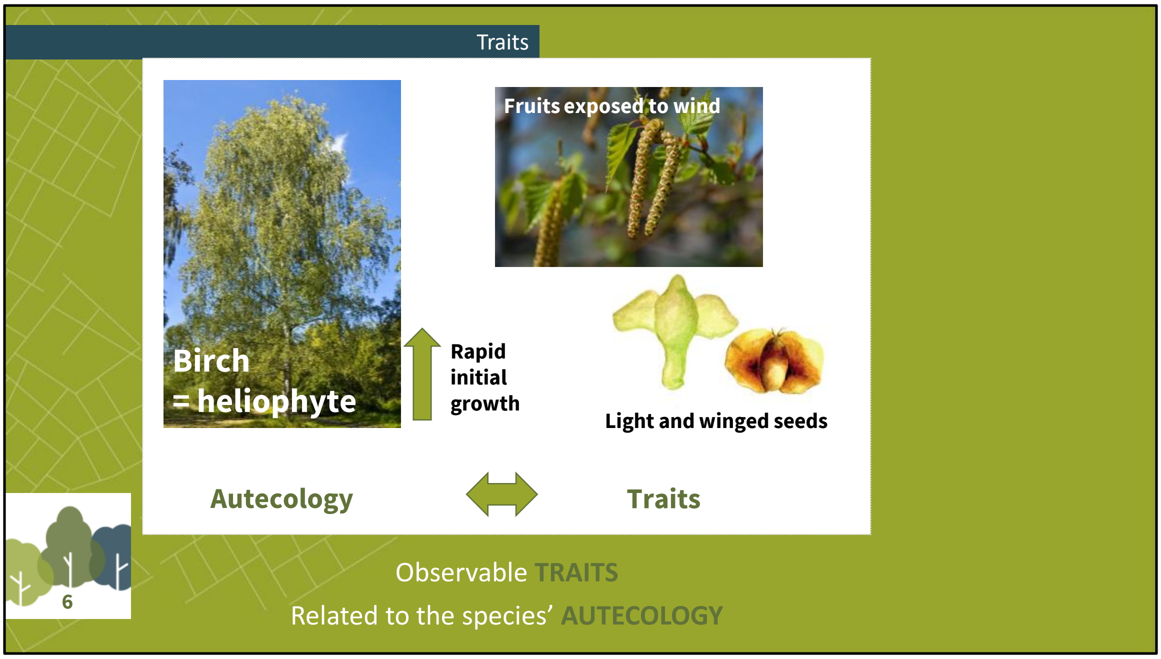
Likewise, we can characterise species according to their preferences with respect to climatic factors, be it thermal regime, abundance of water in the soil, or humidity in the air.

Depending on the soil characteristics, some species can require nitrogen, soils rich in minerals, can be tolerant to waterlogged soils, etc. The set of preferences of a plant species (from trees to mosses) with respect to the physical conditions of the environment is called its ***autecology.***

Knowing these preferences, especially for trees, is an essential dimension of forestry expertise. To describe these preferences, various indices have been developed.

For example, in the 1970s, the German ecologist Ellenberg proposed indices qualifying how much tree species are dependent on light or nitrogen richness in the soil.

These expertise-based approaches are now being replaced by statistical approaches.



Traits

Fruits exposed to wind

Birch
= heliophyte

Rapid initial growth

Light and winged seeds

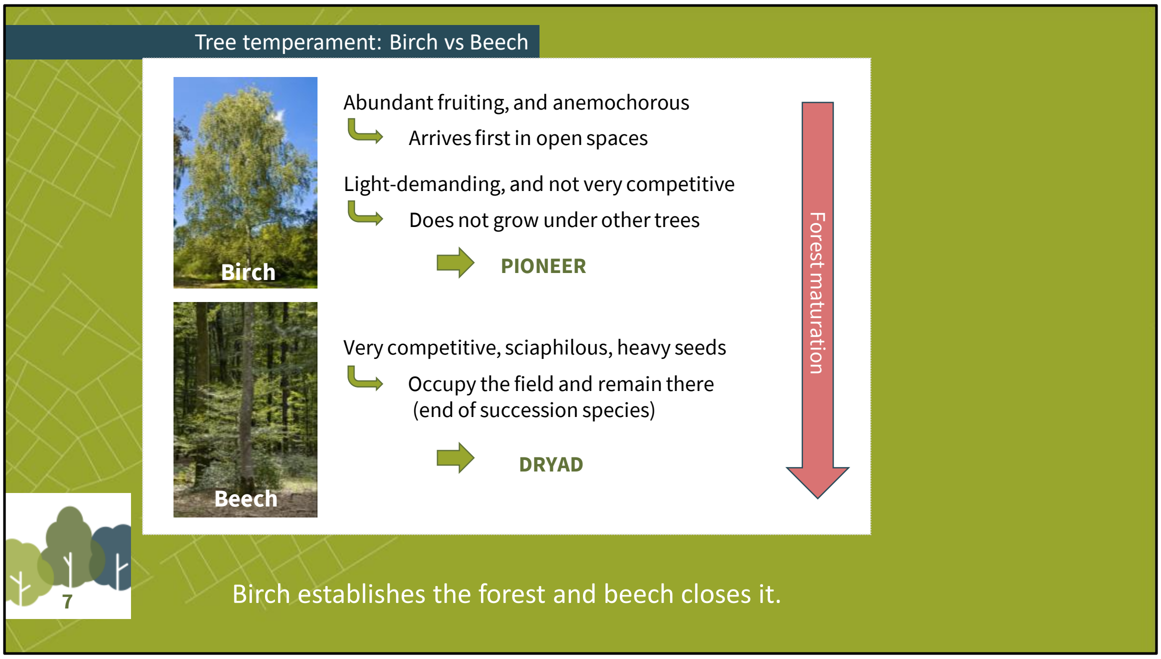
Autecology ⟷ **Traits**

Observable TRAITS

Related to the species' AUTECOLOGY

These environmental requirements are not independent of the directly observable characteristics of the species, such as its growth rate, the size of its seeds or how they are dispersed. For example, one distinguishes the species according to the preferential vector of the seeds: the wind for ***anemochorous species****, and animals, for the ***zoochorous*** ones. Thus birch, being light-demanding, is endowed with light and winged seeds, which can go travel to find new open spaces.

The way a tree releases pollen to reach another individual is also very important to understand the way the species will be able to occupy the land. These characteristics of form or function, measurable at the individual level, and which influence its performance in the ecosystem, such as growth rate or size of seeds, are called the species' "***traits***".



Tree temperament: Birch vs Beech

Birch

Abundant fruiting, and anemochorous

↳ Arrives first in open spaces

Light-demanding, and not very competitive

↳ Does not grow under other trees

➡ **PIONEER**

Beech

Very competitive, sciaphilous, heavy seeds

↳ Occupy the field and remain there (end of succession species)

➡ **DRYAD**

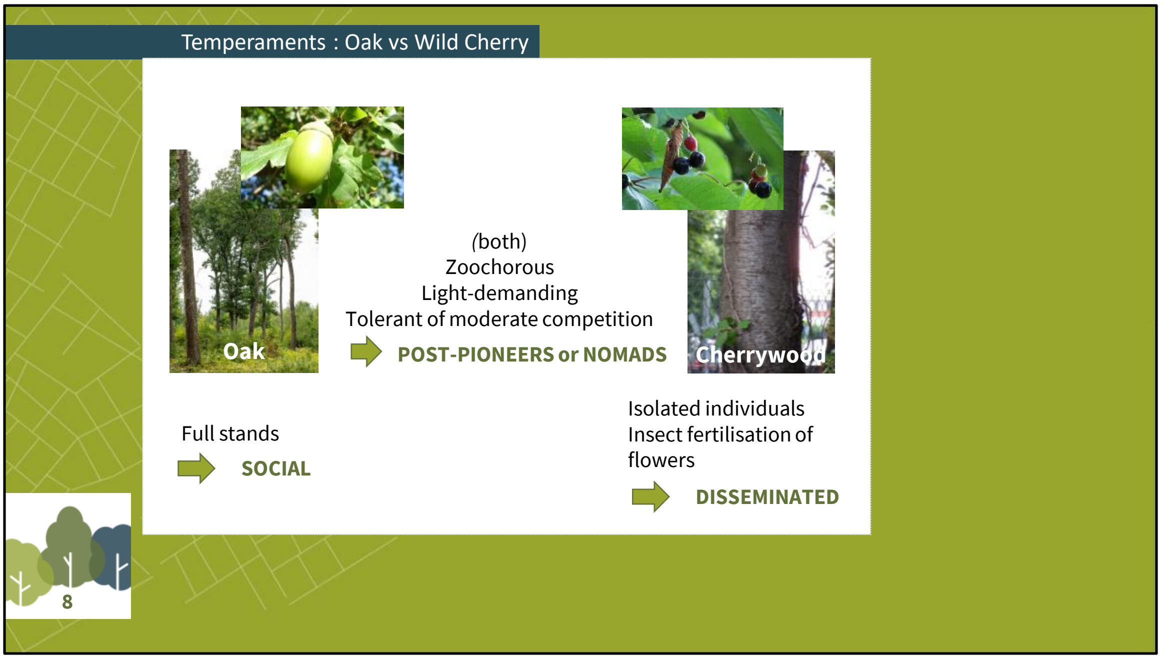
Forest maturation

Birch establishes the forest and beech closes it.

Traits and the set of environmental needs that make up autecology have been shaped by evolution into a cohesive whole, referred to as the species' ***temperament***. This temperament conditions the way in which a species will fit in a plant formation, take its place or lose it, over the course of its evolution.

A few examples will allow you to better understand this. Take for instance, birch and beech. Birch is very light demanding, and cannot stand competition from other trees. It abandons the area as soon as the forest densifies, and will colonise another open area, further away, thanks to its light seeds and abundant fruiting. It is said that birch is a ***pioneer species***.

Conversely, beech is a formidable competitor. The denser the forest becomes, the more beech eliminates other species, to form stands where it can breed. This type of species dominates when a forest matures without disturbance. It is said that the beech is a ***dryad***, or a climax community species.



Temperaments : Oak vs Wild Cherry

Oak

Cherrywood

(both)
Zoochorous
Light-demanding
Tolerant of moderate competition

➡ **POST-PIONEERS or NOMADS**

Full stands

➡ **SOCIAL**

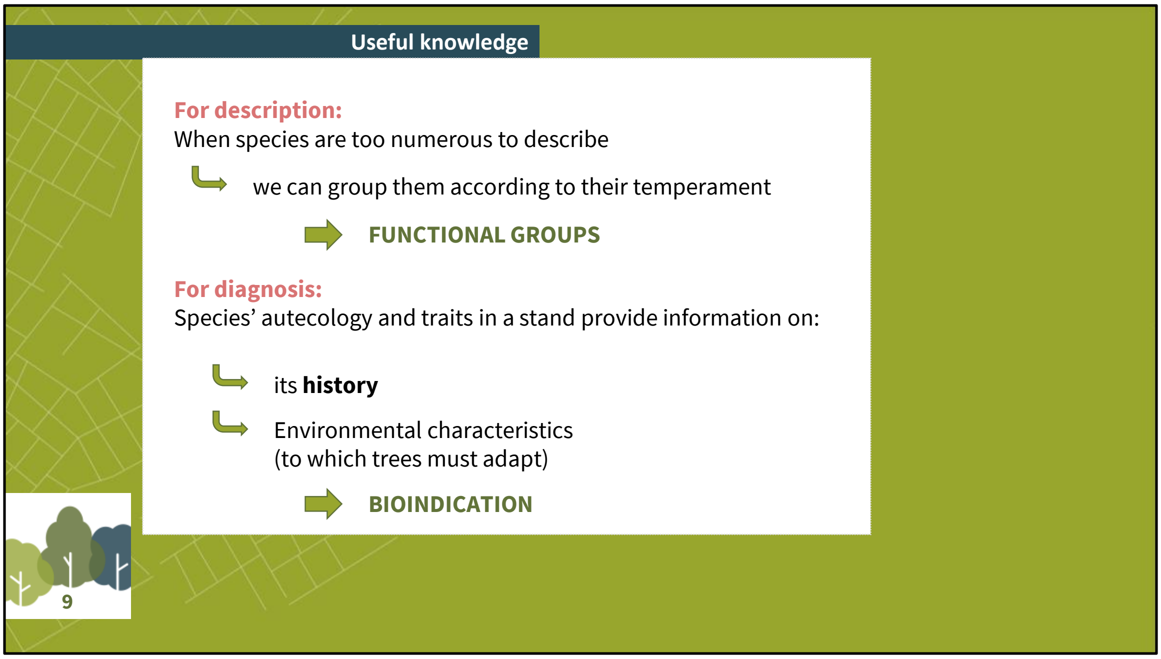
Isolated individuals
Insect fertilisation of flowers

➡ **DISSEMINATED**

Let’s take another couple of species: pedunculate oak and wild cherry.

Both have more or less the same dynamics: light-demanding, but more tolerant of competition than birch. They belong to the category of ***post-pioneers*** or ***nomads***. Both species’ seeds are disseminated by animals, especially birds.

Oak for its part, forms complete stands, called oak groves, whereas wild cherry settles in the form of isolated individuals, distant from each other, but capable of exchanging pollen over long distances thanks to insects. Oak is referred to as a social species, while wild cherry is a disseminated species.



Useful knowledge

For description:
When species are too numerous to describe

↳ we can group them according to their temperament

➡ **FUNCTIONAL GROUPS**

For diagnosis:
Species' autecology and traits in a stand provide information on:

↳ its **history**

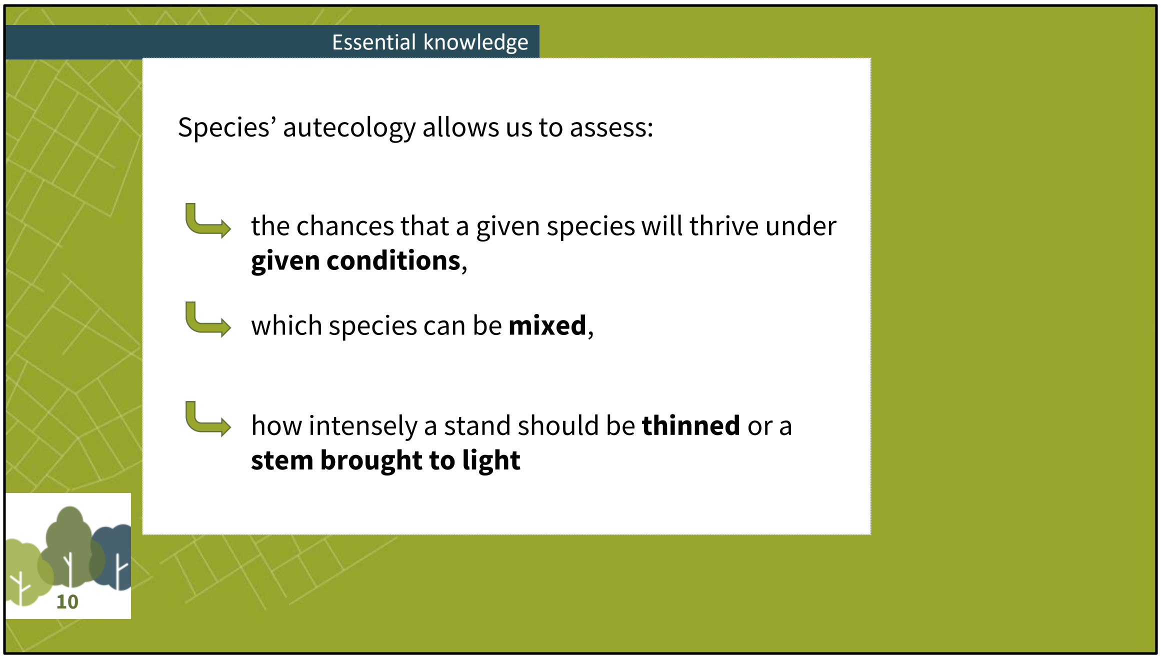
↳ Environmental characteristics
(to which trees must adapt)

➡ **BIOINDICATION**

9

All this knowledge, fascinating in itself because of what it says about the functioning of ecosystems and forming of species, is also of great practical use. We already mentioned the diversity of tropical forests which makes it difficult, if not impossible, to know all the species. We thus use the species' temperament to group them into functional groups, making it possible to describe the composition of a population.

For example, the species of the undergrowth, always living under the others, tolerating low light, living in slow motion but sometimes for a very long time. Those that soar towards the light in long, slender trees, before emerging into the canopy to begin to grow in volume and not just in height. The giants who even manage to create an additional layer by emerging high above the canopy at 70 m or more. They are precious tools for describing flora, or understanding, from a state of plant composition, the trajectory that led to it. The indices mentioned are even used as measuring instruments: we can assess the average temperature of a site or soil acidity thanks to flora surveys. This is called **bioindication**.

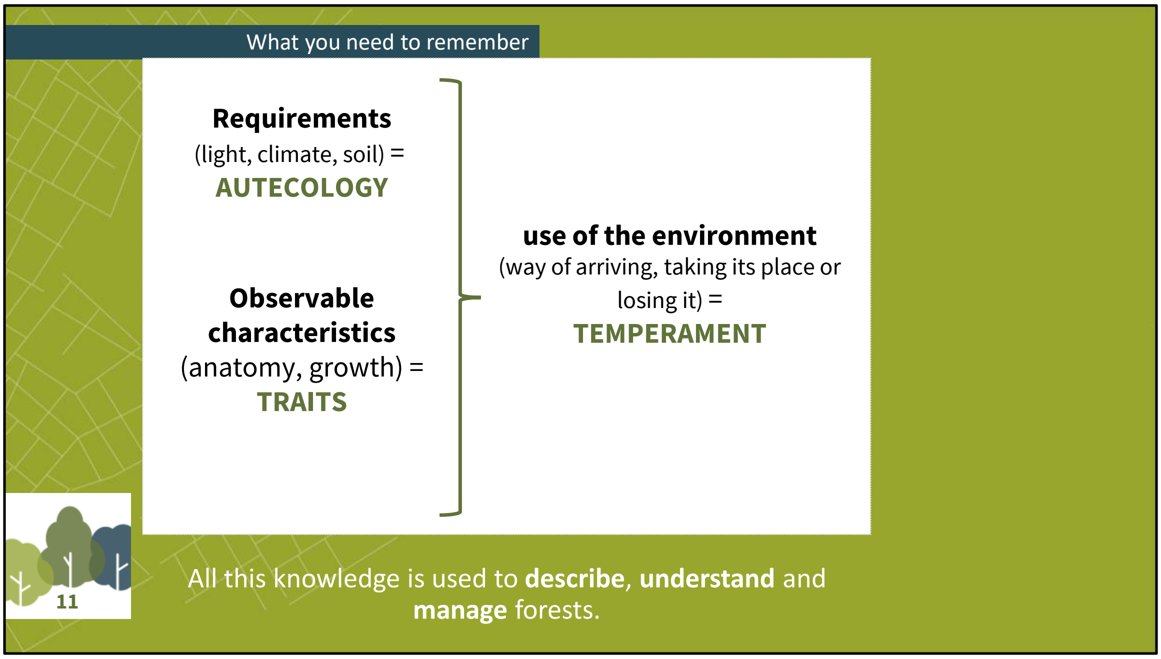


Essential knowledge

Species' autecology allows us to assess:

- the chances that a given species will thrive under **given conditions**,
- which species can be **mixed**,
- how intensely a stand should be **thinned** or a **stem brought to light**

Last but not least, knowledge on the autecology of species is essential for forestry.
For example, it allows you to understand:
-what are the chances that a tree of a given species will thrive under given conditions,
-which species can be mixed,
-how intensely a stand should be thinned.



What you need to remember

Requirements
(light, climate, soil) =
AUTECOLOGY

Observable characteristics
(anatomy, growth) =
TRAITS

use of the environment
(way of arriving, taking its place or losing it) =
TEMPERAMENT

All this knowledge is used to **describe**, **understand** and **manage** forests.

The **preferences** in **physical conditions** of the environment of a plant species are called its **AUTECOLOGY.**

To put it in a nutshell, plant species, and trees in particular, are characterised by their needs of certain environmental physical conditions, called their AUTECOLOGY (light, climatic conditions, soil characteristics).

Different species also have characteristics of form and functioning which can be observed at the tree level. These characteristics condition the trees' performance in the environment, such as for example the size of their seeds, their growth speed etc., called their FUNCTIONAL TRAITS.

Autecology and traits characterise the way trees use the environment, insert themselves, take their place or lose it: their TEMPERAMENT. We can thus distinguish: pioneer species / climax community species, social species / scattered or disseminated species, and so on.

This knowledge has resulted in the development of various concepts and tools: indices, traits, functional groups – all essential to describe, understand and manage forests in the complexity of their species composition.

Photographs and illustrations

Jean-François HAMARD

Léo-Pol JACQUOT

Nicolas BILOT

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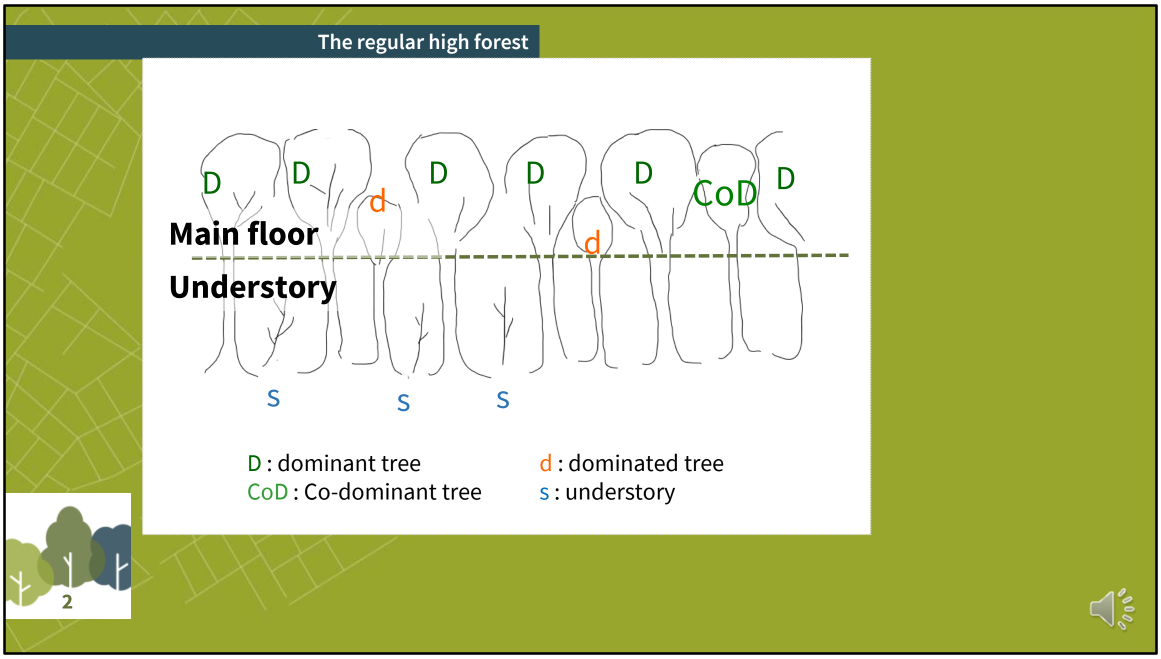
Week 3

What’s forestry?

Video 3

The forestry cycle in regular (even-aged) high forests



The regular high forest

Main floor

Understory

D : dominant tree

CoD : Co-dominant tree

d : dominated tree

s : understory

Do you remember what a regular high forest is called?

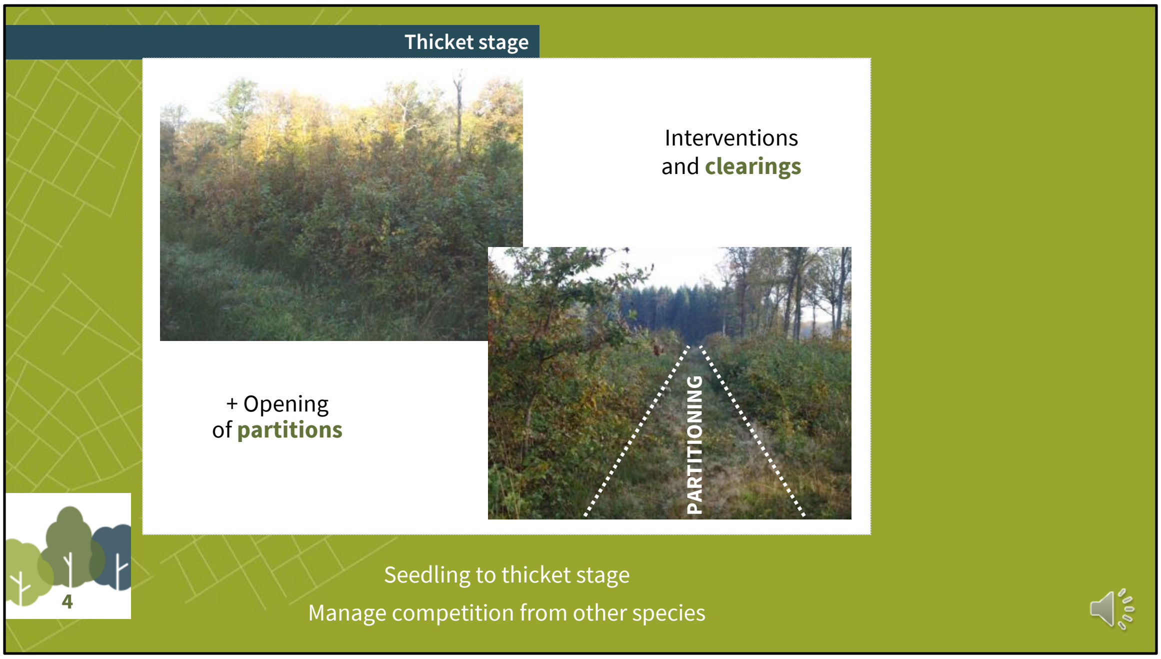
This week (week 3), we saw in the first lesson that it is a stand in which trees on the main floor belong to the same generation, whether it came from a plantation or from a natural regeneration of the previous stand.

Today, we will go through the silvicultural / forestry cycle of a regular high forest stand in more detail, reviewing the succession of operations carried out by foresters as the stand develops, as well as the different criteria and standards they rely on to regulate their action.

Acquiring seedlings

The first phase, called **the youth phase**, starts when the young stand is installed on the whole plot, with a sufficient seedling density. This density takes into account the stems of the mainly sought-after species, which is called the main objective species, and that of other species considered to be interesting in mixture, which is called **accompanying species**.

This initial density thus constitutes a first criterion, controlled by the choice of a planting density (ranging from 1000 to 2000 plants per hectare), or by controlling the almost homogeneous presence of seedlings in natural regeneration (around 2000 seedlings per hectare).



Thicket stage

Interventions
and **clearings**

+ Opening
of **partitions**

Seedling to thicket stage

Manage competition from other species

The growth phase from seedlings to the thicket stage, i.e. up to 3 m in height, is punctuated by silvicultural work. This consists in managing the competition exerted on the sought-after species' seedlings by other herbaceous or ligneous species.

This type of intervention is called **a clearing**, and several successive clearings may be necessary, until the young trees are sufficiently developed to no longer fear competition from other woody plants.

Parallel and regularly spaced paths are opened among the seedlings to find your way around the plot, monitor the stand's progress, and allow access to the workers performing the clearings: they are called "partitions" or "silvicultural nets".

As the young trees grow, their branches come into contact, closing the canopy. They thus enter in **competition**.

Sapling stage

PARTITIONING

Intervention
in **cleaning-depressing**

Sapling stage (3 and 8 m high)
Canopy closing and self-pruning of stems
Manage competition between poles
Check the composition in species

5

As the stems compete, their lower branches are no longer sufficiently sunlit, and die. This is called **self-pruning.**

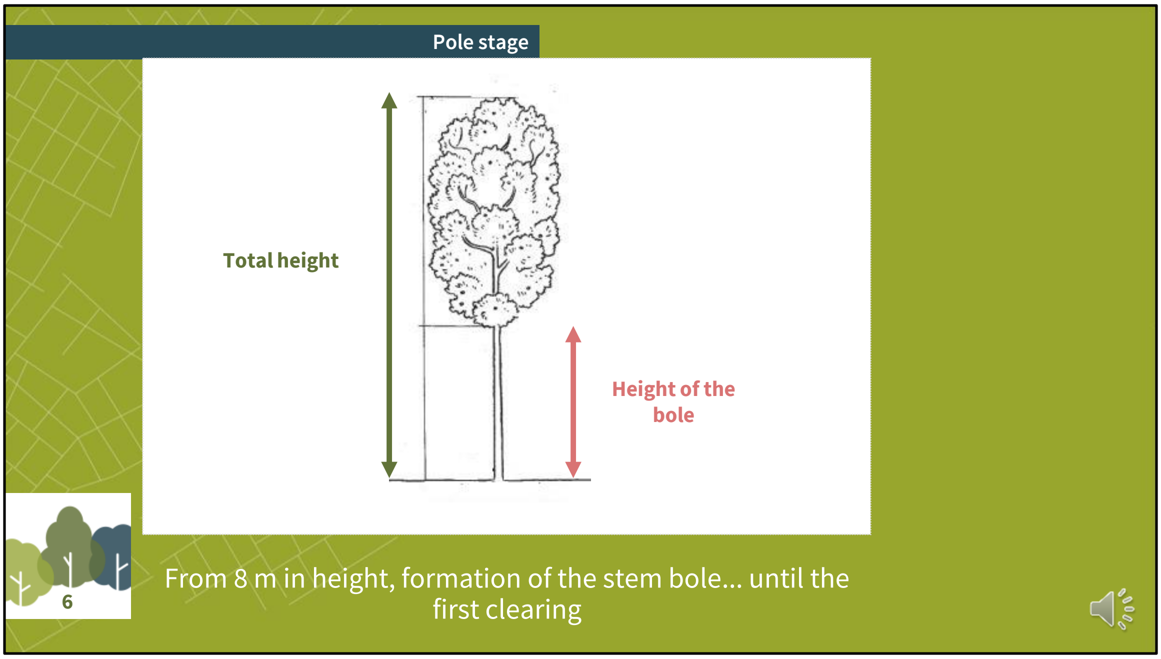
<u>Self-pruning allows the formation of the root ball, that branchless part of the trunk that is present in high forest trees, and provides timber.</u>

<u>For this reason, this period at the end of the youthful phase is called the log shaping period, or else qualifying period.</u>

The stand has thus reached the sapling stage and works of cleaning and thinning out can be initiated.

Cleaning consists essentially in eliminating poorly shaped stems which hinder the development of quality stems, and in adjusting the composition of the stand, in particular by favouring rare species.
Thinning out consists in decreasing stem density, where it is excessive, by favouring quality stems.

Because they are expensive, these cleaning and thinning operations must be limited to what is strictly necessary.



Pole stage

Total height

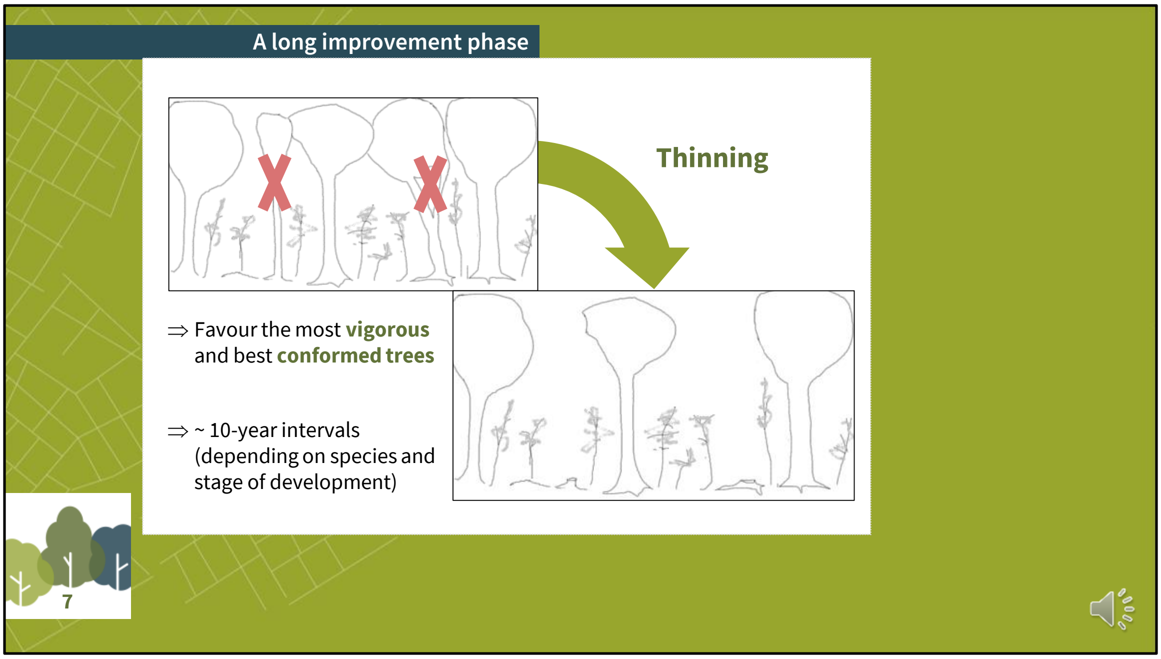
Height of the bole

From 8 m in height, formation of the stem bole... until the first clearing

This phase ends at the ***pole*** stage (from 8m high), with the onset of the first thinning.

This first thinning is triggered on criteria which depend on the species, typically reaching a certain dominant height, from which it is considered that the stem bole is of sufficient length.

The following interventions aim to accelerate stem growth by thinning for the benefit of quality stems.

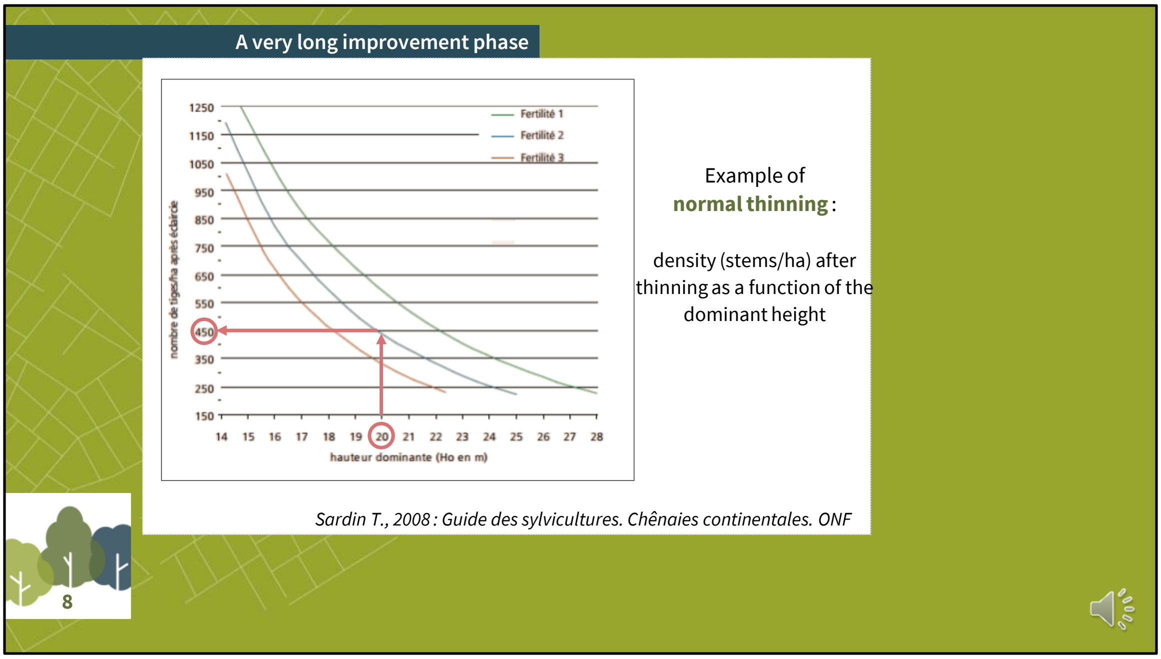


A long improvement phase

Thinning

- ⇒ Favour the most **vigorous** and best **conformed trees**
- ⇒ ~ 10-year intervals (depending on species and stage of development)

Then begins a very long phase, called **the improvement phase**, punctuated by thinning operations, consisting in removing stems to allow the harmonious development of vigorous and beautifully shaped stems, sufficiently well distributed. These thinning operations follow one another at variable intervals, ranging from 5 to 10 years, depending on the species and the stage of development.



A very long improvement phase

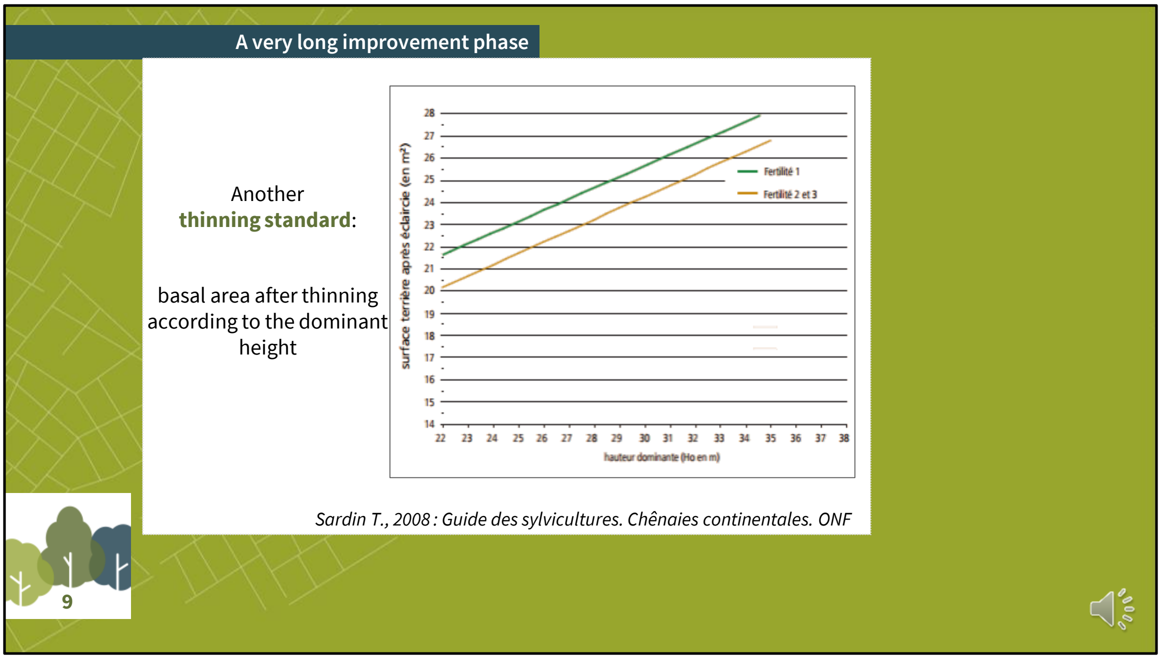
Example of **normal thinning** :

density (stems/ha) after thinning as a function of the dominant height

Sardin T., 2008 : Guide des sylvicultures. Chênaies continentales. ONF

Their intensity, and the choice of trees to conserve or harvest, require significant technical expertise. We will summarize it very briefly by presenting two examples of thinning standards.

The first one here (which concerns oak) gives the density of stems to seek according to the dominant height of the stand. As we see here, when the stand reaches 20m of dominant height, on a moderately fertile soil, thinning should reduce stem density to around 450 stems per hectare.



A very long improvement phase

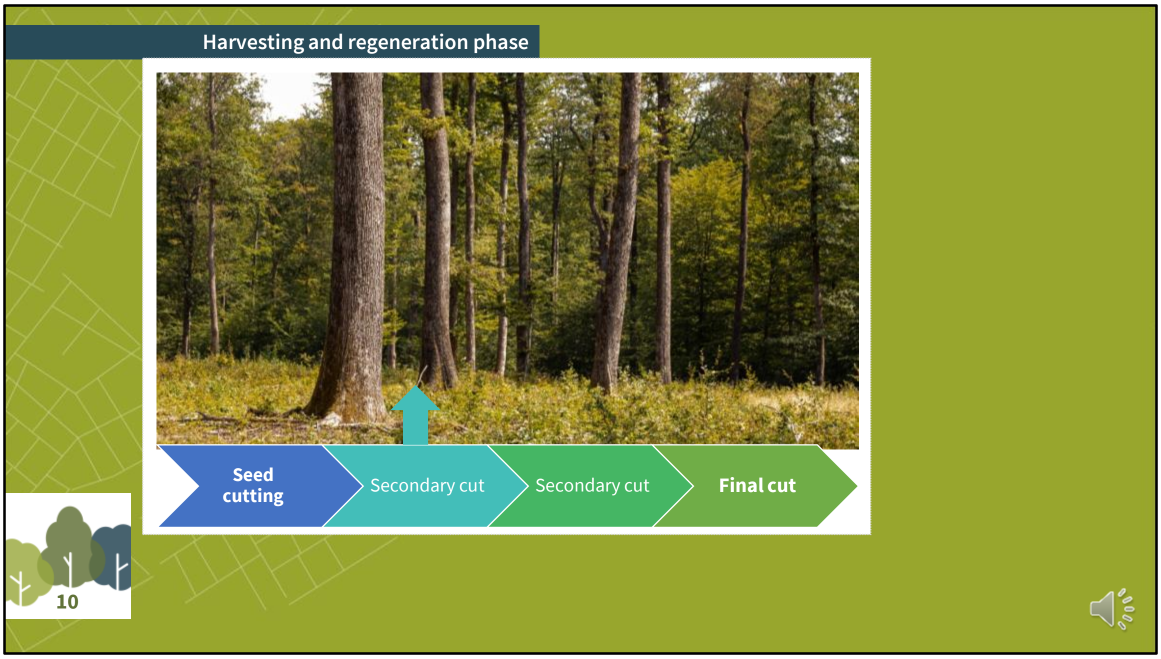
Another
thinning standard:

basal area after thinning
according to the dominant
height

Sardin T., 2008 : Guide des sylvicultures. Chênaies continentales. ONF

Here is a 2nd example of a thinning standard (still for oak), which describes the evolution of the stand beyond 22 m of dominant height, indicating the basal area to be reached, depending on the dominant height of the stand.

For maritime pine, 3 or 4 thinnings follow each other over 20 years, whereas for oak, more than 15 thinnings can take place over more than 100 years!



Harvesting and regeneration phase

Seed cutting

Secondary cut

Secondary cut

Final cut

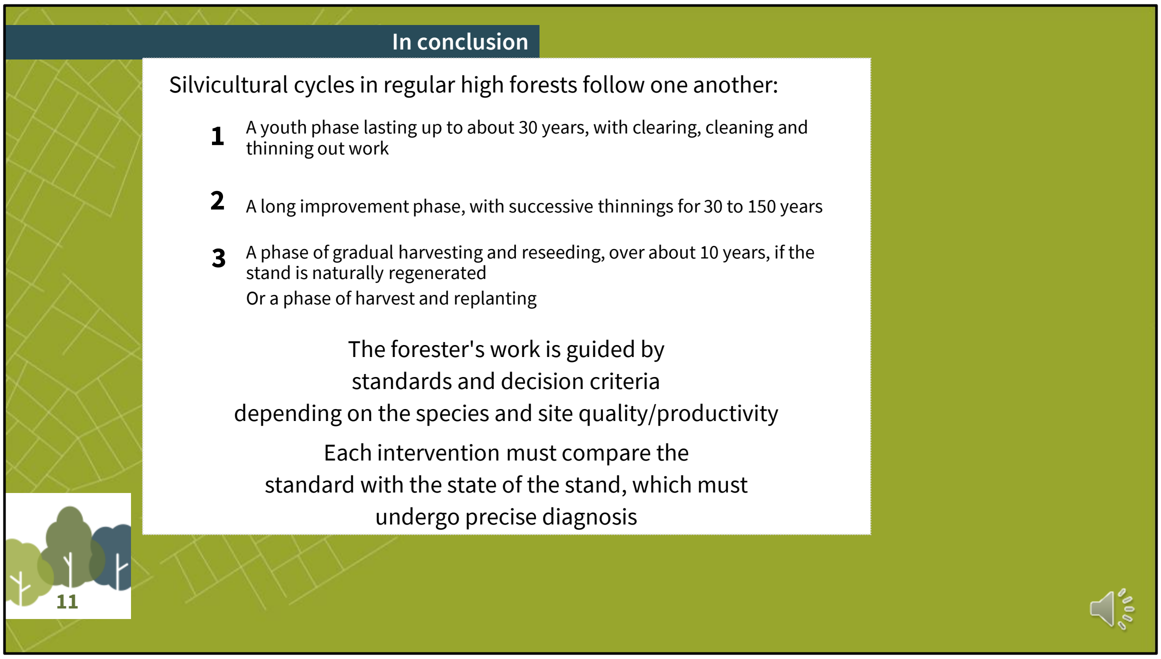
The improvement phase, which lasts from a few decades to more than a century depending on the species, ends with the harvest and regeneration phase, which we described during week 2 lesson 4, dedicated to forest renewal.

Harvest is triggered according to exploitability criteria, when the stand meets a certain age range or, more often, when stems reach a certain diameter range.

In natural regeneration, we will start by cutting the understorey and strong thinning – **seed cutting** - to allow light to reach the ground and tree crowns, to promote seed production.

Successive harvests, called **secondary cuts**, will gradually remove all the large trees as the seedlings are installed, until the **final cut.**

In the case of a plantation, the stand can be harvested in a single operation, called a clear cut. The natural regeneration of a plot thus extends over a variable period from one to several decades, depending on the species and the type of forestry.
The silvicultural cycle then starts again with a new youth phase (seedling installation).



In conclusion

Silvicultural cycles in regular high forests follow one another:

1 A youth phase lasting up to about 30 years, with clearing, cleaning and thinning out work

2 A long improvement phase, with successive thinnings for 30 to 150 years

3 A phase of gradual harvesting and reseeding, over about 10 years, if the stand is naturally regenerated
Or a phase of harvest and replanting

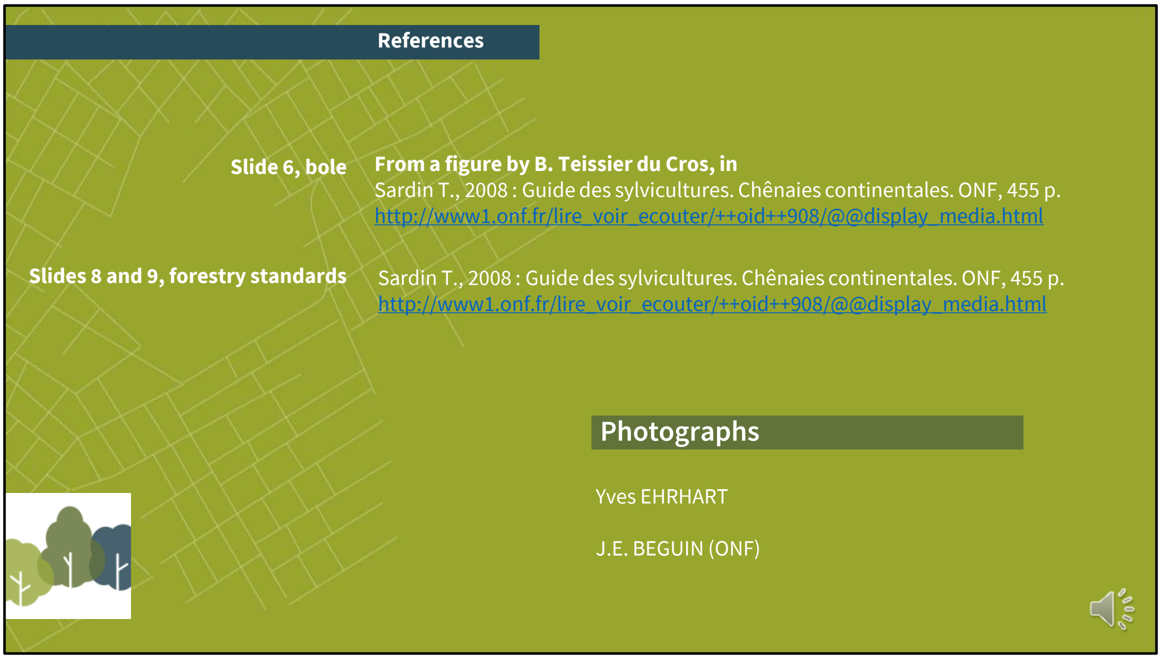
The forester's work is guided by
standards and decision criteria
depending on the species and site quality/productivity

Each intervention must compare the
standard with the state of the stand, which must
undergo precise diagnosis

Silvicultural cycles in regular high forests follow one another:

- -a youth phase, around 30 years, with clearing, cleaning and thinning out work,
- -A long phase of improvement, with successive thinnings for 30 to 150 years.
- A phase of gradual harvesting and reseeding, over about 10 years, if the stand is naturally regenerated
- -Or a phase of harvest and replanting.

All standards and criteria used depend of course on the species, but also on site quality/productivity, and of course on the forestry goals. They must steer the stand’s evolution with consistency. Each intervention must be regulated by comparing the standard with the reality of the stand, which must undergo a precise diagnosis.



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Slide 6, bole

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Sardin T., 2008 : Guide des sylvicultures. Chênaies continentales. ONF, 455 p.
http://www1.onf.fr/lire_voir_ecouter/++oid++908/@@display_media.html

Slides 8 and 9, forestry standards

Sardin T., 2008 : Guide des sylvicultures. Chênaies continentales. ONF, 455 p.
http://www1.onf.fr/lire_voir_ecouter/++oid++908/@@display_media.html

Photographs

Yves EHRHART

J.E. BEGUIN (ONF)

Thank you for your attention and see you soon!

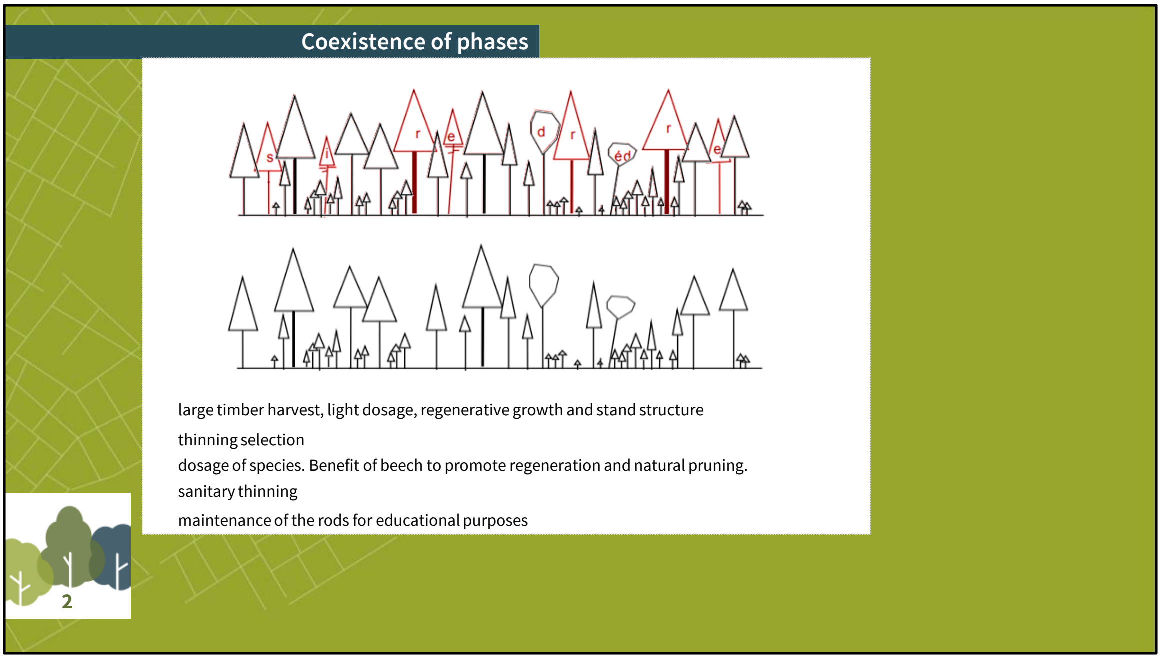
Week 3

Video 5

Silvicultural management of stands in (uneven-aged) irregular high forests

We have seen that stand management in regular high forests (Video 3 of this week) consisted in supporting a cohort of trees of approximately the same age during the different phases of its development, by managing stand density and selecting stems as they grow, until the last remaining stems reach the exploitability criteria.

Finally, we saw the importance of the renewal phase, which begins when we start regeneration and harvesting the final crop. But how about irregular high forests, when trees of all ages and sizes are found side by side in the same plot? This is what we are going to study today.



Coexistence of phases

large timber harvest, light dosage, regenerative growth and stand structure

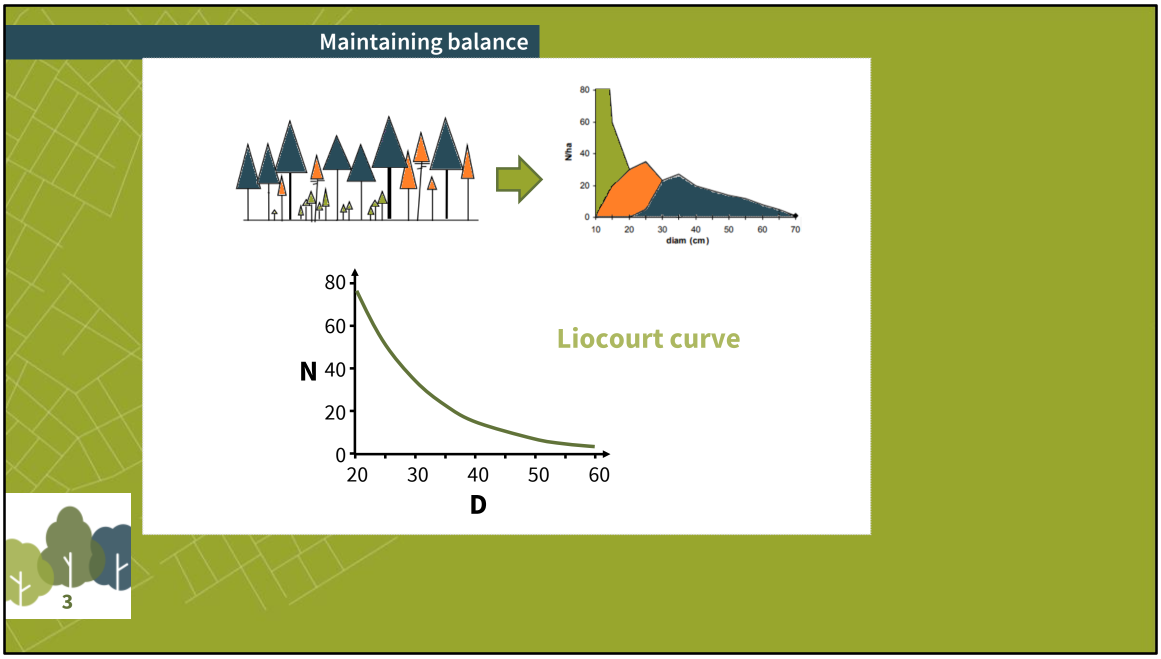
thinning selection

dosage of species. Benefit of beech to promote regeneration and natural pruning.

sanitary thinning

maintenance of the rods for educational purposes

In irregular high forests, the different phases of development and the related actions take place simultaneously in the same plot: the forester harvests mature trees, thins the growing stems, and at the same time ensures and cares for regeneration by working on seedlings.



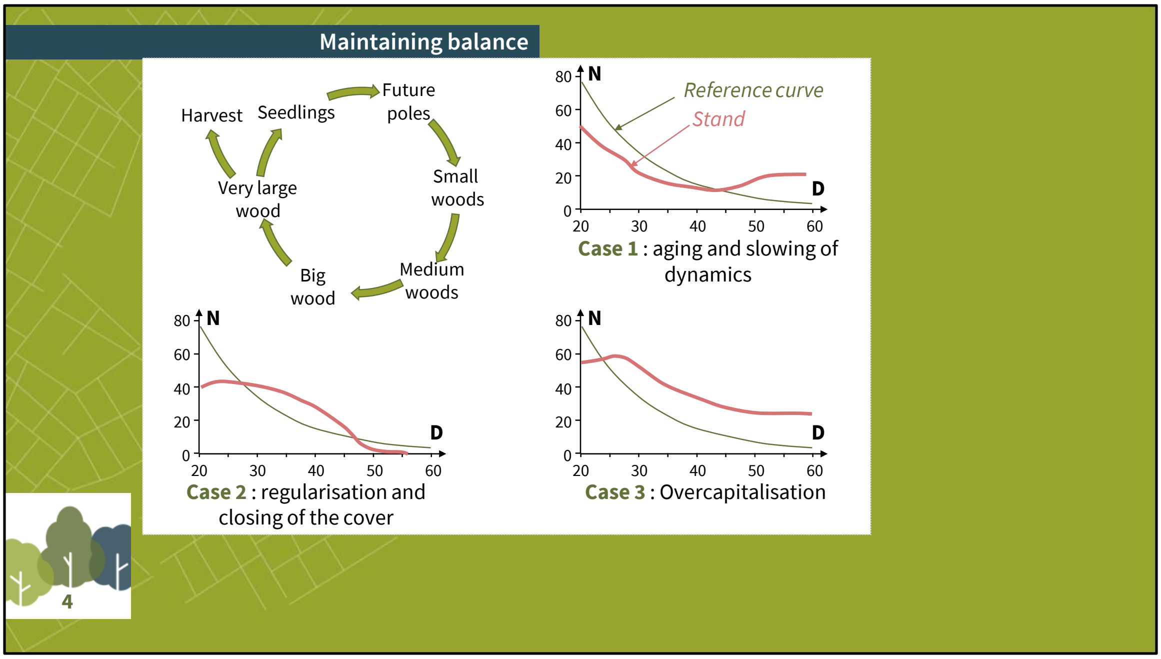
Maintaining balance

Liocourt curve

Then, the silvicultural management of the stand consists in measuring these actions, so that the system is maintained in an equilibrium zone, the principle being to permanently have growing stems to replace mature harvested trees, and seedlings that settle and develop into growing trees.

The right balance between different categories of trees is generally established empirically, and depends on the species, natural conditions and forestry objectives (including harvest criteria). This target balance can be formalised in different ways.

One of them is a curve defining the number of stems from each diameter category to keep after intervention. This standard, called the **Liocourt curve**, is in fact very theoretical, but it shows that in irregular and regular forests, a large number of seedlings are required to obtain a pole, and a large number of poles to obtain a crop tree, and so on.
This is shown in the top diagram, which represents a less theoretical stand where regeneration is in green, stems growing in height are in orange and canopy trees, growing in diameter, are in blue. (phrase rajoutée, dans l'audio mais non transcrite, souhaitez-vous la garder ?)



Case 1 : aging and slowing of dynamics

Case 2 : regularisation and closing of the cover

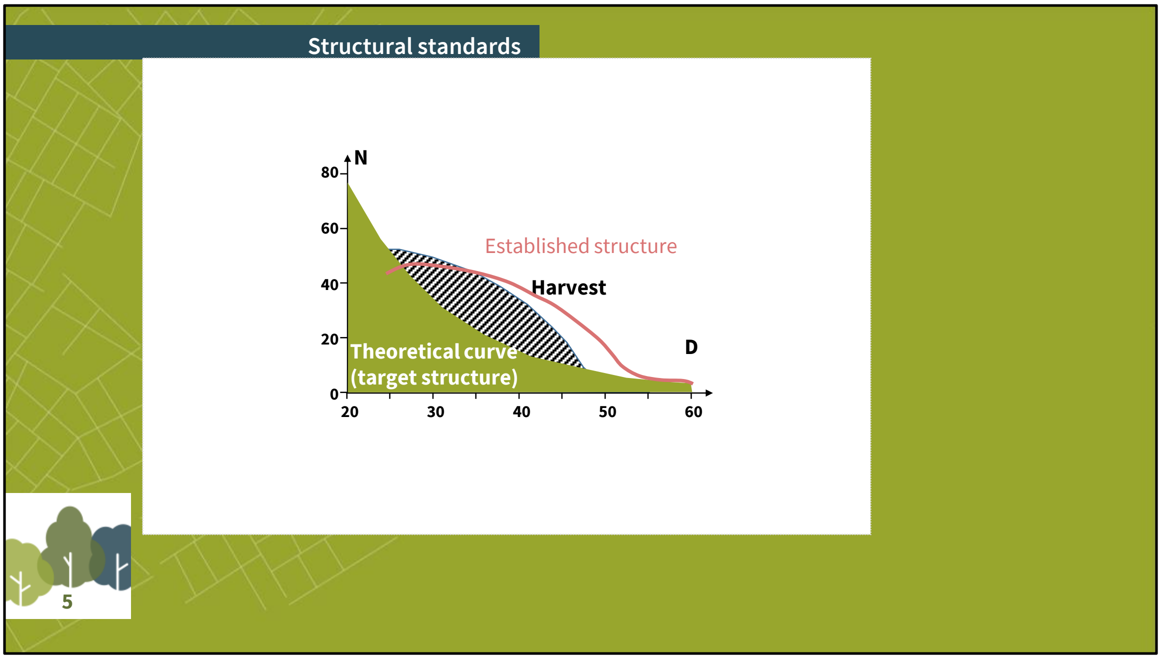
Case 3 : Overcapitalisation

If the harvest of mature trees is not active enough, the entire stand's dynamics is slowed down and young stems' growth may be slowed down or even compromised. This is illustrated in **case n#1**

If the forester focuses on medium-sized, growing stems, by anticipating the harvest of mature trees, then the stand risks becoming regular, depriving the forester of an important advantage in irregular high forests which is the optimisation of the harvest age tree by tree, shown here in **case n#2**

In any case, if the forester doesn't harvest enough trees, the lack of light penetration into the stand may hinder the establishment of seedlings and the recruiting of new stems. case **n#3**

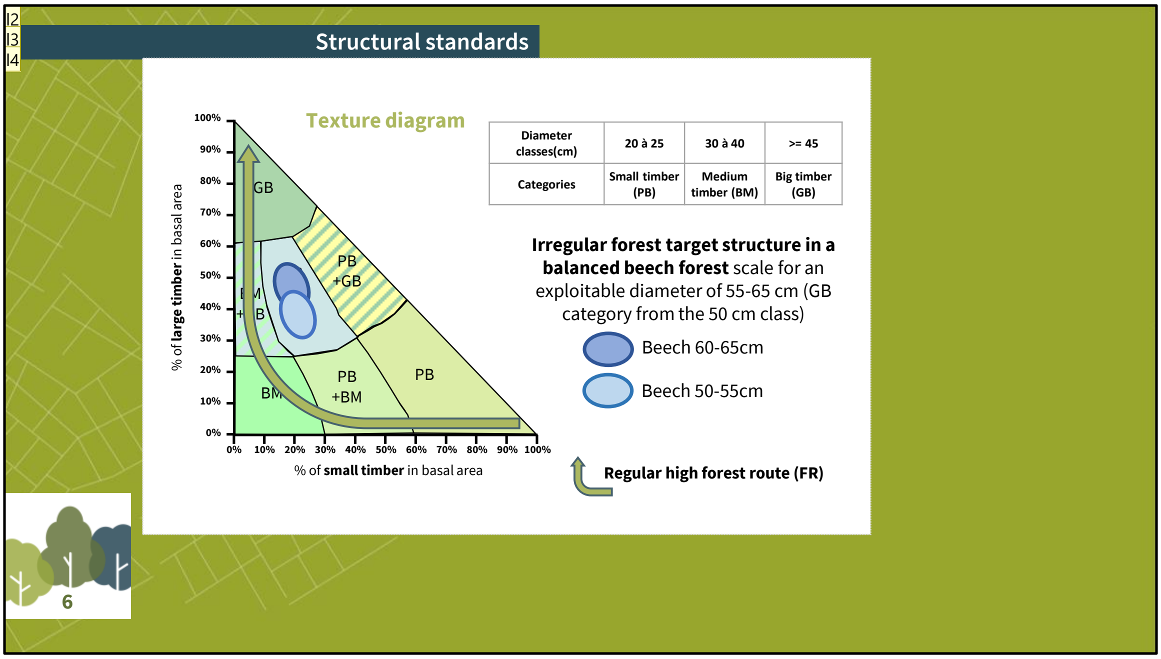
Finally, if the forester doesn't do enough thinning in growing stems, it may run out of vigorous, quality stems capable of supporting future harvests.



Structural standards

To maintain this balance, the forester has tools and management standards which differ from those in regular high forest. We just saw Liocourt's famous theoretical standard, proposed in 1901 as a standard for fir selection forests, which theoretically defines the density of different diameter stems to be sought in selection forests.

In the example you see, comparing the stand’s state with the theoretical curve leads to harvesting timber medium timber, with a diameter ranging between 30 and 45 cm.



Structural standards

Diameter classes(cm)	20 à 25	30 à 40	>= 45
Categories	Small timber (PB)	Medium timber (BM)	Big timber (GB)

Irregular forest target structure in a balanced beech forest scale for an exploitable diameter of 55-65 cm (GB category from the 50 cm class)

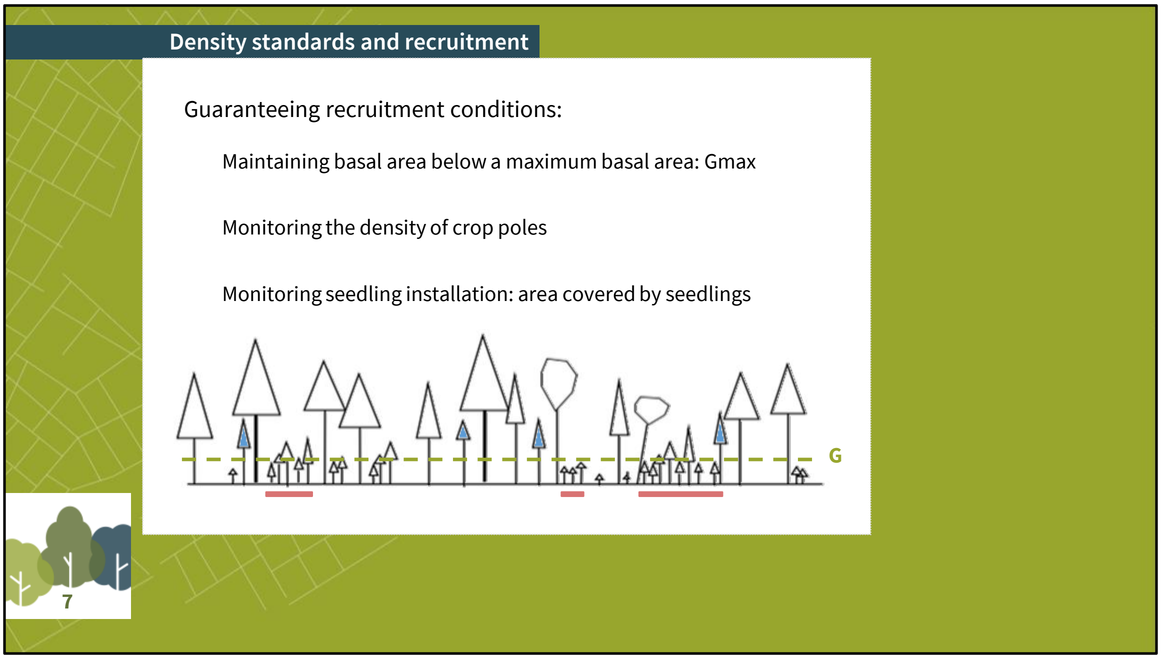
- Beech 60-65cm
- Beech 50-55cm

Regular high forest route (FR)

Here is another example of a more pragmatic formalisation, developed in the context of an irregular deciduous forest resulting from a management coppice with standards. This representation uses a "texture diagram“: on the x-axis, you will find the proportion of basal area occupied by small timber, and on the y-axis the proportion occupied by large timber.

The stand’s composition in trees of different sizes occupying different strata is called **"structure"**. The target structure is defined in this diagram by a certain position range in the diagram.

The two blue circles you see here show two significantly different target ranges depending on the target exploitability diameter.



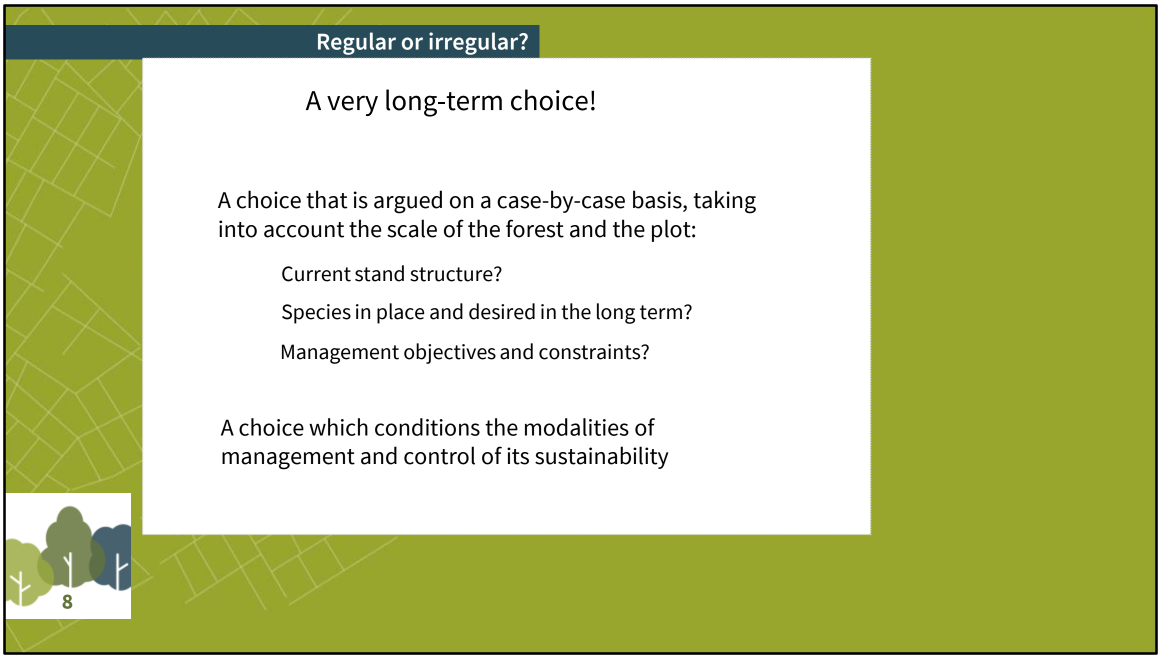
Density standards and recruitment

Guaranteeing recruitment conditions:

- Maintaining basal area below a maximum basal area: Gmax
- Monitoring the density of crop poles
- Monitoring seedling installation: area covered by seedlings

However, these structural standards are not enough.
It’s also necessary to keep an eye on the overall stand’s density, which should remain relatively clear, by monitoring the basal area. Indeed, excessive basal area could lead to gradual canopy closure, and hinder seedling installation. It’s also likely that by the time these problems are noticed, considerable time will have been lost, and the stand will have deviated from the targeted structure, making it very difficult to make up for the shortfall.

This is why we generally also follow direct indicators of renewal, in particular the density of crop poles, as well as the surface occupied by seedlings.



Regular or irregular?

A very long-term choice!

A choice that is argued on a case-by-case basis, taking into account the scale of the forest and the plot:

- Current stand structure?
- Species in place and desired in the long term?
- Management objectives and constraints?

A choice which conditions the modalities of management and control of its sustainability

Obviously, when a forest manager opts for a regular or irregular management system, it is for the long term! How does he make his choice?

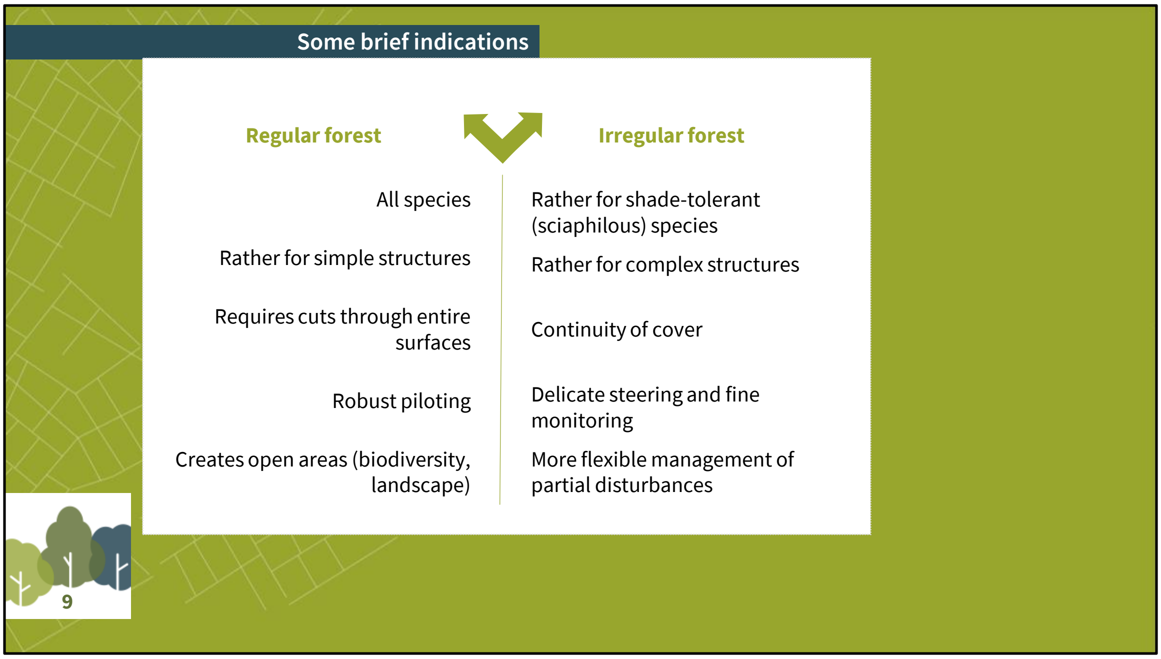
The respective merits of regular or irregular high forests is a question that has fascinated the forestry world for a long time (have fun starting the subject during a foresters meal and you can finish the entire meal quietly while your guests discuss!).

On a more serious note, this is a choice that is binding for the very long term: any change in structure takes a very long time, and has a cost, which must be justified. Changing a regular stand into an irregular one and vice versa will require delaying the harvest of some stems, hastening the harvest of others - resulting in risks and "exploitability sacrifices".

Like all forestry decisions, this choice is not to be made at a general level, it needs to be integrated to a complete and concrete diagnosis of the natural and human context of both the stand and the forest. Which species are in place or do we want to promote in the long term? What is the current structure of the stands? What are the management objectives and constraints?

Finally, as you can begin to see, it is a choice that conditions subsequent management methods, in particular the control of its sustainability.

By way of illustration, know that many stands today in eastern France are still very marked by coppice management under high forest (TSF), an approach that we have not detailed, consisting in managing the mixed stand, part in high forest, part in coppice. However, management in coppice under high forest has been abandoned in favor of high forest for roughly a century. PAS DIT DANS L’AUDIO



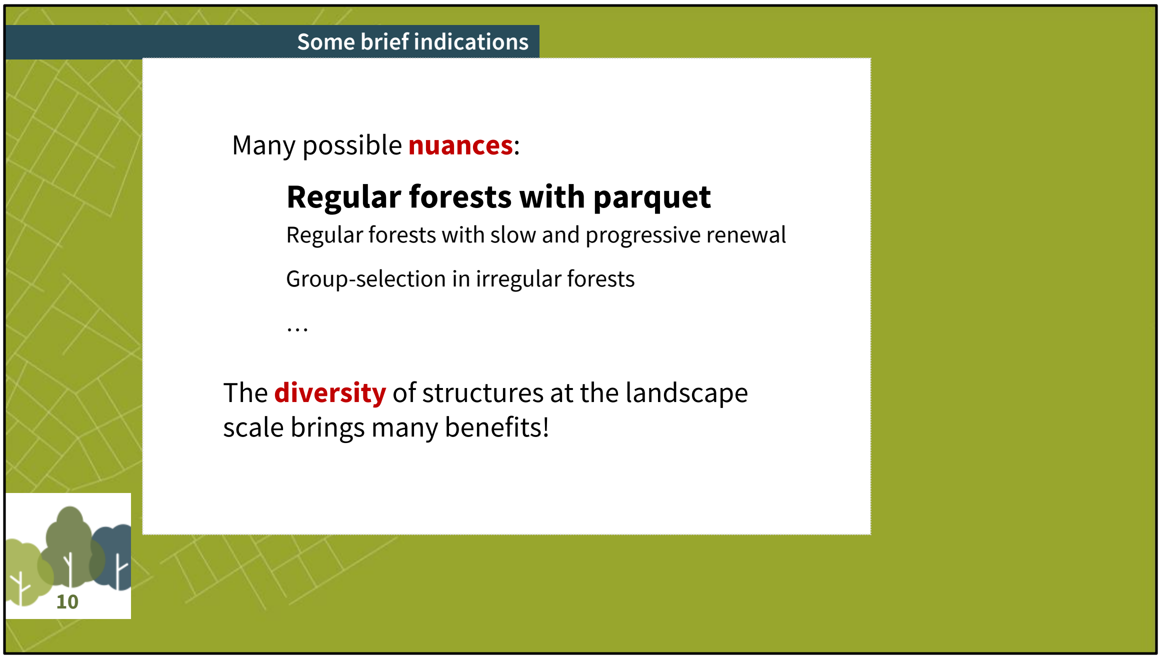
Some brief indications

Regular forest	Irregular forest
All species	Rather for shade-tolerant (sciaphilous) species
Rather for simple structures	Rather for complex structures
Requires cuts through entire surfaces	Continuity of cover
Robust piloting	Delicate steering and fine monitoring
Creates open areas (biodiversity, landscape)	More flexible management of partial disturbances

Even if no species composition excludes an irregular high forest management, structure stability is easier to obtain with shade-tolerant species (sciaphilous). Indeed, with light-demanding species, there is a much greater risk that the regeneration rate will be too slow and insufficient.

Finally, depending on the constraints and the management objectives, a system can have advantages or disadvantages: advantage of keeping continuous cover, for irregular high forests, but disadvantage of requiring demanding monitoring, at the risk of losing control of the forest structure or composition. On the other hand, regular high forests benefit from safe piloting, interest in favouring heliophytes such as oak, or even promoting biodiversity associated with open habitats.

Finally, local traditions, associated with species and history, are more or less familiar with certain management systems: regular high forests of oak groves in the western plains, and irregular high forests in the Jura fir forest, for example. The two systems, in similar natural conditions and identical species, can lead to quite different forest landscapes.



Some brief indications

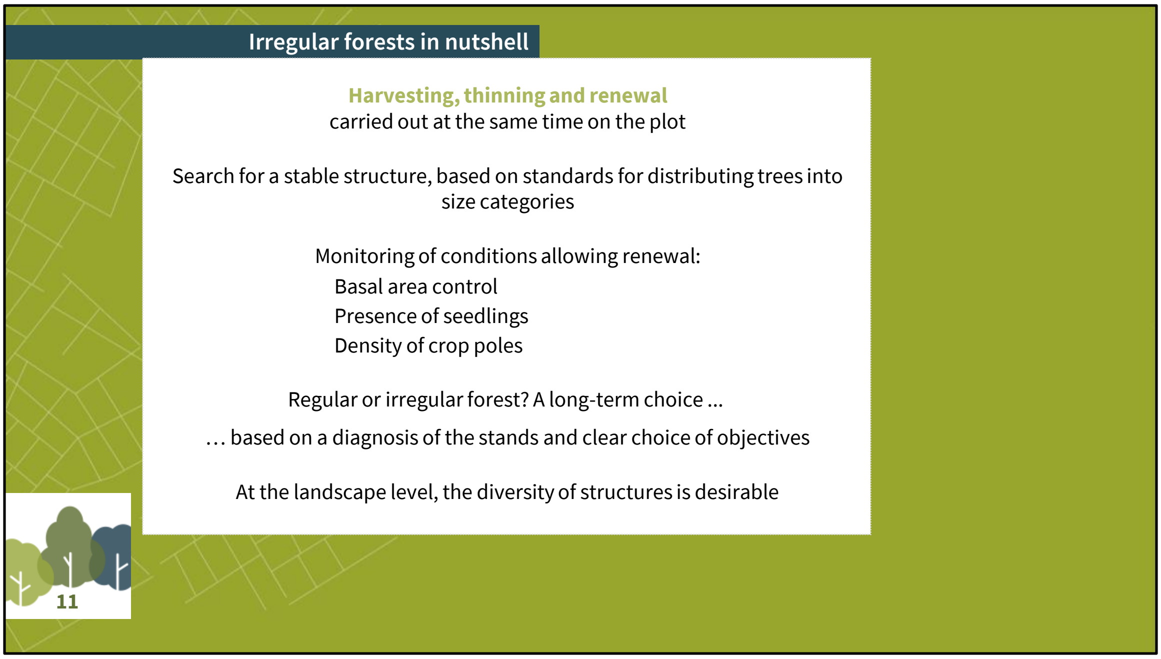
Many possible **nuances**:

- **Regular forests with parquet**
- Regular forests with slow and progressive renewal
- Group-selection in irregular forests
- …

The **diversity** of structures at the landscape scale brings many benefits!

We must remember that there are many nuances which create a quasi-continuum between the two systems, with, for example, regular high forest systems with slow and progressive regeneration by ***parquet***, or of group-selection in irregular high forests.

Finally, it is important to keep in mind that the diversity of systems and structures on a landscape scale brings many benefits, especially in ecological and landscape terms.



Irregular forests in nutshell

Harvesting, thinning and renewal
carried out at the same time on the plot

Search for a stable structure, based on standards for distributing trees into size categories

Monitoring of conditions allowing renewal:
- Basal area control
- Presence of seedlings
- Density of crop poles

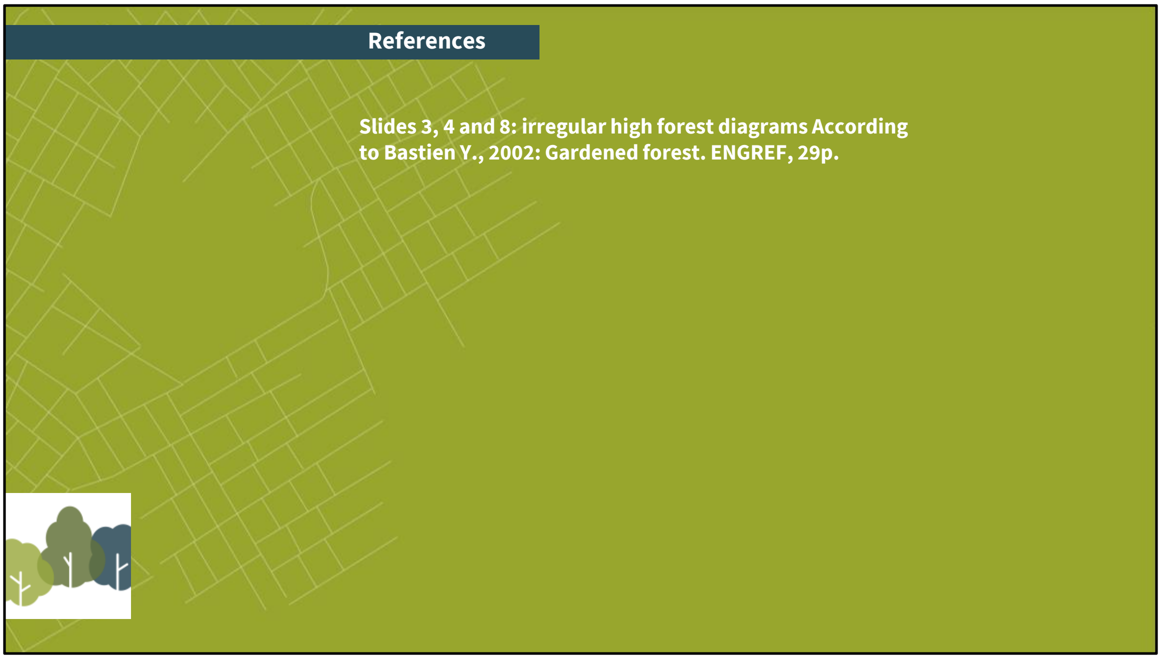
Regular or irregular forest? A long-term choice ...

… based on a diagnosis of the stands and clear choice of objectives

At the landscape level, the diversity of structures is desirable

In irregular high forests, harvesting, thinning and renewal operations are carried out simultaneously on the plot. The search for a stable structure is based on standards, making it possible to help balance the different tree sizes, to ensure that a stand is maintained sufficiently opened to allow the acquisition of regeneration, and finally to follow continuous seedling installation and effective development of regeneration.

The choice of sylvicultural system, regular or irregular, is made for the long term, at the forest scale, and is based on an analysis of the environment, the stand and the management objectives and constraints. A diversity of management methods at the landscape-scale, or of a large forest property, presents many ecological and landscape benefits.



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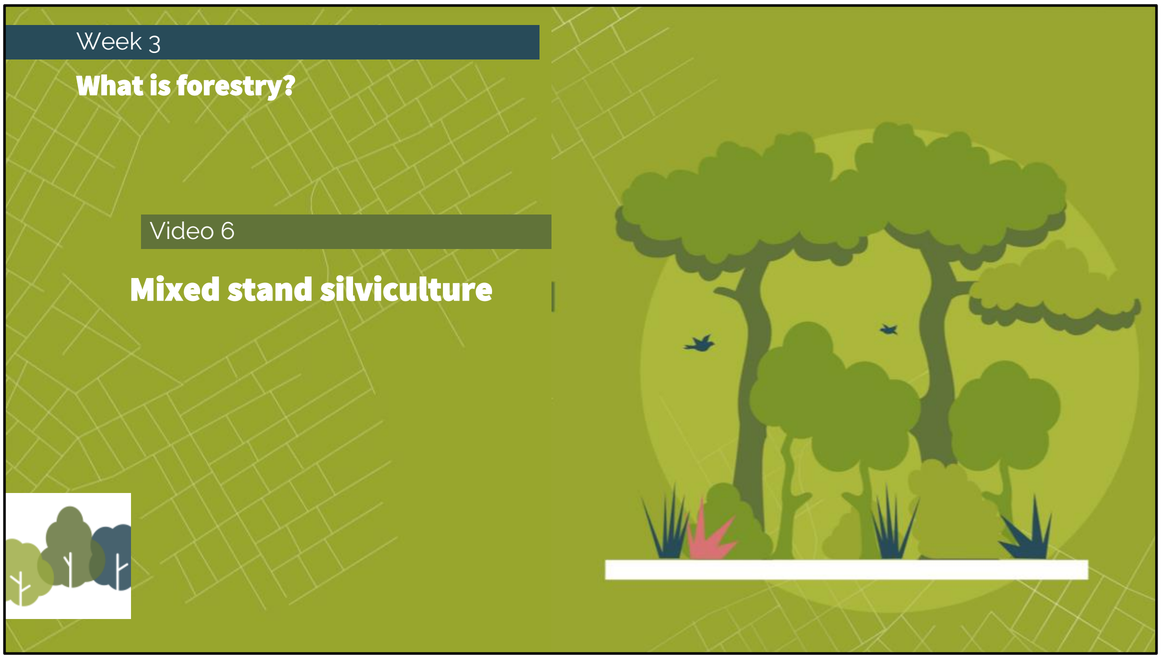
Slides 3, 4 and 8: irregular high forest diagrams According to Bastien Y., 2002: Gardened forest. ENGREF, 29p.

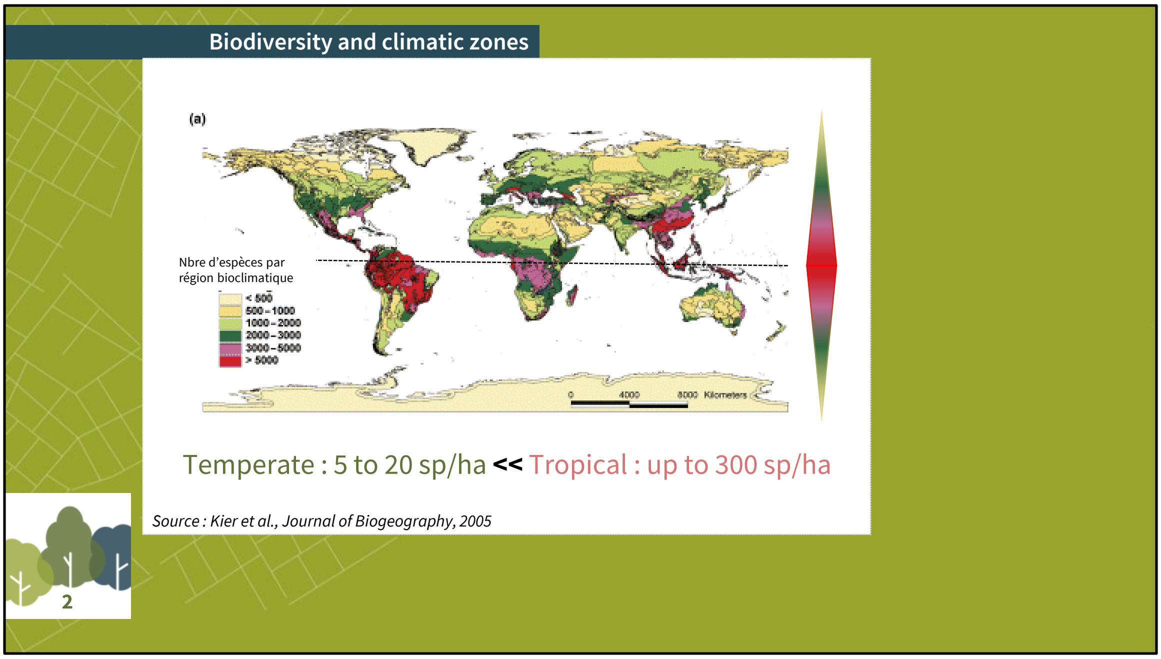


Week 3

What is forestry?

Video 6

Mixed stand silviculture



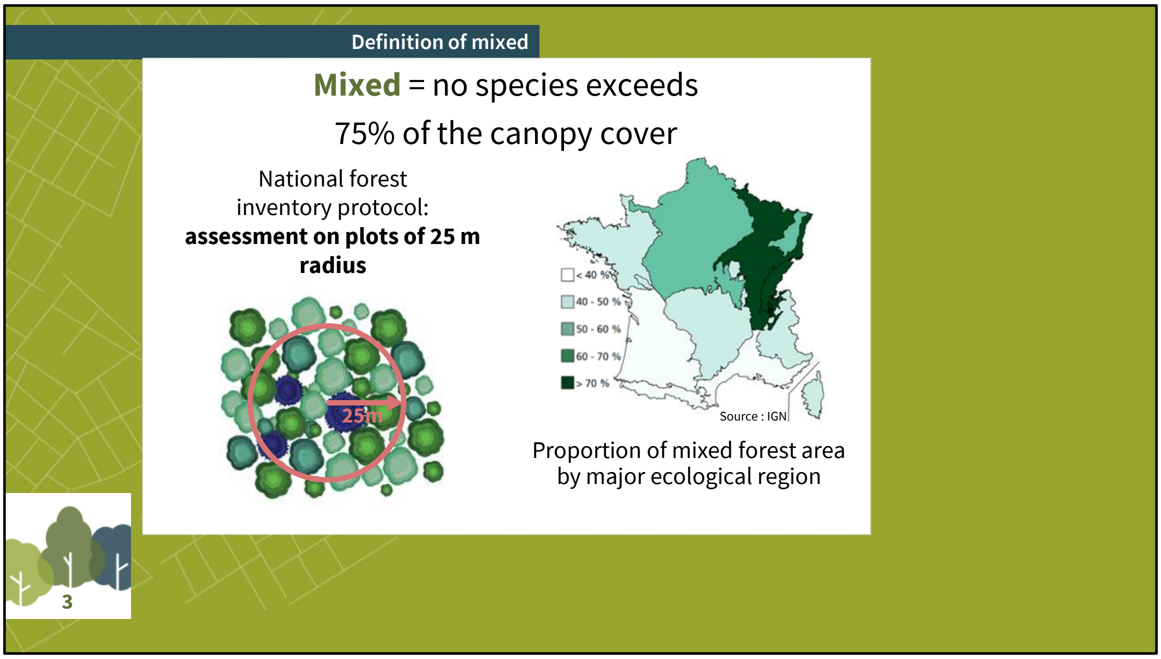
Biodiversity and climatic zones

Temperate : 5 to 20 sp/ha **<<** Tropical : up to 300 sp/ha

Source : Kier et al., Journal of Biogeography, 2005

We saw during week 2 that the biodiversity of forests varied according to major climate types. The same is true if we consider the diversity of tree species in the canopy.

Thus, in one hectare of forest, you will be able to count up to 300 species of trees in the Guiana forest, against 20 to 40 in a warm temperate forest in the Appalachians, and rather around 10 in Europe. Nevertheless, even though the number of mixed tree species in our European forests is limited, they are frequently mixed - and that will be the subject of this last lesson on forestry.



Definition of mixed

Mixed = no species exceeds 75% of the canopy cover

National forest inventory protocol: **assessment on plots of 25 m radius**

Source : IGN

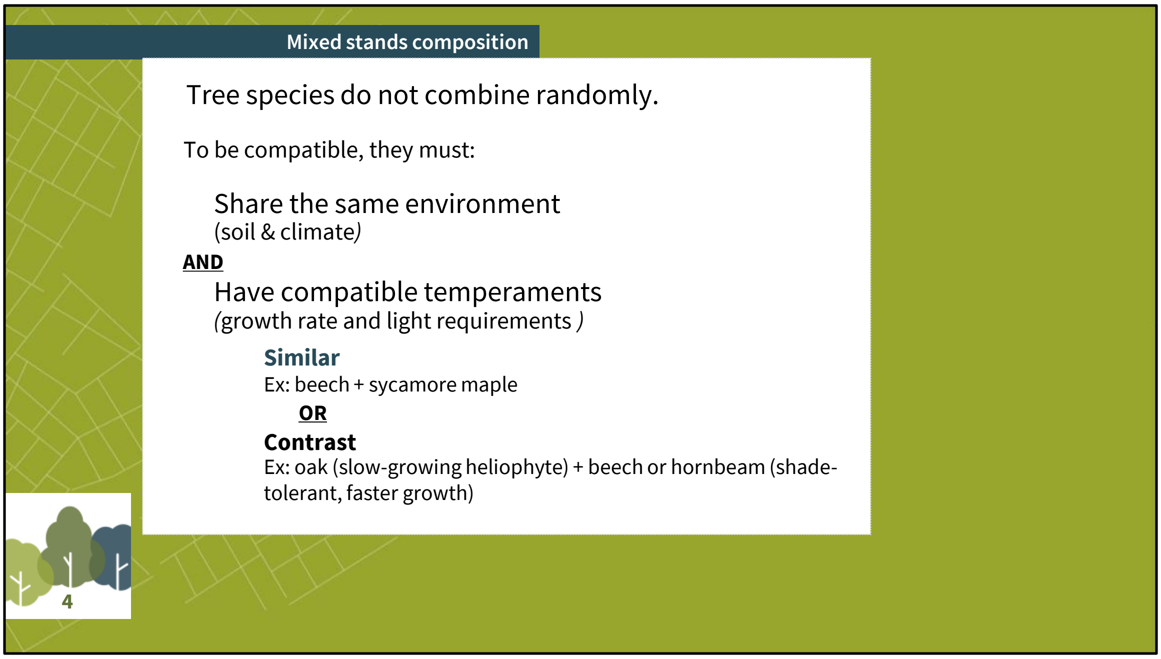
Proportion of mixed forest area by major ecological region

First of all, in order to consider a mixed stand, several species must reach the top of the canopy in significant proportions. According to the national forest inventory, a stand is considered mixed when no single species reaches **75% of the canopy**.

This is a challenging definition. For example, an oak stand with a beech understory would not be considered a mixed stand. So even if beeches make up 20% of the overstory cover, it would be considered a lowland stand with oak dominance, not a mixed stand.

Applying this criterion to plots measuring 25 m in radius, the forest inventory considers that half of the forest stands in France are mixed, with differences depending on the region.

The forests of the northeast quarter of France being the most mixed, as you can see on this map.



Mixed stands composition

Tree species do not combine randomly.

To be compatible, they must:

Share the same environment
(soil & climate*)*

AND

Have compatible temperaments
*(*growth rate and light requirements *)*

Similar
Ex: beech + sycamore maple

OR

Contrast
Ex: oak (slow-growing heliophyte) + beech or hornbeam (shade-tolerant, faster growth)

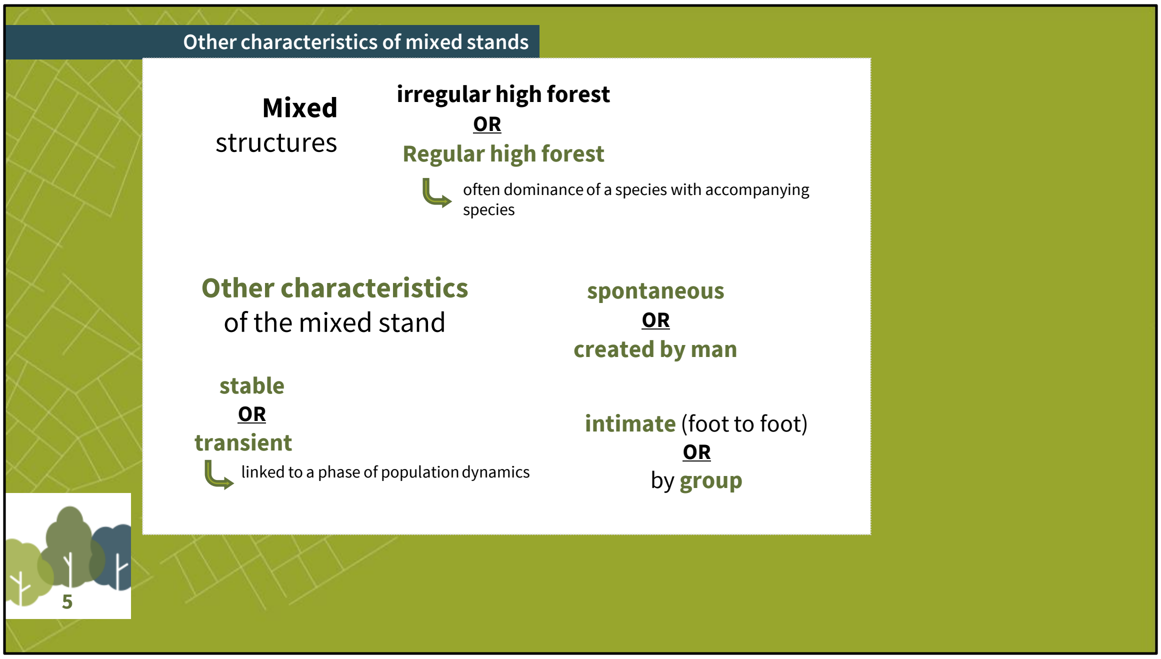
We cannot mix species randomly!

An inappropriate mixture quickly converts to a pure stand by eliminating the species least suited to the conditions thus created. The growth rate and light requirements of the components of the mixture must be compatible.

Thus, if the species have comparable growth rates, their light requirements must also be comparable.

An example of this type of mixture is that of beech with hornbeam, or with large maples.

If the growth rates of the species that constitute the mixture are very different, then they must also have contrasting light requirements. This is the case with the mixture of oak (slow growth and fairly high light requirements), with beech or hornbeam (faster growth and less light requirements), a mixture which is not stable without human intervention.



Other characteristics of mixed stands

Mixed structures

irregular high forest

OR

Regular high forest

↳ often dominance of a species with accompanying species

Other characteristics of the mixed stand

spontaneous

OR

created by man

stable

OR

transient

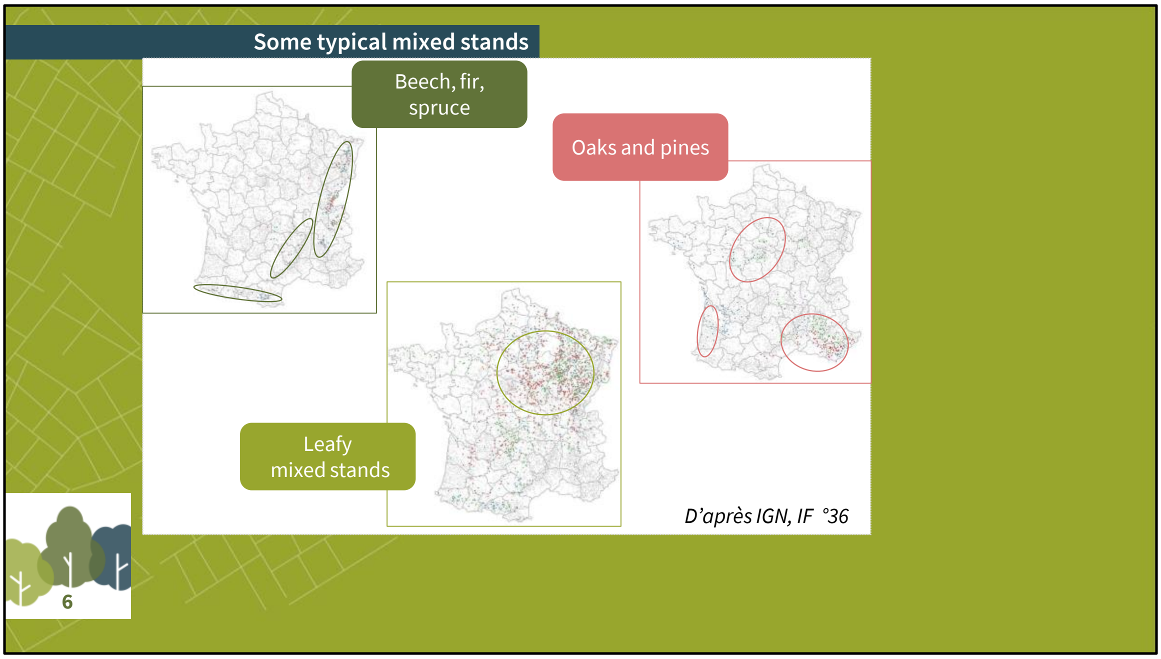
↳ linked to a phase of population dynamics

intimate (foot to foot)

OR

by **group**

Tree species can mix in regular or irregular structures, the regular structures however more often present associations where one species dominates, accompanied by one or more secondary species. The mix can be intimate, foot by foot, or by groups of trees. Mixing can be temporary, that is, only exist during a certain phase in the life of the stand, or it can be stable.



Some typical mixed stands

Beech, fir, spruce

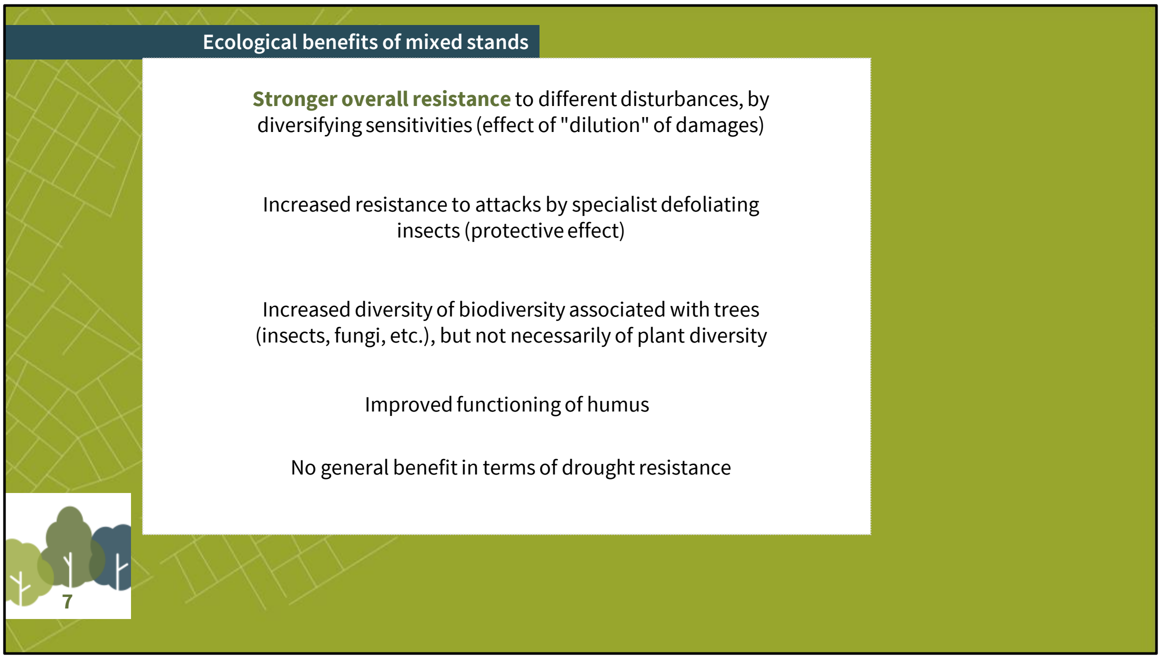
Oaks and pines

Leafy mixed stands

D'après IGN, IF °36

Here are some examples of mixed stands typical of our forests:

- The mixture of beech, fir, spruce, characteristic of European mountain regions
- The mixture of oaks and pine is found in many variations, for example sessile oak and Scots pine in the plains of the Paris Basin or holm oak and Aleppo pine in the Mediterranean forest. Oak and pine combine more in groups than foot by foot;
- Mixed stands of hardwoods: oak, beech, maple, fruit trees in the North Eastern plateaus.



Ecological benefits of mixed stands

Stronger overall resistance to different disturbances, by diversifying sensitivities (effect of "dilution" of damages)

Increased resistance to attacks by specialist defoliating insects (protective effect)

Increased diversity of biodiversity associated with trees (insects, fungi, etc.), but not necessarily of plant diversity

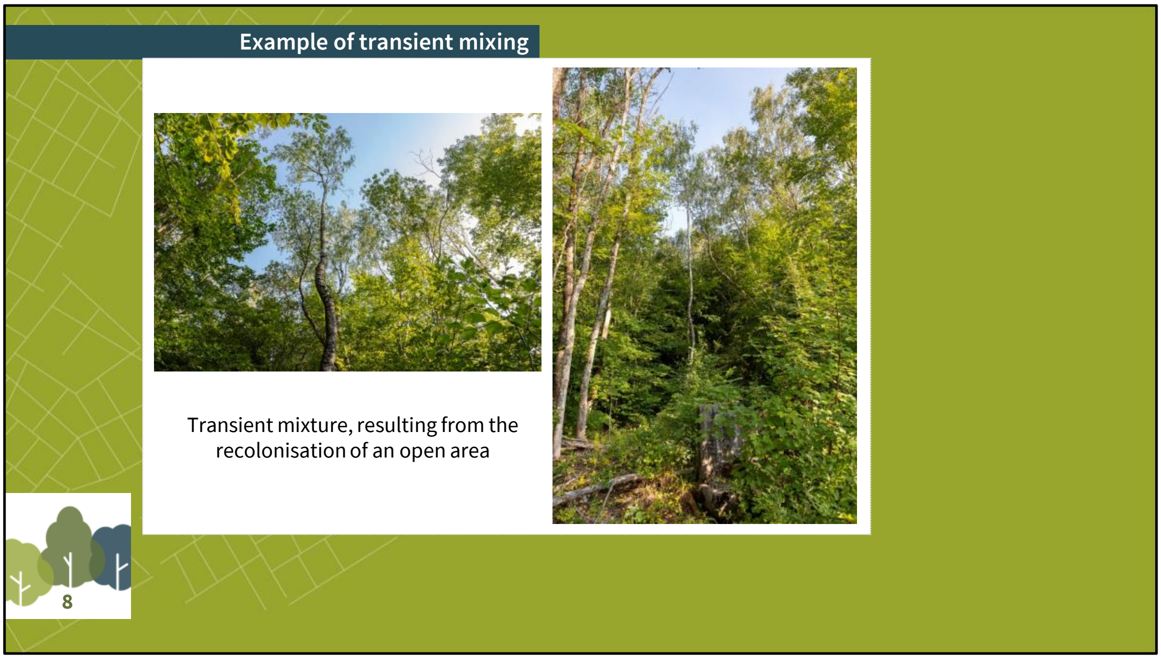
Improved functioning of humus

No general benefit in terms of drought resistance

What are the benefits of the mixed stand?
In general, there is less risk of the entire stand being destroyed by any disturbance, thanks to the differences in sensitivity and behaviour of the species. You could call this a dilution effect, as the damage rarely affects all species at once.

In some cases, such as an attack by a specialist defoliator insect, the mixed nature of the stand can even mitigate the damage to the species consumed, this time providing some protection to that species.

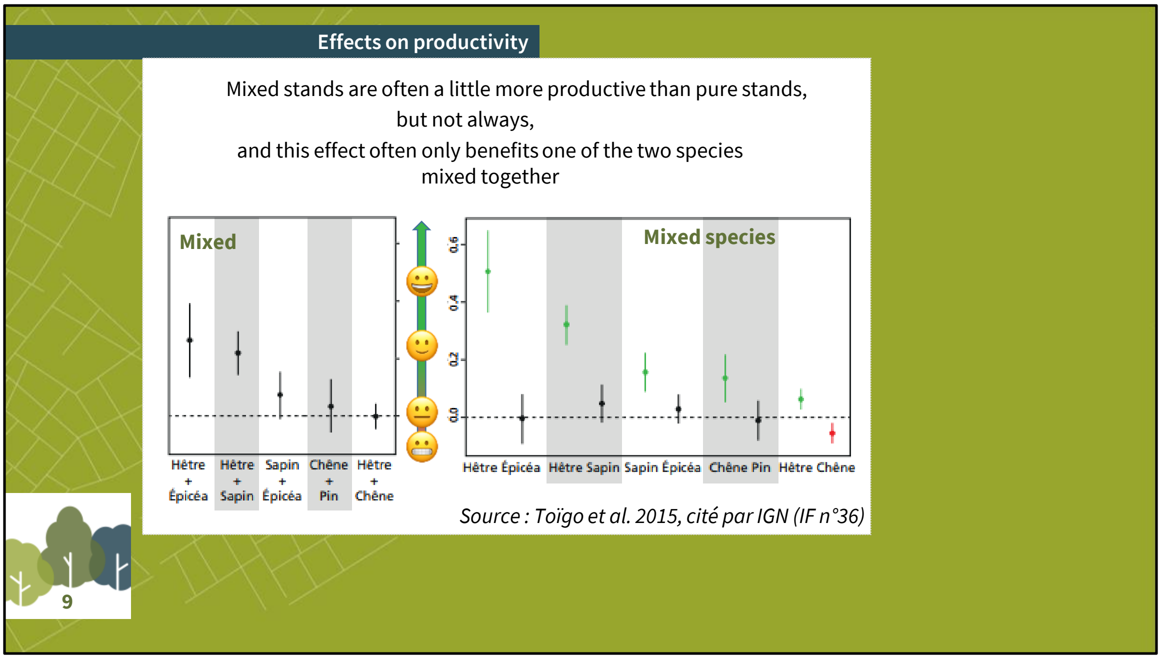
The diversity of insects and fungi and the functioning of humus can be favoured, and the diversity of litter, that is to say leaves that fall and get incorporated in the humus, can improve the functioning of the humus and recycling of mineral elements. On the other hand, mixed stands are generally not more resistant to drought than pure stands, and therefore cannot constitute a unique solution for adaptation to climate change.



Example of transient mixing

Transient mixture, resulting from the recolonisation of an open area

Here is an example of spontaneous and transient mixing resulting from the recolonisation of an open area.



Effects on productivity

Mixed stands are often a little more productive than pure stands,
but not always,
and this effect often only benefits one of the two species
mixed together

Source : Toïgo et al. 2015, cité par IGN (IF n°36)

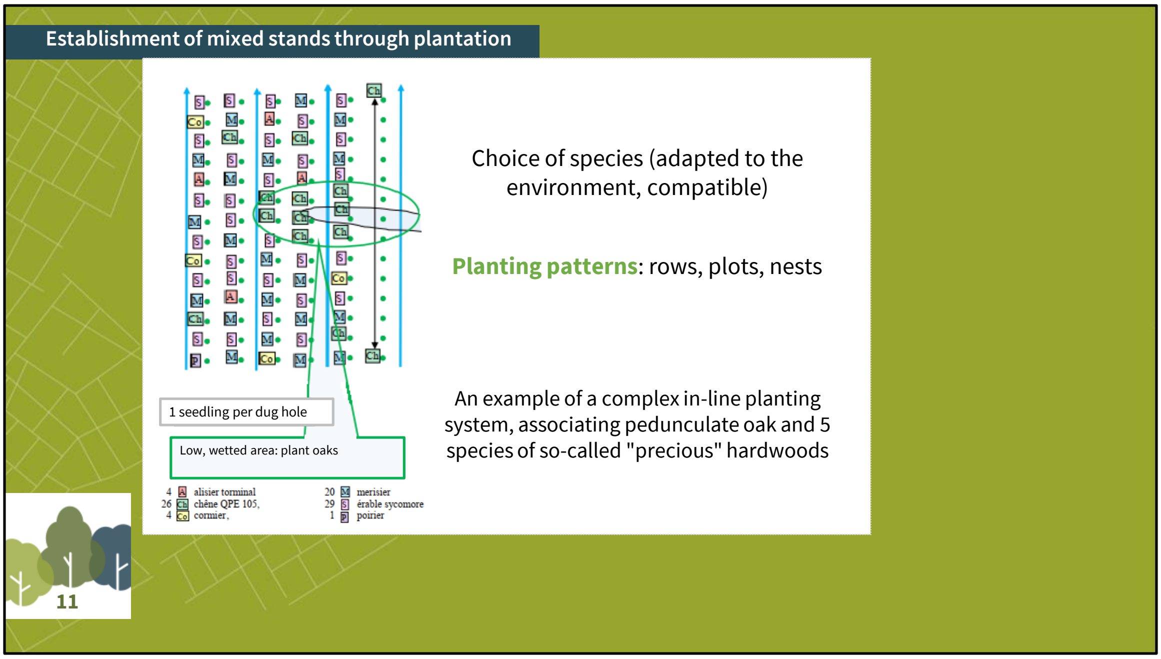
These differences in behavior between mixed species often allow trees to compete with each other a little less and thus use resources more efficiently. Mixed stands are therefore often slightly more productive than pure stands of the same species.

This is shown in the graph on the left, with a greater effect on the beech-spruce mixture, and no effect on the beech-oak mixture. But this is not always the case, and if we look closely at what happens in these stands, we generally find that the mixture favors the growth of only one of the two species. This is shown in the graph to the right, where we see that mixing beech and spruce actually benefits only the growth of the beech.

Some species, capable of enriching the soil in nitrogen, can directly promote the growth of other species in a mixed stand. For example, this is the case with alder when it is associated with ash.

Aesthetic and landscape interest

Mixed stands are widely valued for their aesthetics and their ability to form beautiful landscapes.



Establishment of mixed stands through plantation

Choice of species (adapted to the environment, compatible)

Planting patterns: rows, plots, nests

1 seedling per dug hole

Low, wetted area: plant oaks

An example of a complex in-line planting system, associating pedunculate oak and 5 species of so-called "precious" hardwoods

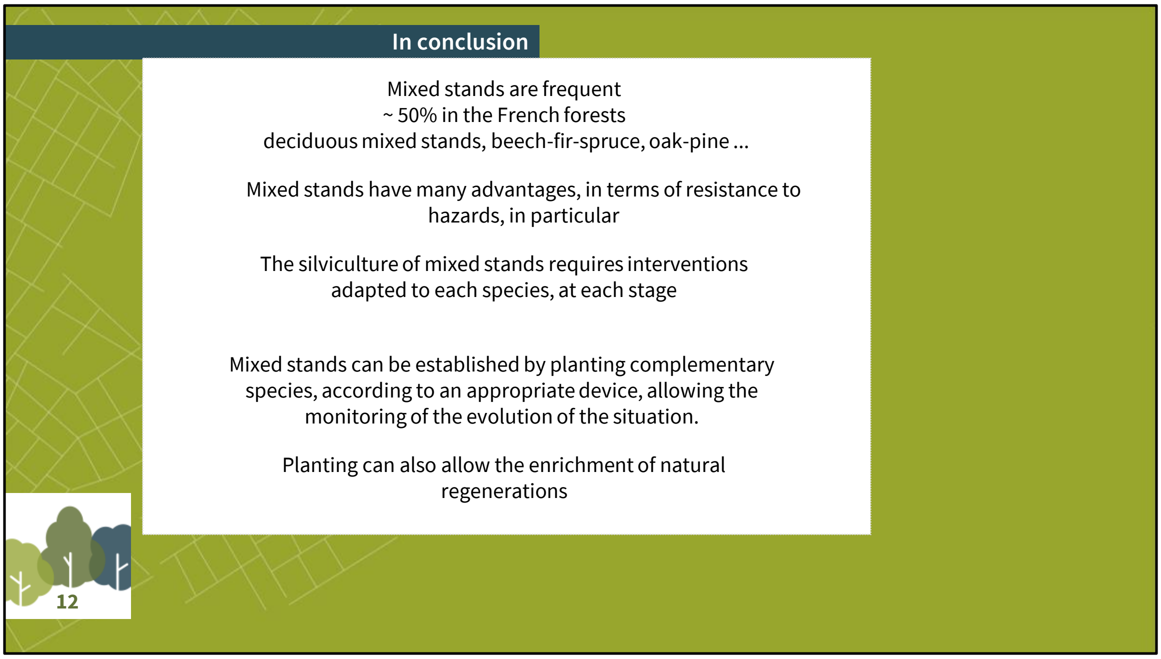
4	A	alisier torminal	20	M	merisier
26	Ch	chêne QPE 105,	29	S	érable sycomore
4	Co	cormier,	1	P	poirier

Establishing a mixed stand through plantation is quite tricky.

It is necessary to choose the constituting species, as we have seen previously, and to define a planting scheme adapted to their requirements and also allow to easily find the seedlings of each species in order to be able to follow them in time and carry out the necessary interventions.

Different schemes have been tested: alternating lines, with varied spacing on the line and between the lines depending on the species, plots of a few dozen plants, or even nests, which are small plots of very dense plants.

Plantations can also serve as a means of providing diversity in natural regeneration. It will be particularly important to be able to find the plants and make the interventions that will allow them to thrive.



In conclusion

Mixed stands are frequent
~ 50% in the French forests
deciduous mixed stands, beech-fir-spruce, oak-pine ...

Mixed stands have many advantages, in terms of resistance to hazards, in particular

The silviculture of mixed stands requires interventions adapted to each species, at each stage

Mixed stands can be established by planting complementary species, according to an appropriate device, allowing the monitoring of the evolution of the situation.

Planting can also allow the enrichment of natural regenerations

In summary, about half of the stands of the French metropolitan forests are mixed, and the most frequent mixed stands include oak with other hardwoods, mixed stands of beech, fir and spruce, and mixed stands of oak and pine.

Mixed forests have many ecological, cultural and landscape interests.

The silviculture of mixed stands is complex, and requires careful interventions adapted to the different species’ temperament, at all stages of stand development.

It is difficult to succeed in planting a mixed stand. It requires a choice of complementary species and a planting pattern that is adapted to their requirements, and which allows for their development’s monitoring to ensure the necessary interventions - otherwise the stand may fail or quickly become monoculture forest.

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Photographs

Jean François HAMARD

Yves EHRHART

Week 4

Using wood sustainably

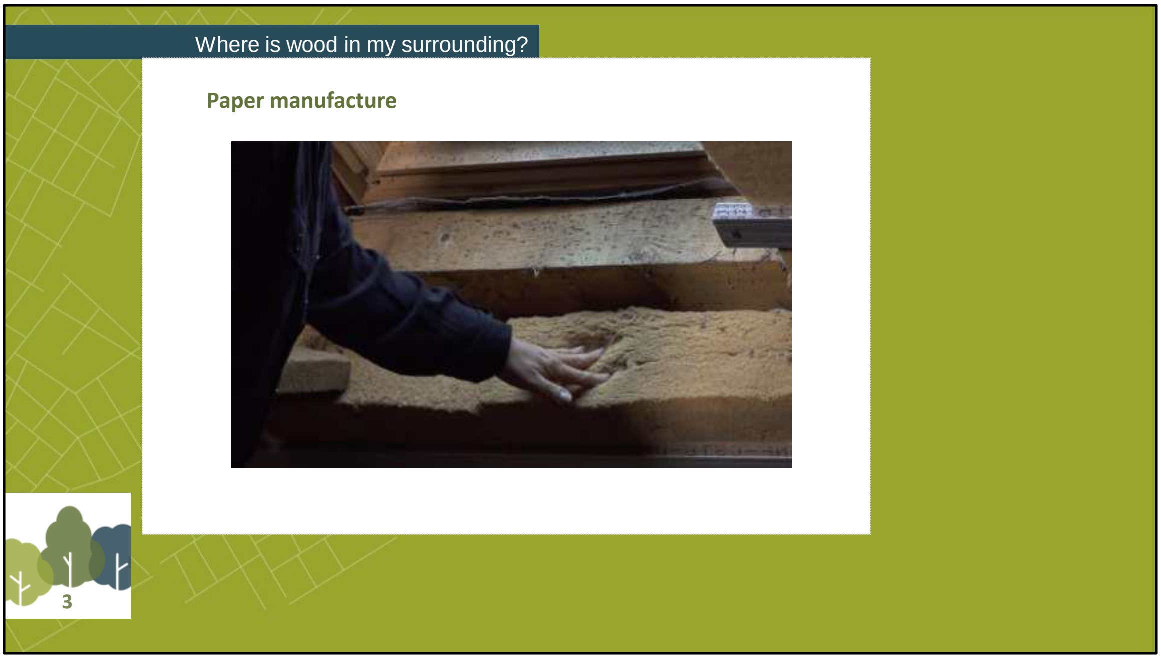
Video 1

What is wood used for?

Wood is an important resource provided by forests, as it has always been part of the evolution of mankind as a building product or as a source of energy.

Where is wood in my surrounding?

Traditional frames & insulation



Where is wood in my surrounding?

Paper manufacture

This photo shows how paper manufacturing begins.

Where is wood in my surrounding?

Half wood-half stone housing

A half wood-half stone (Vosges sandstone) house because a solid (and affluent) house in France used to be made of stone ... except that now the owner likes modern, living wood:

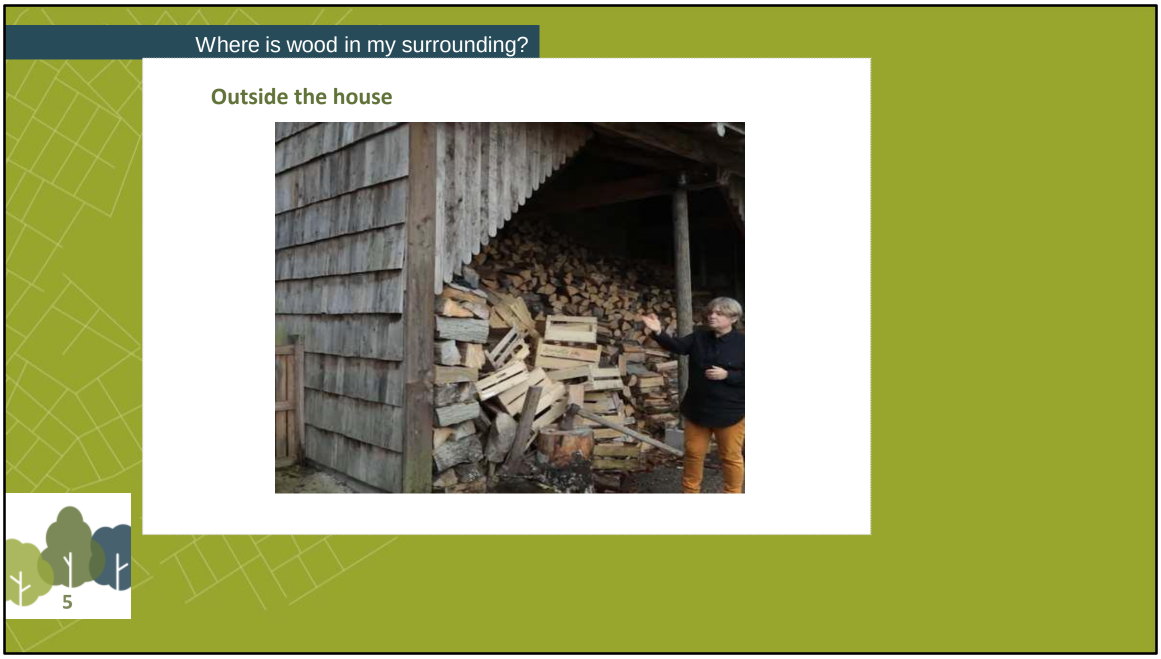
So there is a glued plywood veranda and a timber frame extension.

In the house, there is a staircase, a bit of stone (we are rich), a bit of oak (noble wood), and resinous (poorer wood) with a stair nosing in oak (harder wood).

Wood is everywhere in the house, furniture, doors, windows, and especially the wood of books, material carrying history and transmission of knowledge.

In the living room, we lay and observe :
- solid wood and reconstituted veneer (chipboard, medium, etc.), less noble but very important for our furniture and our daily life
- packaging wood (crates, cardboard boxes, but also barrels and casks that enhance

spirits and wines).
- The story of chain number 5 missing?
- Wood provides molecules (little story of Chanel n°5); it also provides medicines.
--Wood gives me clothes. Wood-based textiles have always existed (rayon) and should develop more and more (without mentioning a brand, easy to find).
Cellulose-based fabrics allow a reconversion of the paper industry and these textiles are good substitutes for synthetic textiles or even for cotton (a very water-intensive crop).



Where is wood in my surrounding?

Outside the house

- Recyclable wood: the owner has recovered pallets, crates and telephone poles.

- Wood for heating; we put a log back into the stove.

Conclusion

Wood is essential to our societies.

One in five people in the world lives in a wooden or bamboo house, traditional or modern, poor, rudimentary or high-tech.

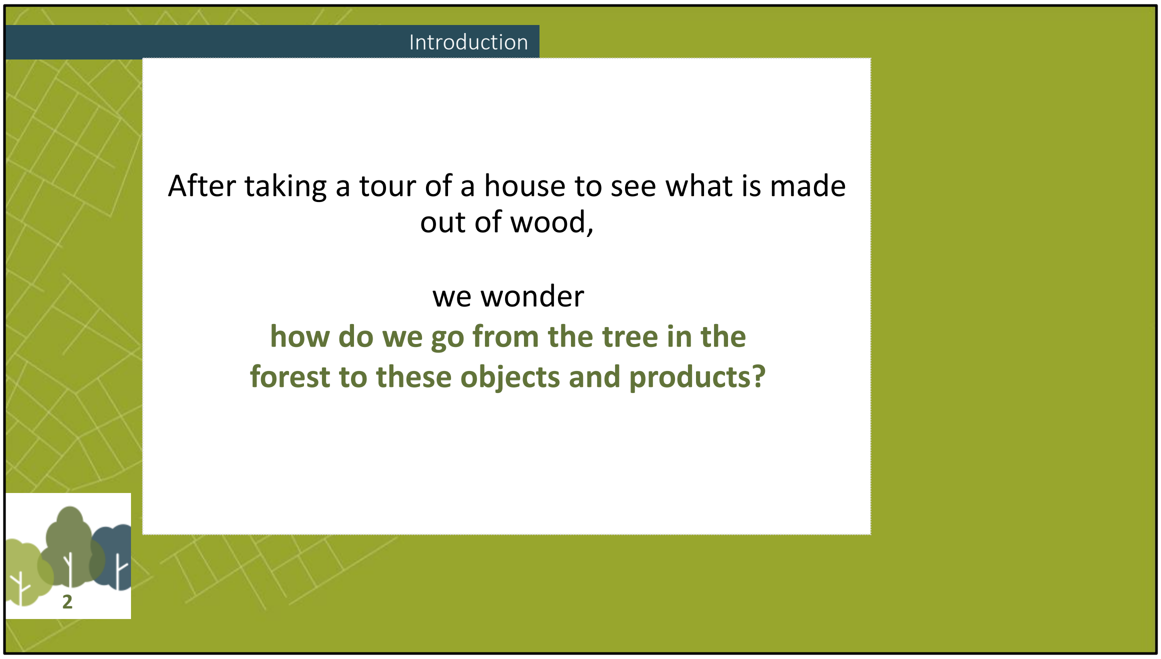
And wood ... comes from the forest and the trees we cut down.

Week 4

Using wood sustainably

Video 2

What happens between timber in the forest and the wood in your home?



Introduction

After taking a tour of a house to see what is made out of wood,

we wonder

how do we go from the tree in the forest to these objects and products?

After taking a tour of a house to see what is made of wood, we wonder how do we go from a tree to these objects and products ?

The wood market

- **Energy/Fuelwood/wood energy**
- **Paper and cardboards**
- **Construction/ Carpentry**
- **Industrial carpentry (doors, windows)**
- **Parquet floors, panelling (moulding rods)**
- **Furniture**
- **Packaging (pallets, crates, etc.)**

Timber market (objects and sectors) is often represented this way.
Note that this representation :

- ignores growing markets such as textiles, which are known to potentially be a wood-intensive market.
- does not represent niche markets, i.e. uses that may be high value-added but use small quantities of wood (musical instruments, sports goods, alcohol aging barrels)

The timber industry: logging

LOGGING

The three types of timber harvest

Lumber (L)

Industrial Wood (IW)

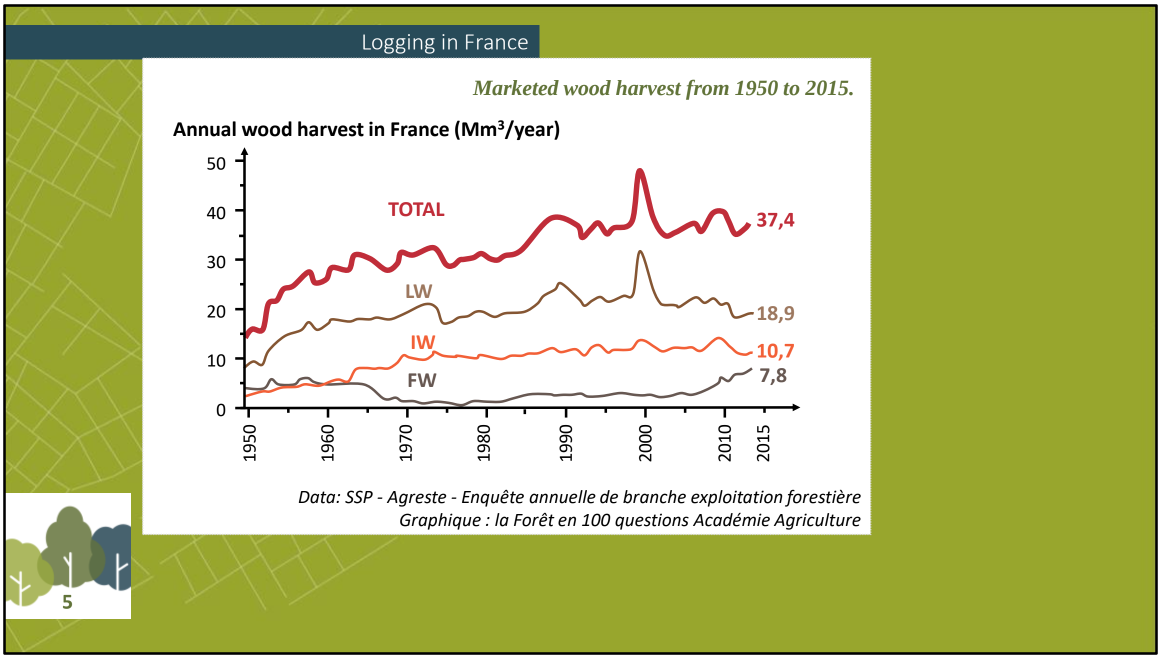
Fuelwood (FW)

How does one proceed from harvesting wood in the forest to these end markets? / target market ?

At the time of harvest, it is standard practice to separate the harvested wood into three categories:

- Lumber L
- Industrial wood IW
- Fuelwood FW

When you walk in the forest, near logging sites, you can see piles of wood alongside the road, sorted by these three quality types (and even many sub-quality types).



Logging in France

Marketed wood harvest from 1950 to 2015.

Data: SSP - Agreste - Enquête annuelle de branche exploitation forestière
Graphique : la Forêt en 100 questions Académie Agriculture

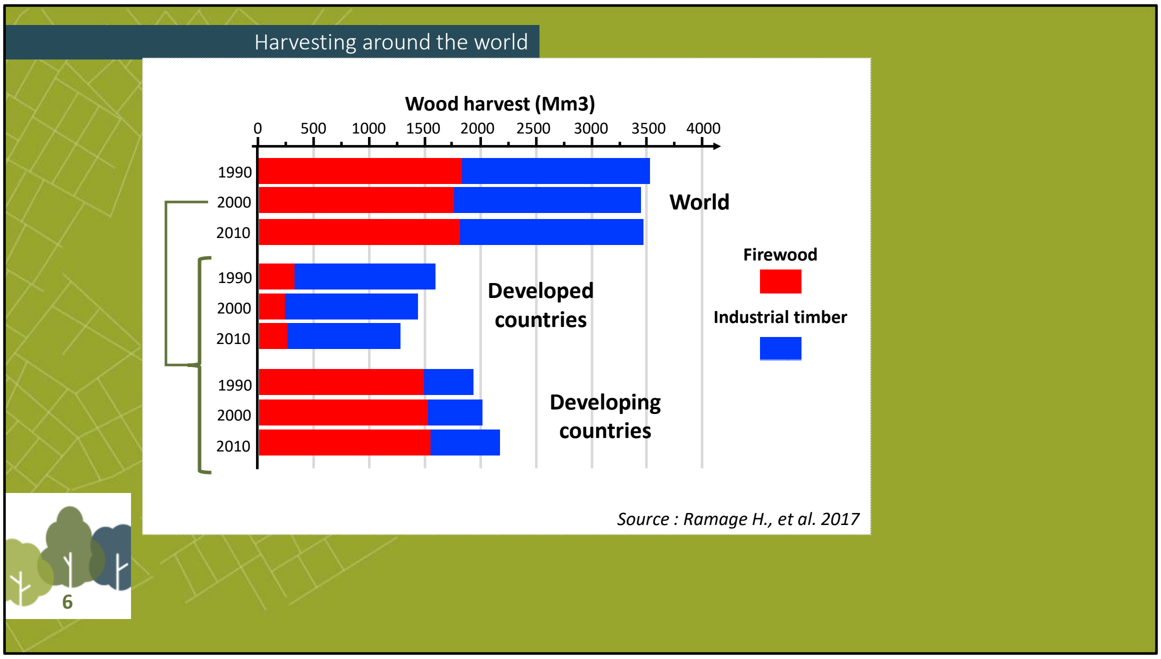
This chart shows the evolution of harvested wood sold in France since 1950.

The upper curve represents the total, below you can see the details of the three categories of wood.

More timber is harvested than industrial and energy wood.

The harvest, after a strong increase during the 30 glorious years (from 1945 to 1975), has stagnated in recent years.

Firewood has increased in recent years. The peak in timber harvesting in 2000 was due to the 1999 storm, which left a lot of blown wood that had to be disposed of.



Harvesting around the world

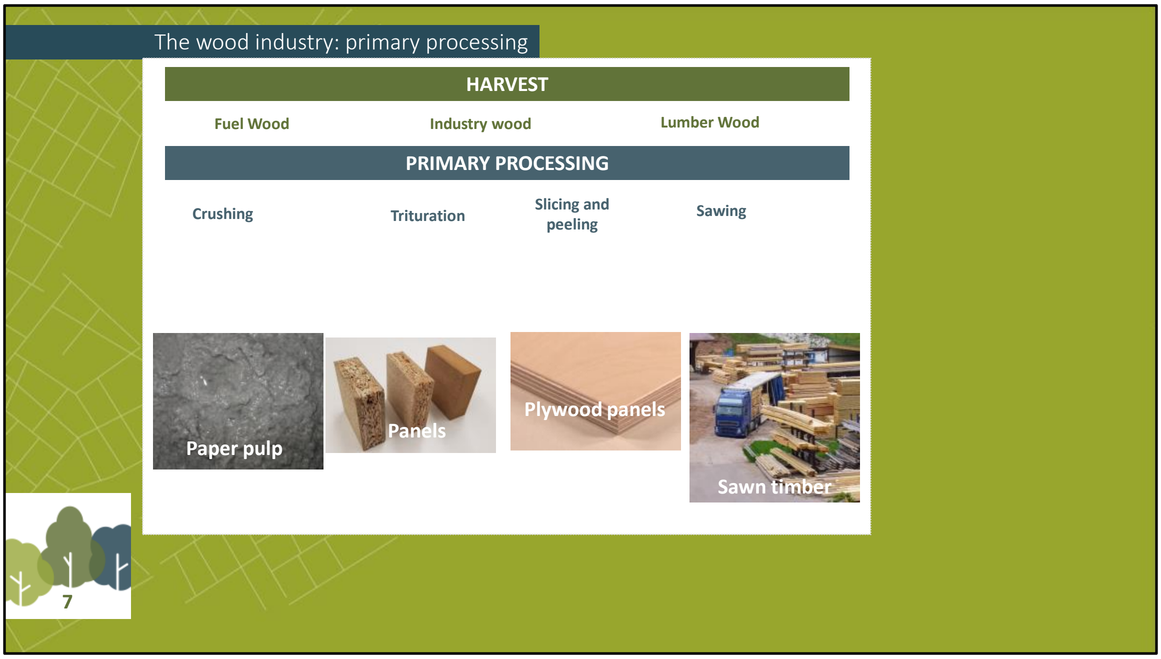
Source : Ramage H., et al. 2017

Overall, the data are divided into two main categories: energy wood and industrial wood, which in this case includes both lumber and industrial wood.

Overall, the harvest has been fairly stable between the years 1990, 2000 and 2010, and fairly balanced between the two categories.

But if we distinguish between developed and developing countries, the contrast is great. Developed countries primarily use wood as a material, while developing countries use wood as a fuel. Indeed, in many poor countries, wood remains the primary source of energy for the population.

Developed countries are harvesting less and less, whereas developing countries are harvesting more and more, due to their strong demographic expansion. PHRASE NON DITE



The wood industry: primary processing

HARVEST

Fuel Wood

Industry wood

Lumber Wood

PRIMARY PROCESSING

Crushing

Trituration

Slicing and peeling

Sawing

Wood harvests supply the primary processing sector whose role is to manufacture intermediate products such as paper pulp, panels, and sawn timber that are sorted, dried, and graded. Its expertise lies in the ability to acquire wood from the forest and to handle a multitude of processes in order to satisfy customers with a product that, with the exception of logs, has little to do with the tree from which it originates.

Primary processing - sawmills, pulp or panel factories - is a heavy industry, meaning that the profit margins are not great, the investment is significant. You don't create a sawmill like you would a start-up.

Source infographie **www.boisforet-info.com**
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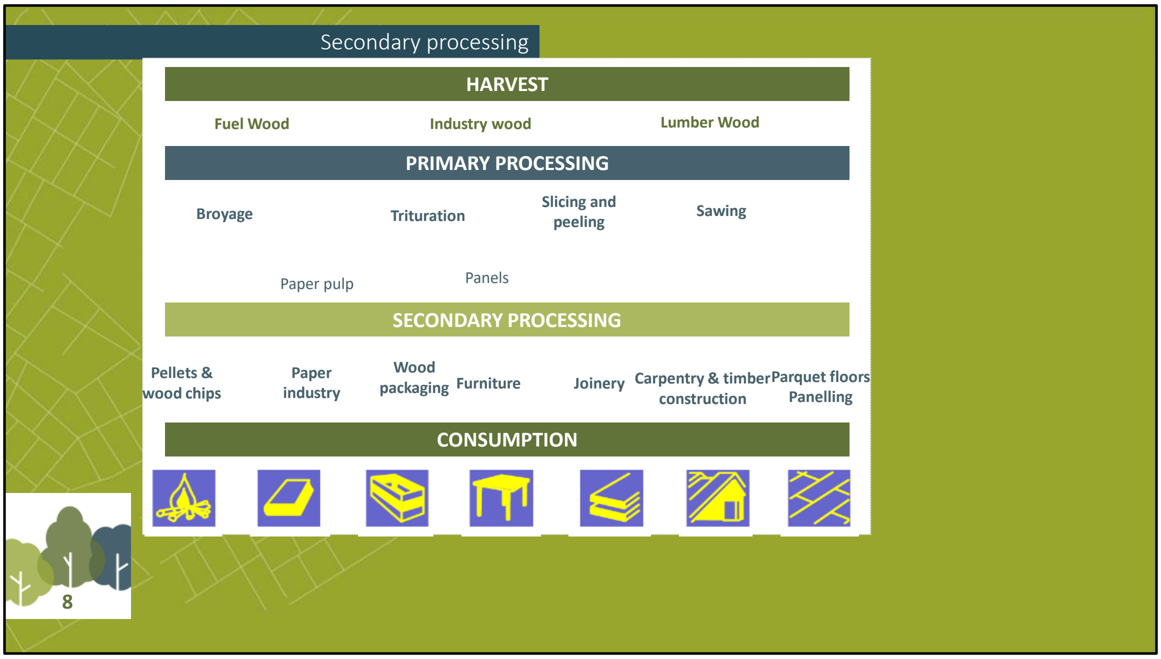


Secondary processing

HARVEST

Fuel Wood
Industry wood
Lumber Wood

PRIMARY PROCESSING

Broyage
Trituration
Slicing and peeling
Sawing

Paper pulp
Panels

SECONDARY PROCESSING

Pellets & wood chips
Paper industry
Wood packaging
Furniture
Joinery
Carpentry & timber construction
Parquet floors Panelling

CONSUMPTION

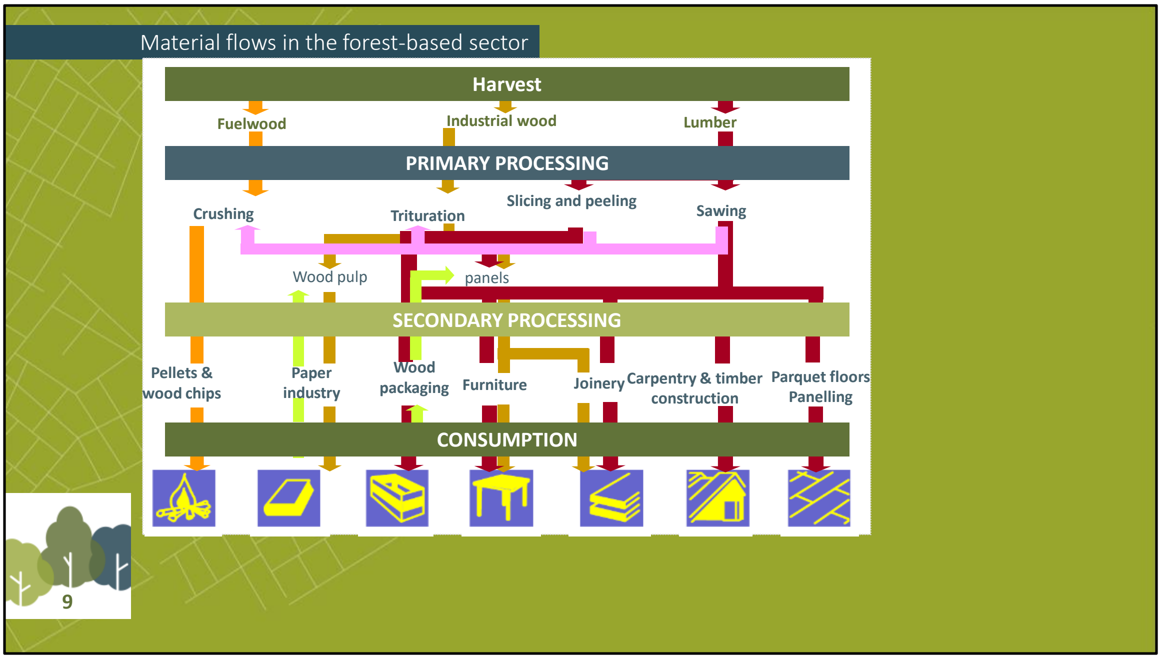
Now, the **secondary processing**.

It involves the acquisition of semi-finished products (sawn timber, panels, paper pulp, etc.) originating from the former to manufacture finished products.

While primary processing is directly linked to the forest, secondary processing is linked to the final buyers. Likewise, secondary processing - which produces furniture, houses, flooring - often uses more than just wood (furniture is not made of wood alone).

It will therefore turn to other sources of raw materials when needed. For example, in the case of wood energy, this is often the case of fuel oil sellers who also sell wood chips or logs.

Source **www.boisforet-info.com**



Material flows in the forest-based sector

Harvest

Fuelwood

Industrial wood

Lumber

PRIMARY PROCESSING

Crushing

Trituration

Slicing and peeling

Sawing

Wood pulp

panels

SECONDARY PROCESSING

Pellets & wood chips

Paper industry

Wood packaging

Furniture

Joinery

Carpentry & timber construction

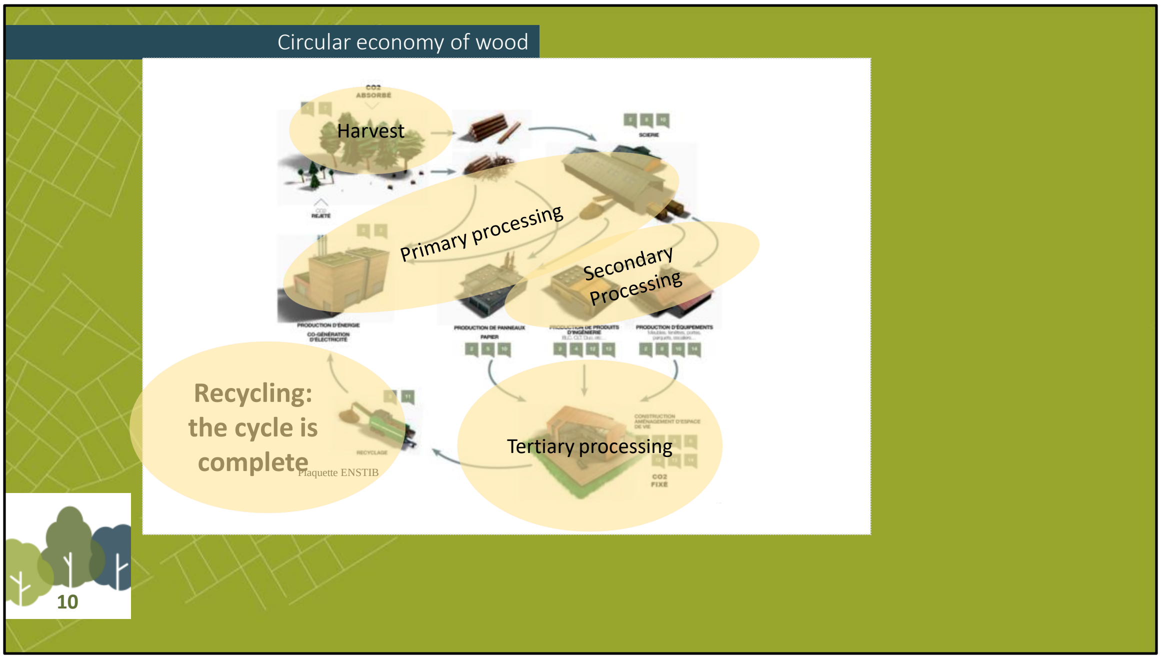
Parquet floors Panelling

CONSUMPTION

If we want to represent the material flows between these different links in the chain, it is fairly simple and quick for wood energy, but a little more complex for timber and industry wood.

In particular, the primary processing of timber produces a lot of offcuts, " by-products ", which are fed to the crushing and pulping industries. Sawdust and shavings are produced at the end of the sawing process and are used in the manufacture of panels or for energy production.

And the flows are not only going down, bu t also going backwards: recycling replenishes the supply chain: for example, paper or chipboard are less and less made from fresh wood. Recycling is a very important issue.



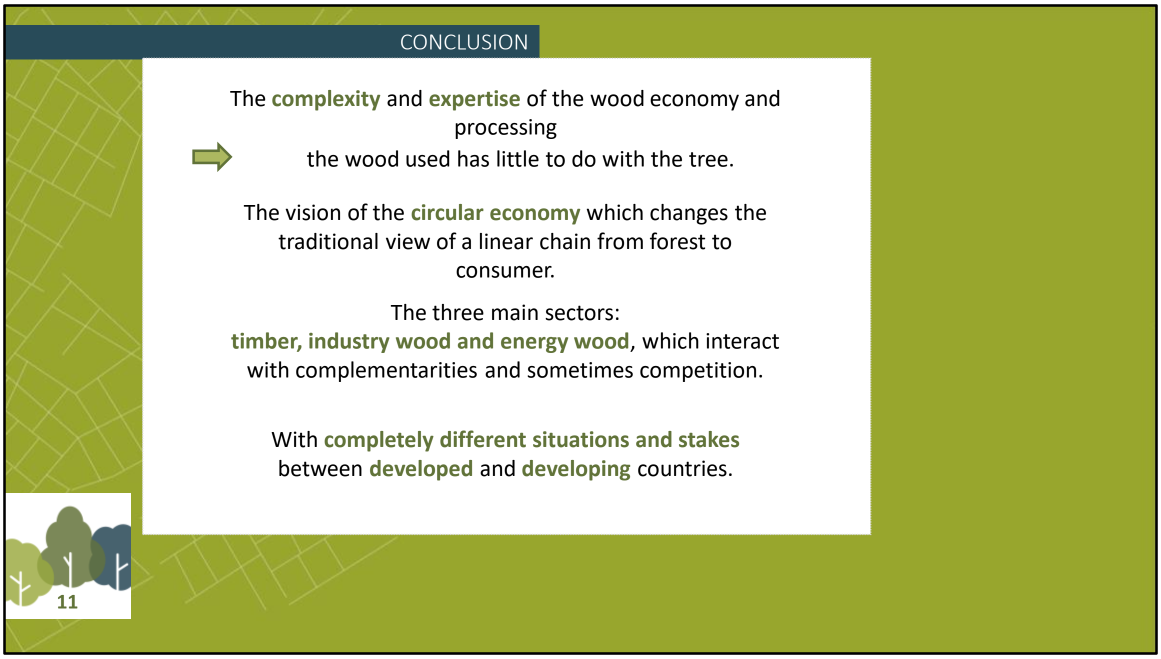
Circular economy of wood

Plaquette ENSTIB

The traditional image of the sector needs to be revisited. Here the ENSTIB booklet shows a more modern vision of the circular economy. It shows the harvest, the 1st processing which produces energy, sawn timber, panels, the secondary processing which produces engineered products and equipment. But we don't stop there.

With circular economy, a “tertiary processing" is added. It looks at the layout of the living environment and the way in which the wood product is implemented and used, in order to be able to consider its recycling.

We are interested in the product throughout its life especially in the way it will be recycled, not just its marketing. Recycling comes to complete the carbon cycle, because, if done properly, it will release CO2 into the atmosphere, which will be stored in the growing trees. We’ll see more about CO2, but the important thing in this vision is that the cycle is complete. The sector is part of the circular economy of the 20th century.



CONCLUSION

The **complexity** and **expertise** of the wood economy and processing

⇨ the wood used has little to do with the tree.

The vision of the **circular economy** which changes the traditional view of a linear chain from forest to consumer.

The three main sectors:
timber, industry wood and energy wood, which interact with complementarities and sometimes competition.

With **completely different situations and stakes** between **developed** and **developing** countries.

Key messages today are:

Thank you for your attention

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Source : Ramage H., et al. "The wood from the trees: The use of timber in construction." *Renewable and Sustainable Energy Reviews* 68 (2017): 333-359.

Plaquette de l'Ecole Nationale Supérieure des Technologies et Industries du bois

www.enstib.univ-lorraine.fr/fr/accueil/a-propos/presentation-de-lecole/

Pictures

Nicolas BILOT

Yves EHRHART

Liliane TARDIO-BRISE (Wikimédia commons)

Ironpolywood (Wikimédia commons)

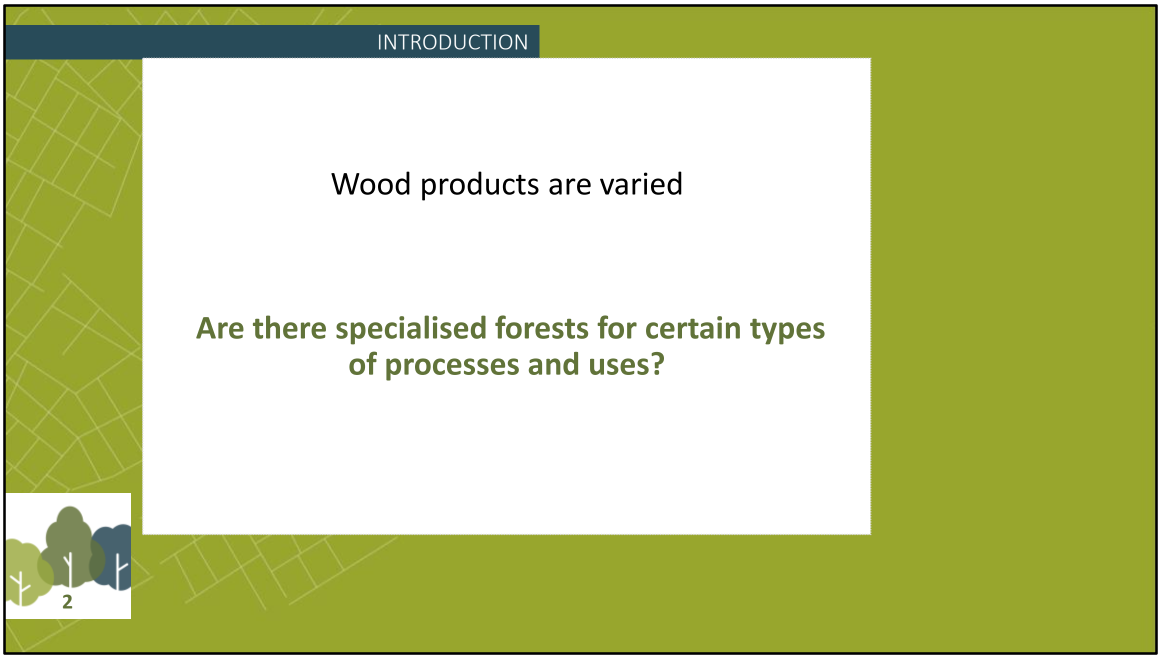
Lithium 57 (Wikimédia commons)

Week 4

Using wood sustainably

Video 3

Are there forests dedicated to the supply in specific wood uses?



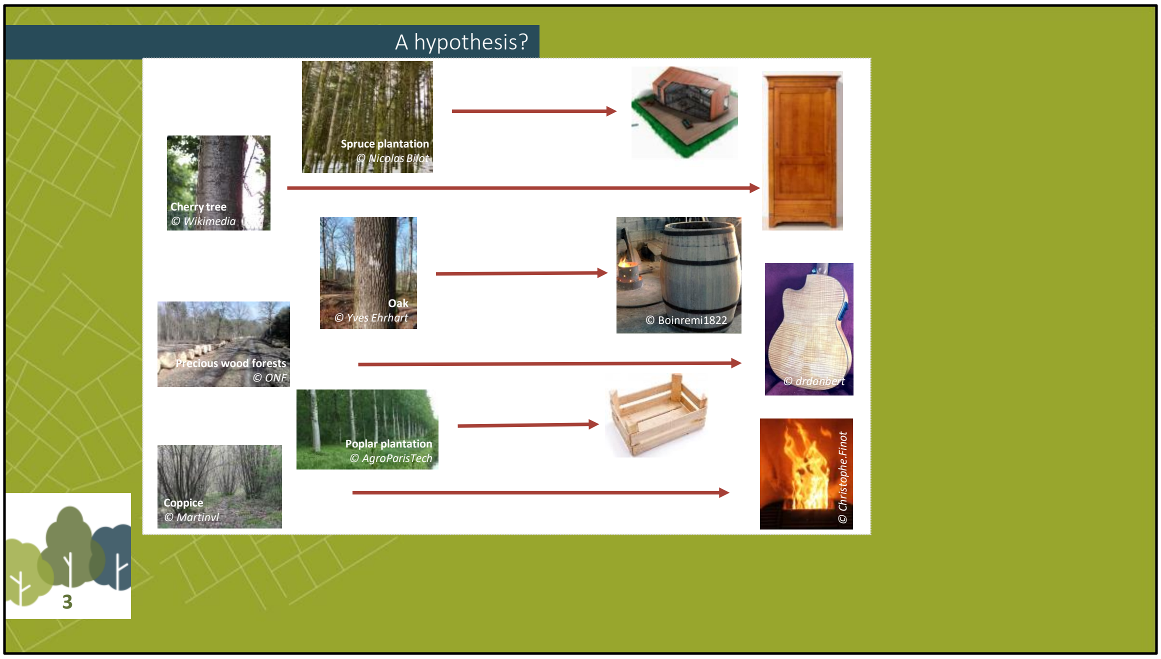
INTRODUCTION

Wood products are varied

Are there specialised forests for certain types of processes and uses?

We have just seen that wood products are very varied, with a diversity of transformation processes that certainly require a great diversity of raw materials.

We will now ask ourselves: Are there specialized forests for certain types of processing and use?



A hypothesis?

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One could imagine something like this: the wood construction sector uses softwoods, which could justify the planting of specific softwood forests, for example, spruce forests, for the construction industry.

The furniture industry could justify planting forests containing more valuable wood.

Oak is strongly associated with barrels and casks, so oak forests could be reserved exclusively for barrel making.

Musical instruments require woods of very special quality, which should be grown in specific forests.

Poplar is used for crates and packaging; are all poplar groves devoted to these products?

Simple coppicing is useful for energy wood.

Is this how it works? Does each forest have its own use? Well, no!

A tree has many uses

© Yves Ehrhart

60% loss
Crowns, chips, sawdust

40%

© Yves Ehrhart

30%

25% loss
sawdust, scraps bark

Less than 10% of the wood harvested in the barrel

10%

65% loss
Knots, scraps, barks

© Olivier Colas

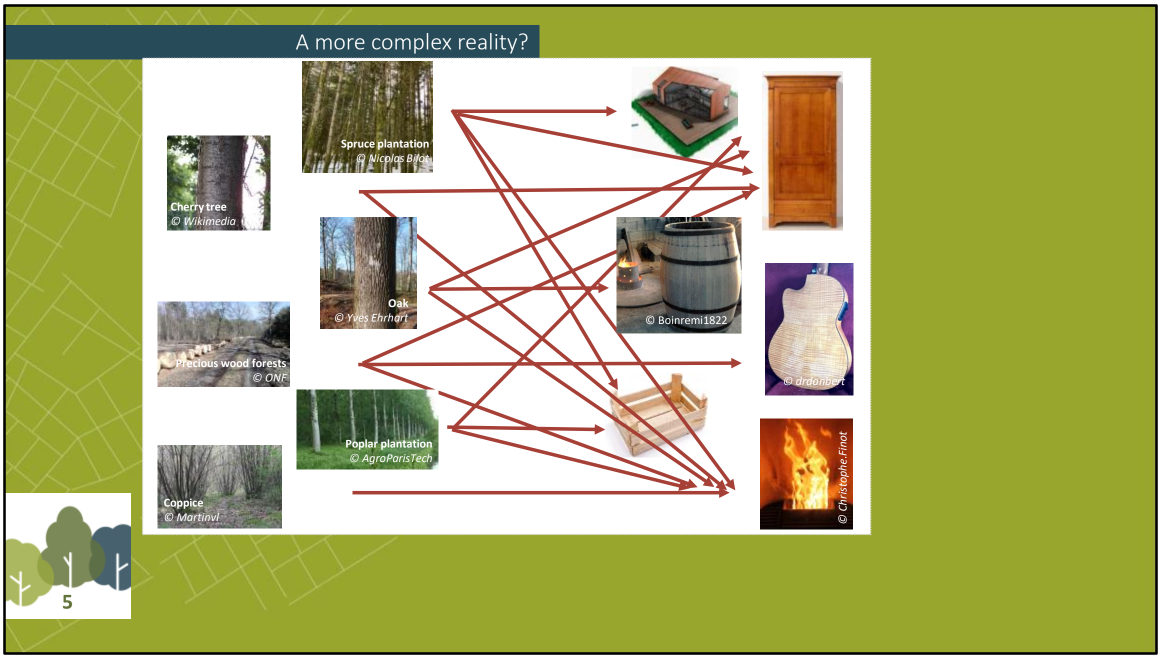
© Boinremi1822

Of course, it's not like that. A tree always has several uses.

I'll explain why: if you start with an oak tree, for example, which will end up making a barrel for wine... Only 40% of what is harvested will be injected into the lumber wood sector, as 60% is lost at harvesting. Then another 25% will be lost during bucking, etc. with the stave-producer. Then another 65% of losses between the stave and the barrel stage. In the end barely 10% of the wood harvested goes into the barrel.

What do we do with the 90% that aren't in the barrel? We use them for other purposes of course. A tree is always of interest for several uses because of the several qualities of wood in the same tree. And so in the manufacturing process, there are always reusable by-products, not just the most noble products.

So, oak groves aren't specific to barrel-making; they supply several sectors.

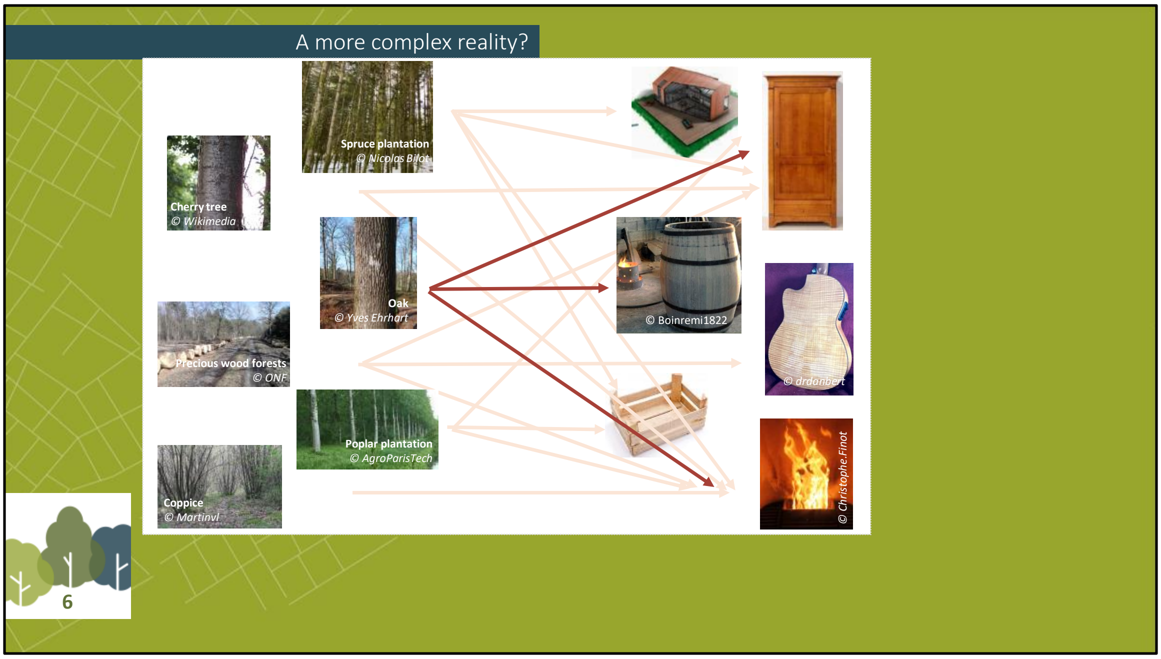


A more complex reality?

And since we don't throw anything away, at every stage.

We supply several sectors, the wood for the panels, for the energy.

Ultimately, that's how it works.



A more complex reality?

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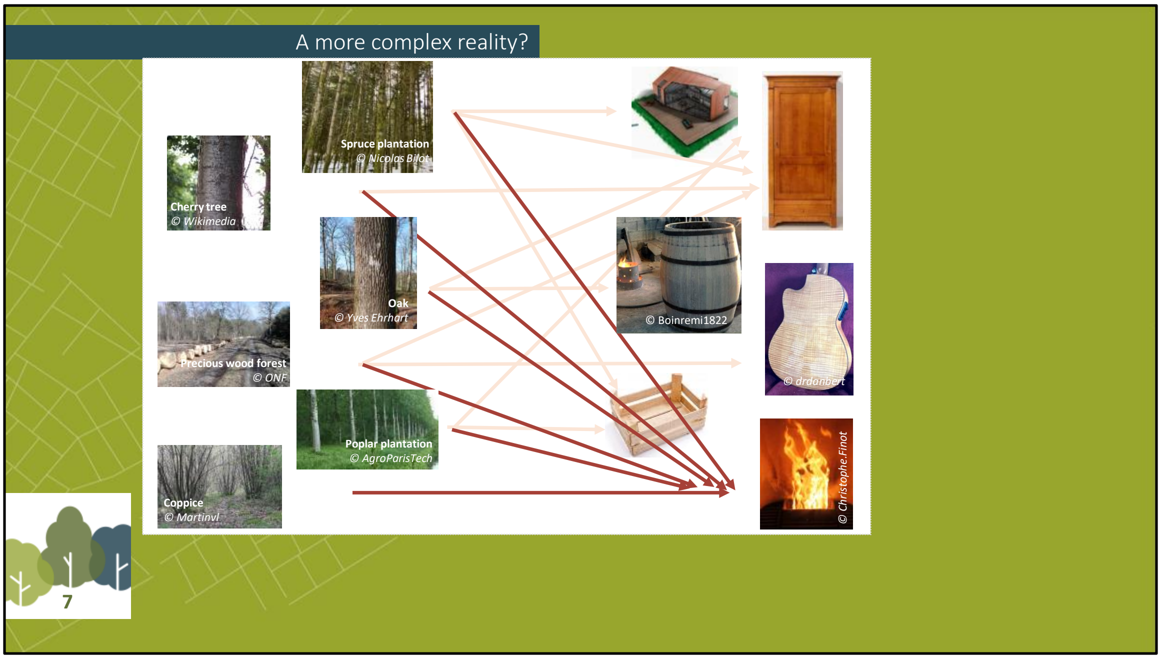
More precisely, a very specialized use such as barrels requires oak of a very special quality, which is only a very small part of the forest harvest.

This oak forest will therefore also produce wood for furniture, mostly made of panels rather than solid wood, as well as fuel wood.

Oak is known for its calorific value; it is perfect for energy.

The wood paid for by the cooper supplies the energy in offcuts, whether these offcuts come directly from the forest or from the transformation process.



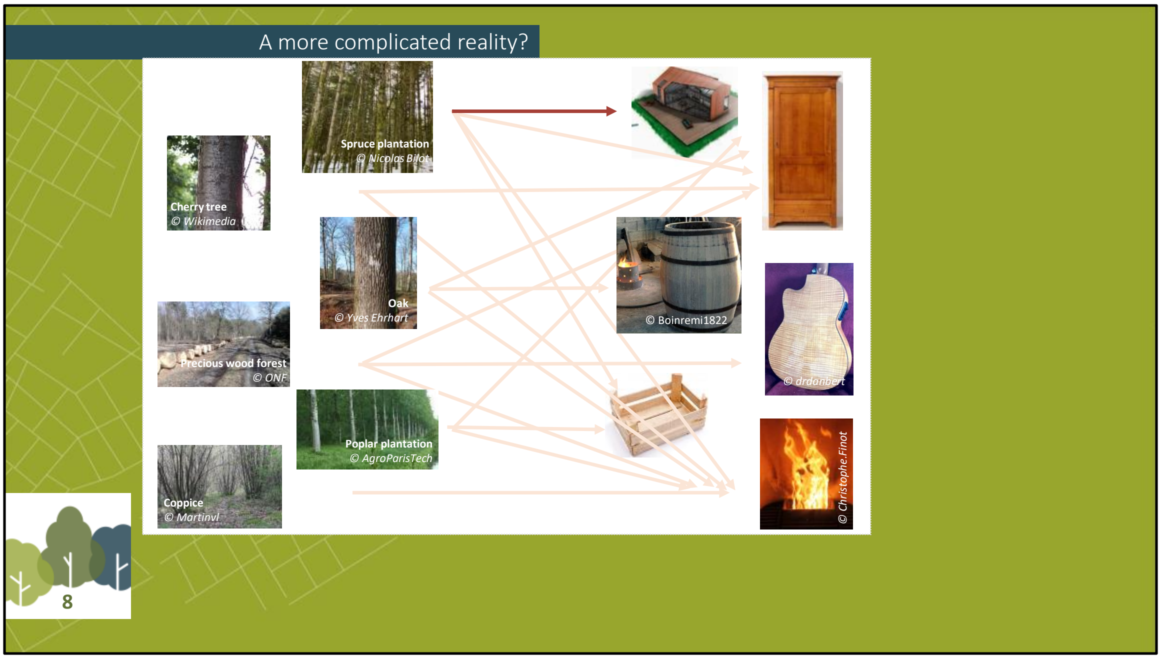
A more complex reality?

You will then notice that all forests produce firewood, as energy can be generated from all types of off-cuts and by-products.

Any wood can be used for fire!

Therefore, all processing sectors produce fuelwood and there is no need to manage forests specifically for fuelwood.

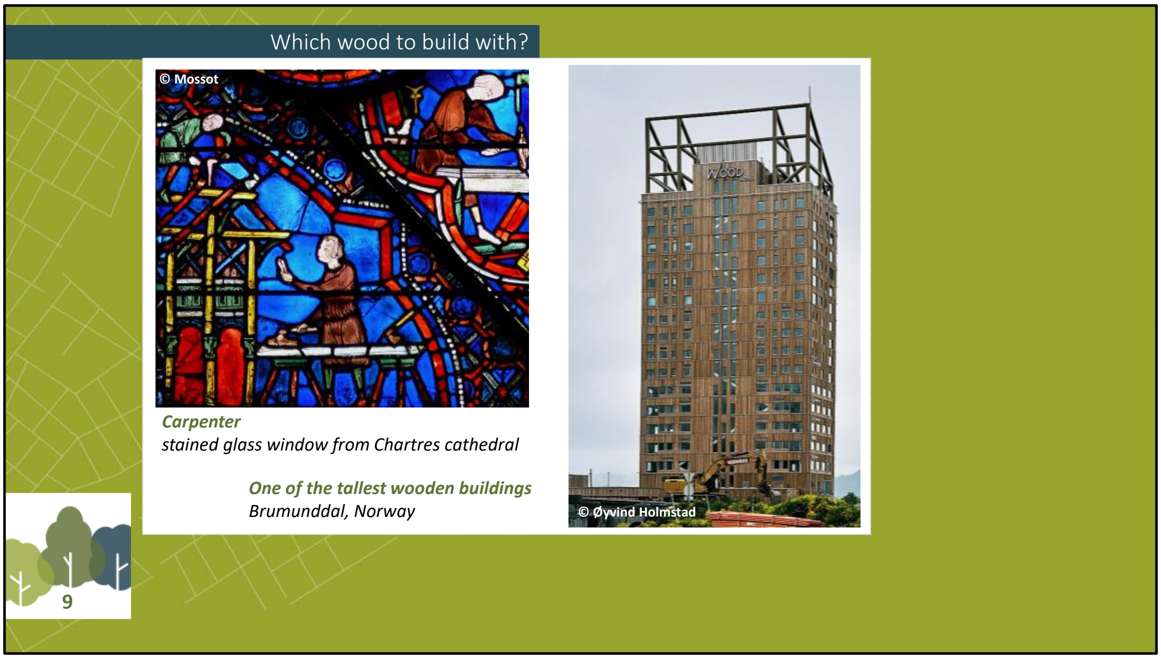
Just as logs can be produced in any forest, in a well-designed system, firewood is the waste product of everything else.



A more complicated reality?

However, it can be said that some forests and management systems are more suitable for certain uses.

For example, modern timber construction prefers softwoods because they are both light, mechanically rigid and strong with moderate production costs, especially when they are produced in plantations and cut at standardized diameters allowing the sector to produce construction products and houses at competitive prices.



Which wood to build with?

© Mossot

Carpenter
stained glass window from Chartres cathedral

One of the tallest wooden buildings
Brumunddal, Norway

© Øyvind Holmstad

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In the Middle Ages, people built massive structures out of oak. Of course, this traditional know-how still exists and we are very proud to have kept it.

But construction is a mass activity where precision, reliability, and economy are required in order not to use more wood than necessary, but also to pay the least amount possible.

After all the efforts of technical and economic development on some softwood species, it is not easy to use other species, even if in France our forest is mainly composed of hardwood.

It is necessary to reinvent the whole construction system, the whole sector from the sawyer to the architect, in order to use something other than these softwoods.

Modern wood construction from these softwoods has made great progress, and today nothing stops it, the new wood construction systems know how to make high-rise buildings.

Which wood to build with?

Beech wood construction with pinned joints
(Vélo's house, Xertigny, 88)

It's not impossible, above is a photo of a building constructed in beech with very innovative construction processes completely adapted to hardwood.

Luxury wood

© ONF

Parc de St Avold where the most beautiful logs of precious hardwoods in the Grand Est are gathered

Uses of curly maple

© drdanbert

© Richard

11

Certain niche uses absolutely require particular woods and trees.

The violin making sector and even cabinet making require rare woods called resonance spruce or wavy maple. These woods can also be used in high-end woodworking.

These uses represent very small volumes, but the owner, forester or logger is paid a very high price for this woo.

It’s a niche and a luxury use, meaning that you’ll have to find a few fine trees in the forest which are going to be of extraordinary value.

Niche markets

the stave

© Yves Ehrhart

© Yves Ehrhart

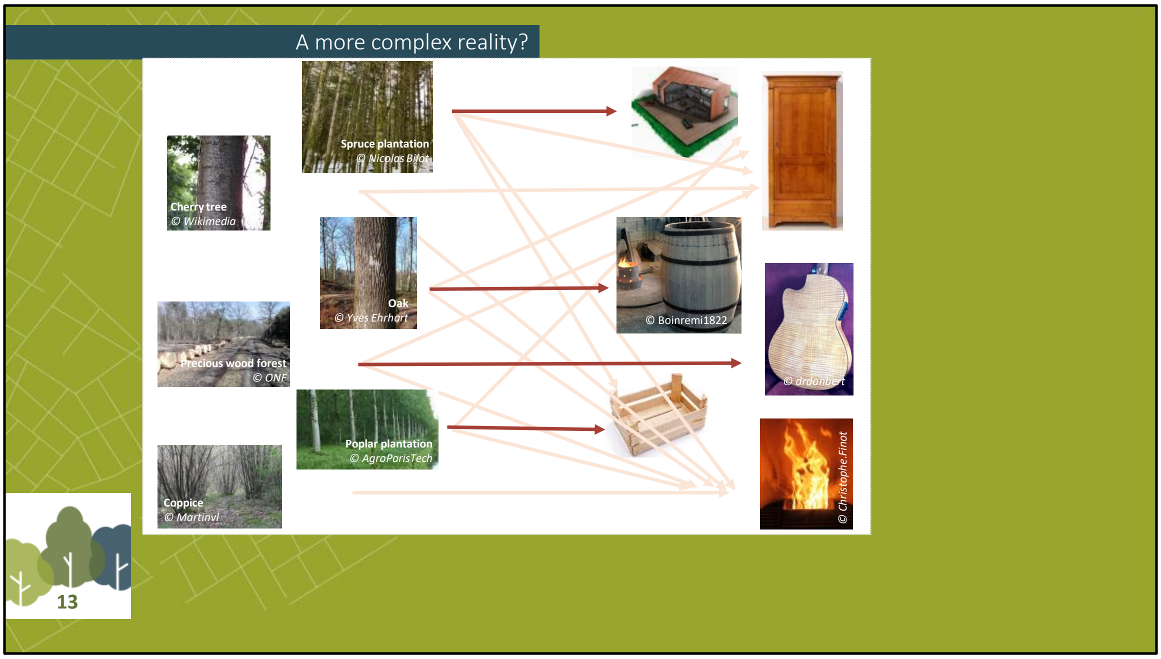
© Boinremi1822

© Olivier Colas

To come back to barrels and stave oaks.

This is a sector where tradition dominates and where demand is constantly increasing, particularly under the influence of Asian markets.

Thanks to the high price of wood for these uses, which require large, beautiful old trees, it is possible to finance the oak forestry in long cycles of 200 years.



A more complex reality?

Cherry tree
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Precious wood forest
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Poplar plantation
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So there are still preferences in the absence of strictly specialized forests.

When these preferences are for mass uses such as construction or packaging, they can stimulate specific forestry such as softwood plantations or poplar growing.

When these are niche uses in high added-value markets, such as musical instruments or barrels, they influence forest management because the wood price paid to the owner is very high and it is quite an art and a task for the manager to know how to produce and market these woods.

Industrial plantations

Eucalyptus plantations
(Aracruz Celulose Aracruz company, Brasil)

© Denis Rizzoli

Highly specialized systems of industrial wood plantations, i.e. integrated systems where forests are there for the needs of the industry, are developing all over the world.

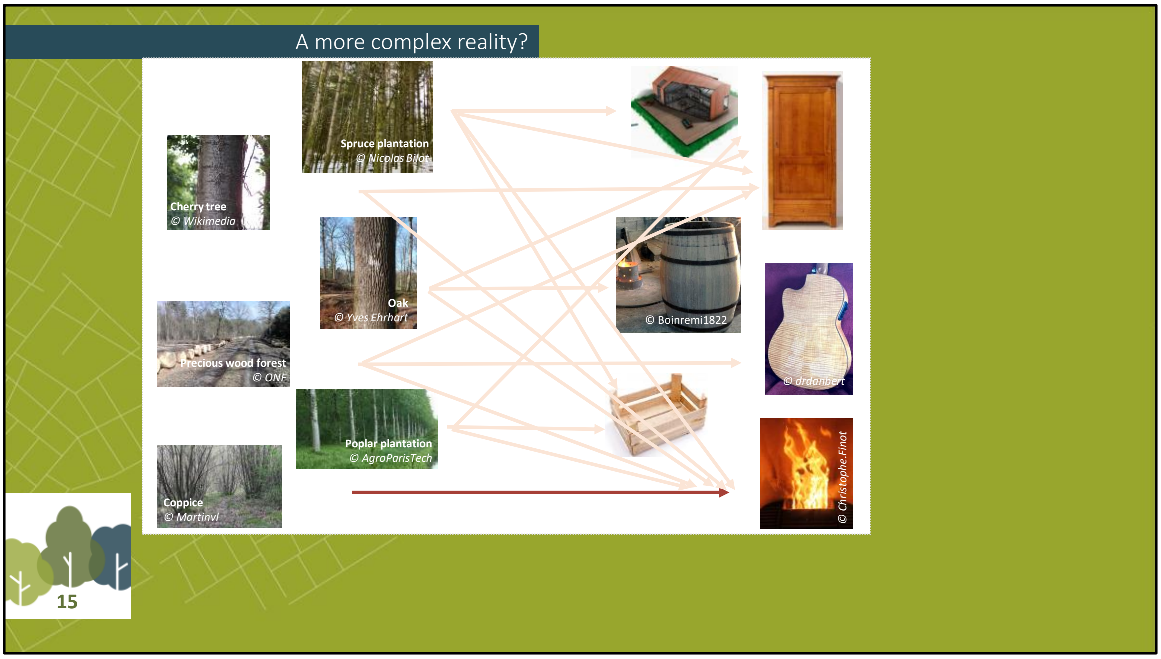
There are none in France in this sense.

Douglas fir or maritime pine in France, which can be similar to industrial systems, still relatively long to produce, with non-industrial owners.

But this exists in many countries.

When an industry has the land and guide resources, it will create forests that are extremely well adapted to these resources, and industries often seek very short-cutting cycles.

Eucalyptus, for example, is very well adapted since it produces trees over 30 m tall in 5 to 8 years!



A more complex reality?

And the simple coppice? Can it only be used for firewood?

This is what is implied in the diagram.

Coppices have historically been the way to produce wood quickly for energy, and remain so in southern countries that need mass timber for the poor populations.

It is not unusual to extract timber from a coppice

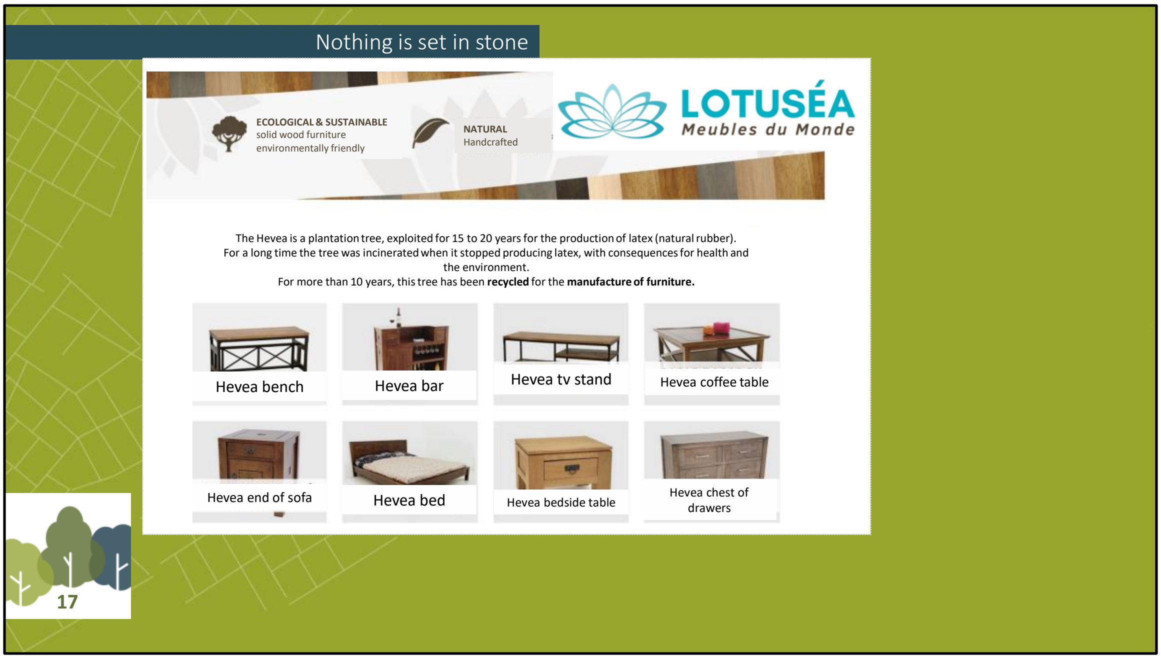
Coppice
© Martinvl

16

A forester will probably tell you that coppice wood can only be used for firewood.

We have seen that a coppice can be converted into a forest.

Even a simple chestnut coppice can produce small logs for parquet flooring, for example. In Italy they are famous for getting the best out of chestnut coppice.



Nothing is set in stone

ECOLOGICAL & SUSTAINABLE
solid wood furniture
environmentally friendly

NATURAL
Handcrafted

LOTUSÉA
Meubles du Monde

The Hevea is a plantation tree, exploited for 15 to 20 years for the production of latex (natural rubber).
For a long time the tree was incinerated when it stopped producing latex, with consequences for health and the environment.
For more than 10 years, this tree has been **recycled** for the **manufacture of furniture.**

Hevea bench

Hevea bar

Hevea tv stand

Hevea coffee table

Hevea end of sofa

Hevea bed

Hevea bedside table

Hevea chest of drawers

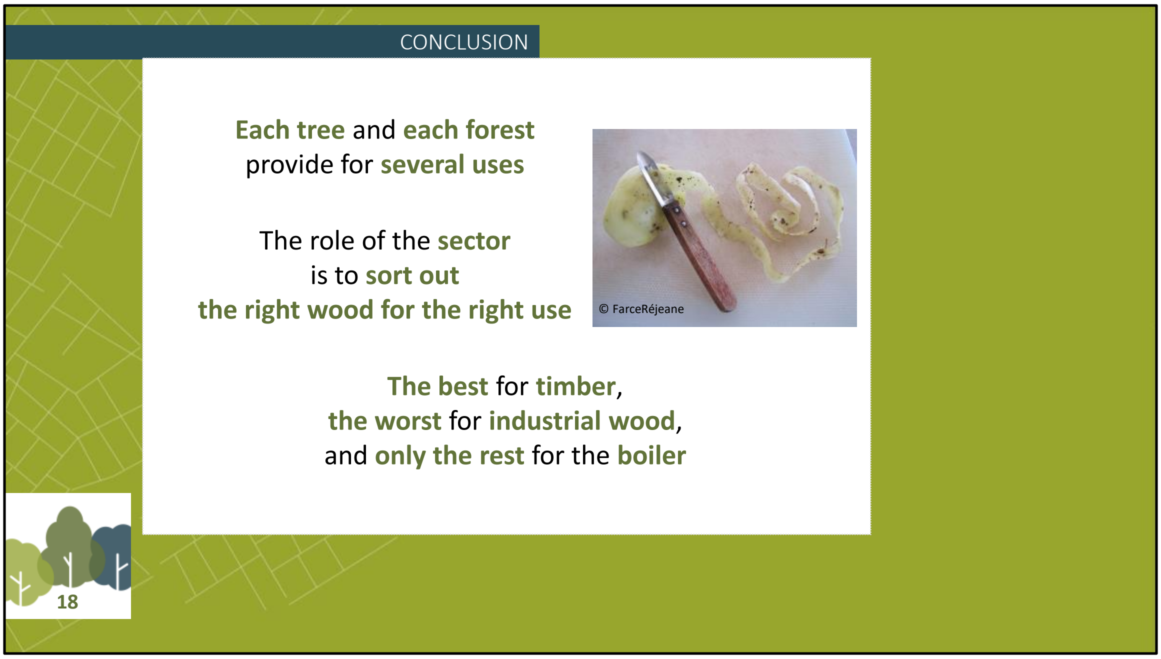
17

Nothing is set in stone and markets evolve.

Who would have thought in the last century that Asian markets would sell us furniture made of Hevea or Mango tree? These were deemed unsuited for wood production and today they are flooding the market.

On the contrary, who could have imagined that woods with a reputation for being precious, such as cherry wood, would lose their market?

No one seems to want to buy the red furniture made from them any more, and cherry wood now stays in the forest due to the lack of market opportunities.



CONCLUSION

Each tree and **each forest**
provide for **several uses**

The role of the **sector**
is to **sort out**
the right wood for the right use

© FarceRéjeane

The best for **timber**,
the worst for **industrial wood**,
and **only the rest** for the **boiler**

In conclusion, wood has multiple uses, and the forest, like most everything that emerges from the earth, has multiple uses.

The best potatoes are eaten fried or au gratin, the worst ones can be mashed and the peelings can be composted or burned to produce hot water.

Forest production can be designed in the same way, the best for lumber, the worst for industrial wood, and only the rest for the boiler.

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www.lotusea.fr/1029-meubles-en-hevea-massif

Photographs

Nicolas BILOT

Yves EHRHART

ONF

AgroParisTech

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- *Olivier Colas*
- *Richard*
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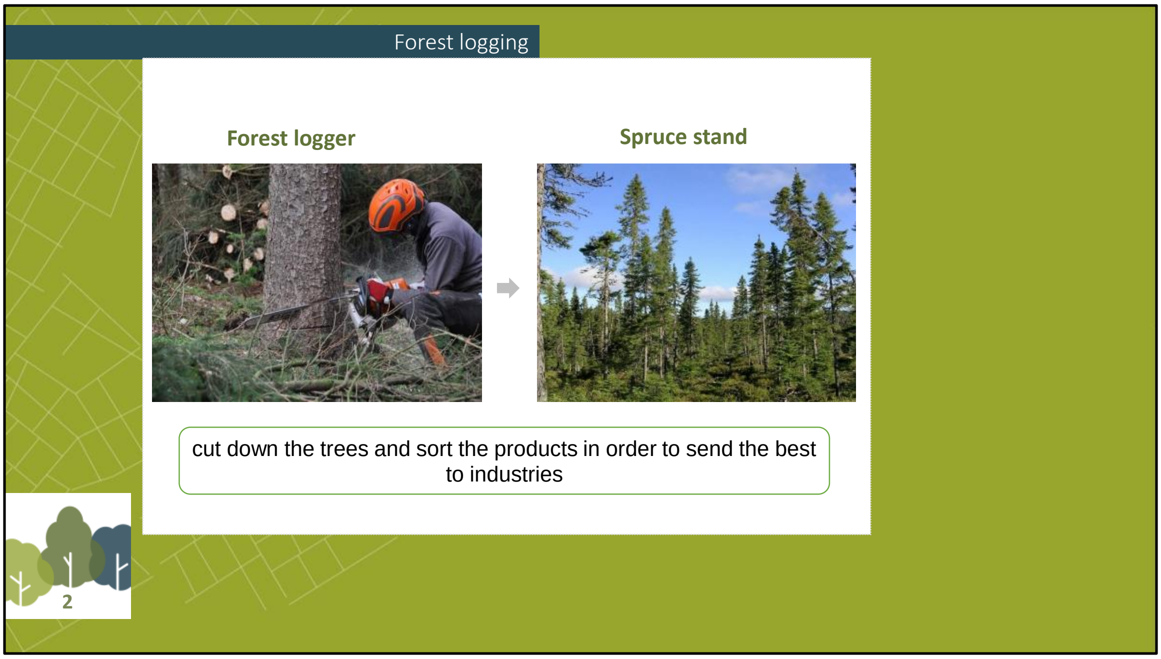
Week 4

Using wood sustainably

Video 4

Harvesting trees for the wood industry



Forest logging

Forest logger

Spruce stand

cut down the trees and sort the products in order to send the best to industries

2

His job is to be able to cut down the trees and sort the products in order to send the best to all the industries that use them.

Here is an example of a spruce tree: within this tree, there is wood for carpentry, pulp mills, and fuelwood.

The logger has a purchase contract with an owner (who may have a manager).

Currently, loggers work a lot on forests undergoing stress that are cut down prematurely. In this instance, on a spruce plot with bark beetles, the management plan is not respected, and a request must be made to the DDT and the CRPF to obtain authorization for clearcutting (sanitary cutting).

Tour of an operating site: machinery

Harvesting

Forwarding

Sorting

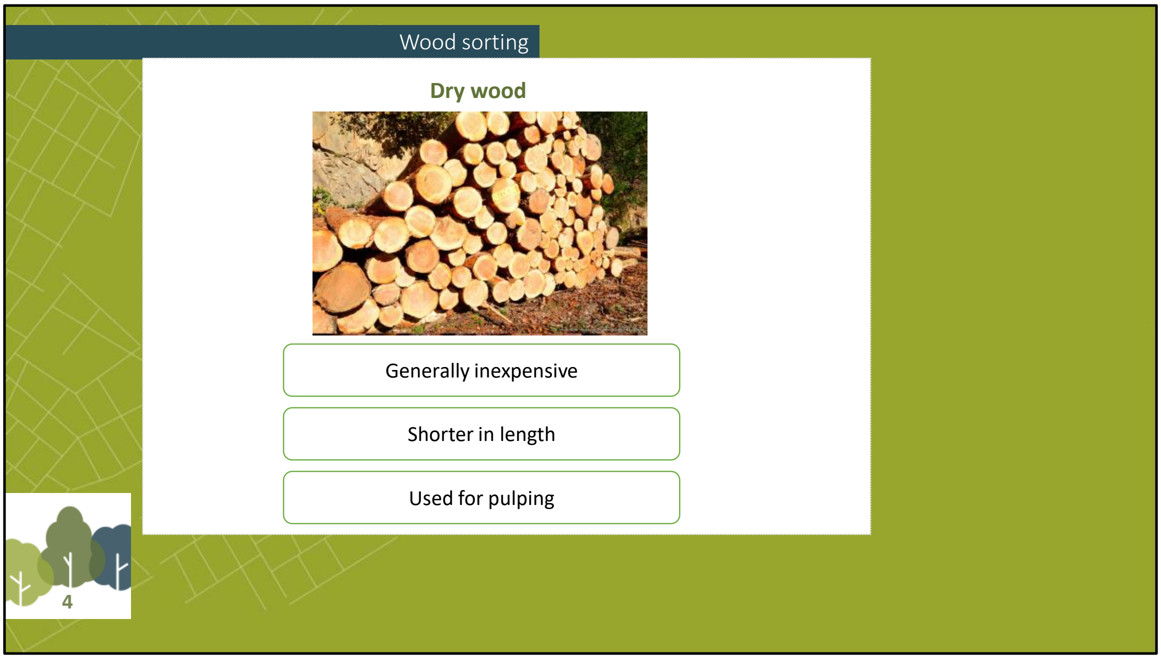
The harvester with its logger cuts down the trees and trims the branches.

The forwarder, with its skidder, takes the wood out with his basket and crane.

These belong to service providers, the forestry contractors. To avoid compacting the soil, the machines roll over the branches left on the ground, which will also help to replenish the humus. The wheels are equipped with tracks to grip the slope.

The different products on the skip: The wood is sorted into several categories.

Sorting of "dry" or debarked wood (presence of larvae under the bark) and "fresh/green" wood that is not debarked.



Wood sorting

Dry wood

Generally inexpensive

Shorter in length

Used for pulping

Dry wood can only be used for pulping (panels) or for wood energy. In this case, the logs are stacked (short length).

Wood sorting

Green wood

More expensive and intended for the construction industry

Not barked and is often longer in length

The green logs are the most expensive part of the cut. They go to the sawmill to make construction products. They will be transported in length 16m (the maximum allowed) on the road. The best qualities of spruce (for carpentry or violin making) are not found here, as slower growing wood is needed, here we are in a productive plantation. There are several products (several piles of logs) depending on the dimensions and other quality criteria, because there are different sawmills that do not all make the same products.

Green pulpwood is small-diameter but green logs (not barked) that can be used for pulp or cardboard production.

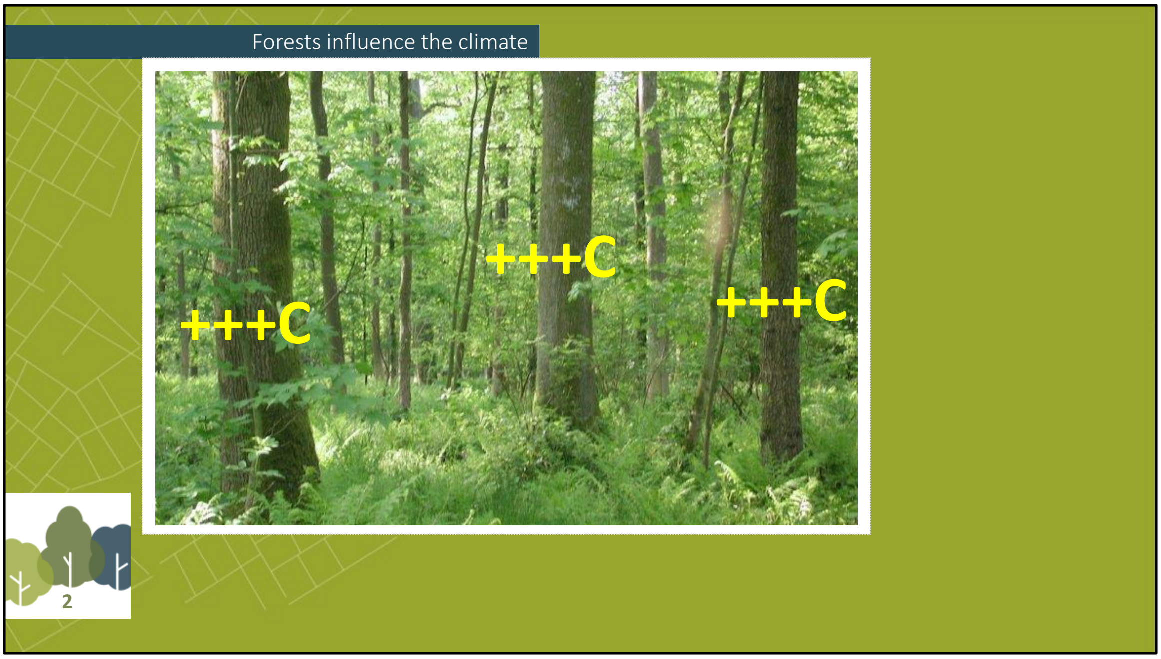
The forest manager knows about both the wood in the forest and the needs of his clients, the sawyers or panel or pulp mills. The job has become more complex, sawmills are becoming more specialized and there is more sorting to be done upstream than before, whereas this sorting work used to be done in the sawmill's log yard.

Week 4

Using wood sustainably

Video 5

Is timber harvesting good for the climate?

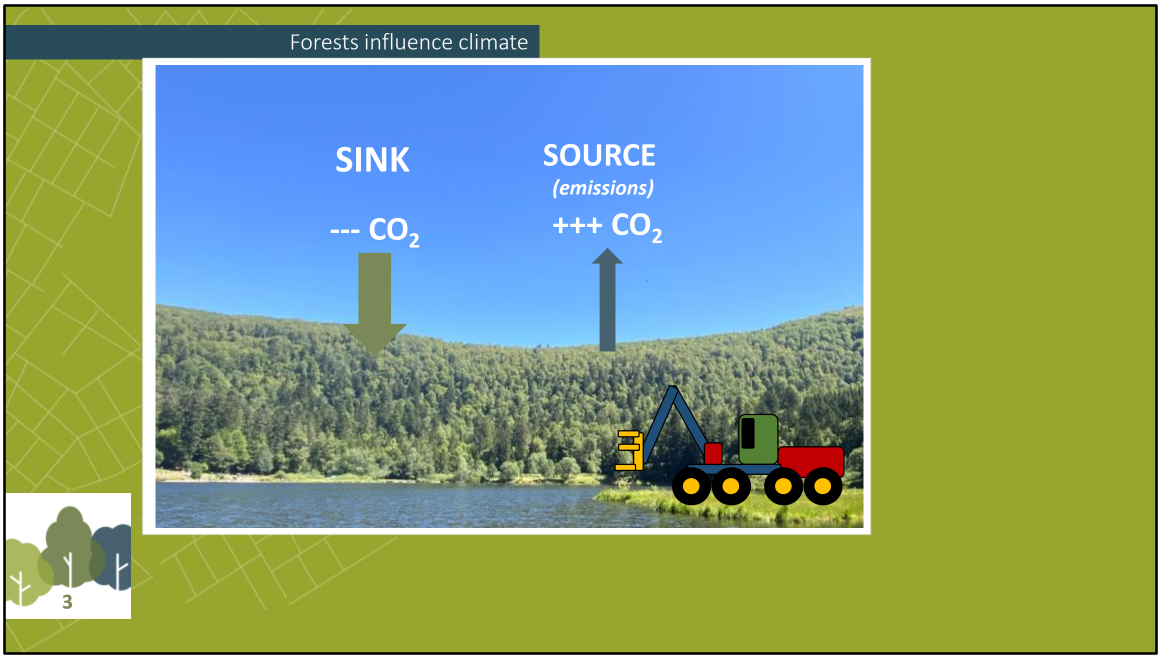


Forests influence the climate

We have already mentioned the important climate services provided by forests, which act as carbon sinks. They contain carbon, in the wood, the trunks, and the soil.

So you might think that the best way to maximize the role of forests on climate would be to stop harvesting wood, to maximize the carbon stock of forests.

The reality is a bit more complex than that.



Forests influence climate

SINK

--- CO_2

SOURCE

(emissions)

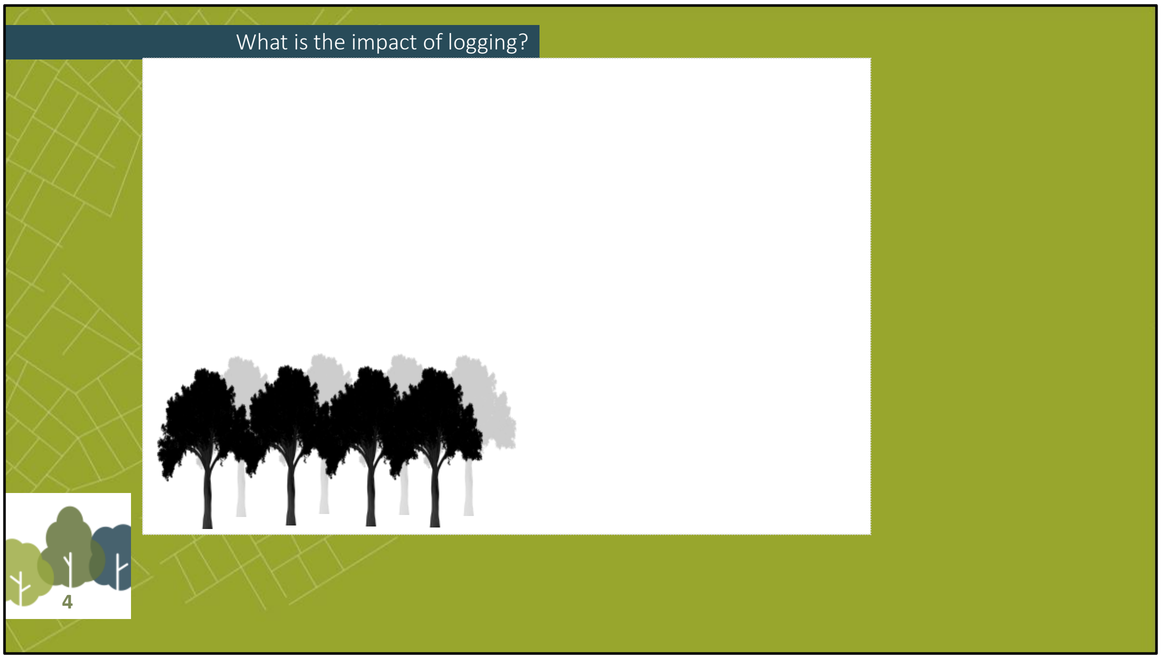
+++ CO_2

In fact, the main thing is the balance between forest production, i.e. CO2 emissions:

These emissions are recorded as positive by international accounting standards even if their impact is negative.

And the inputs, thanks to the photosynthesis carried out by the forests and their sponge effect on carbon, will be accounted for as negative.

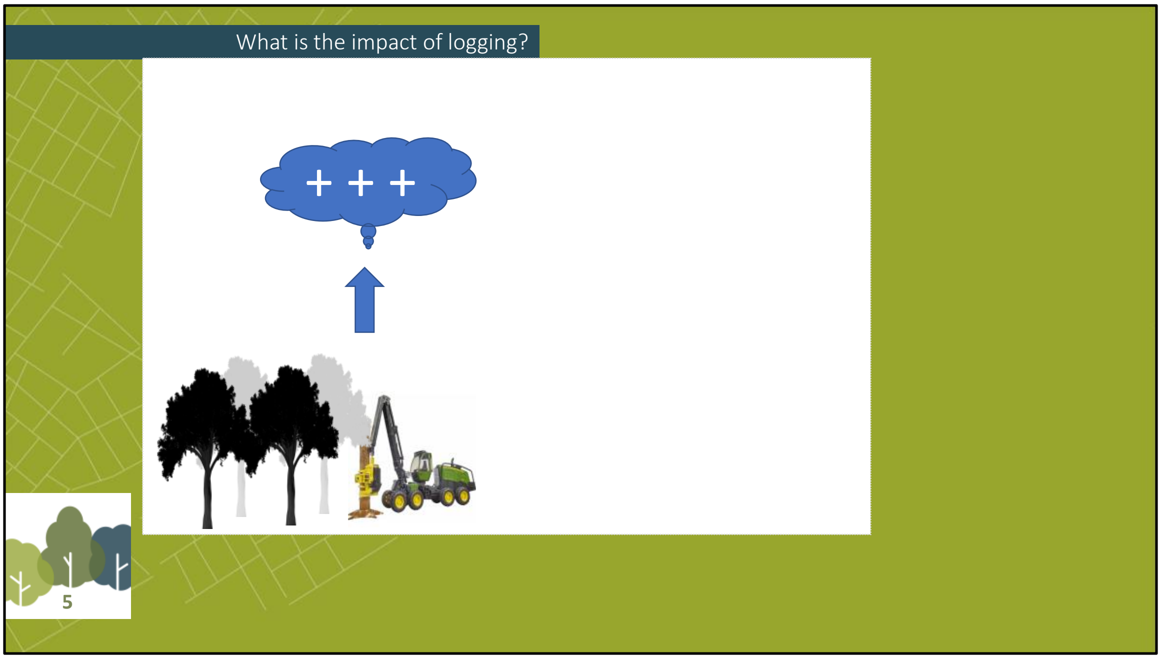
We thus want to have a negative carbon balance between inputs and outputs!



What is the impact of logging?

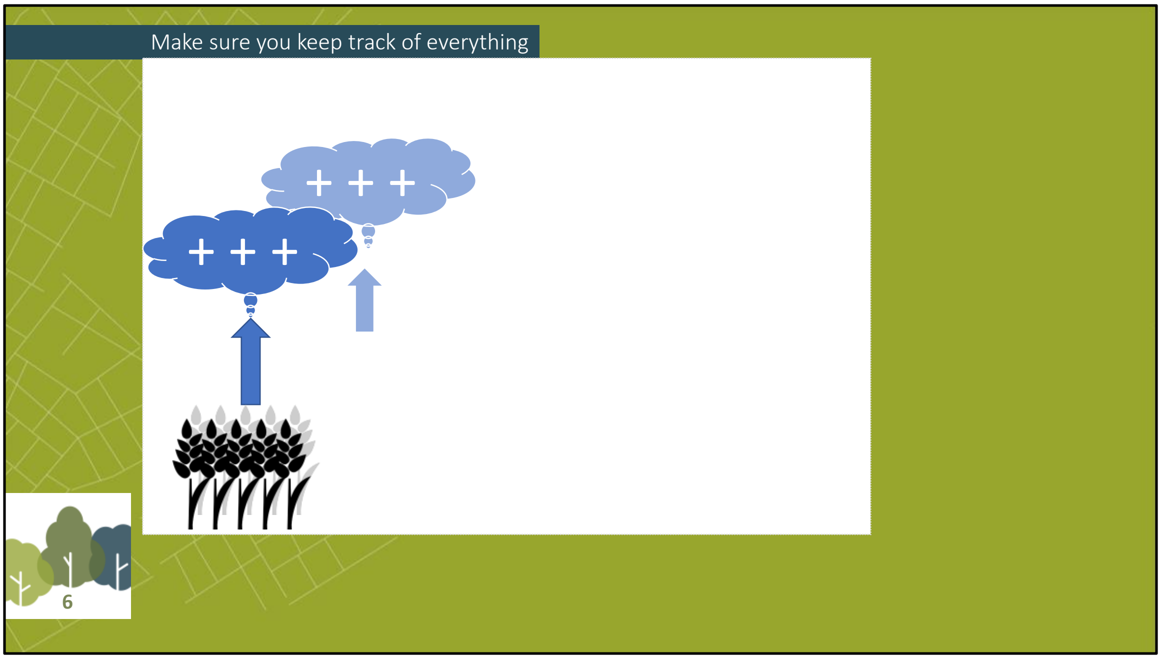
But why are there positive and negative emissions from forests? When we harvest wood, machines and engines also emit CO2 that must be included in the equation.

Let's look at this in more detail: here is a forest.



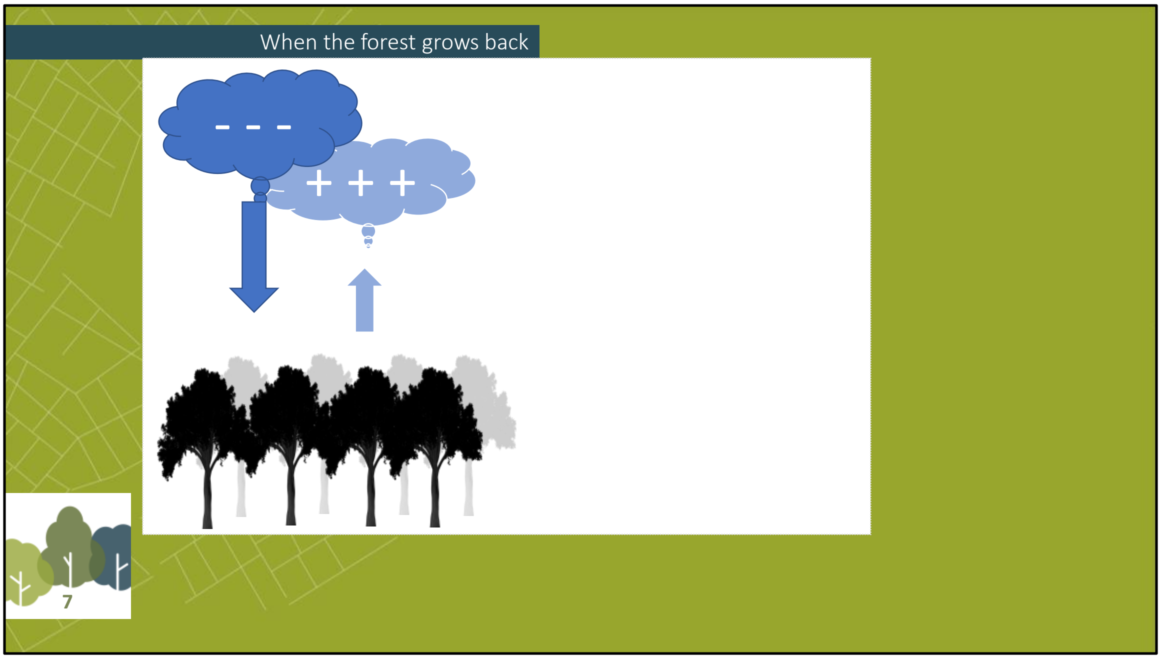
What is the impact of logging?

Timber harvesting will result in GHG emissions, as will any human activity.



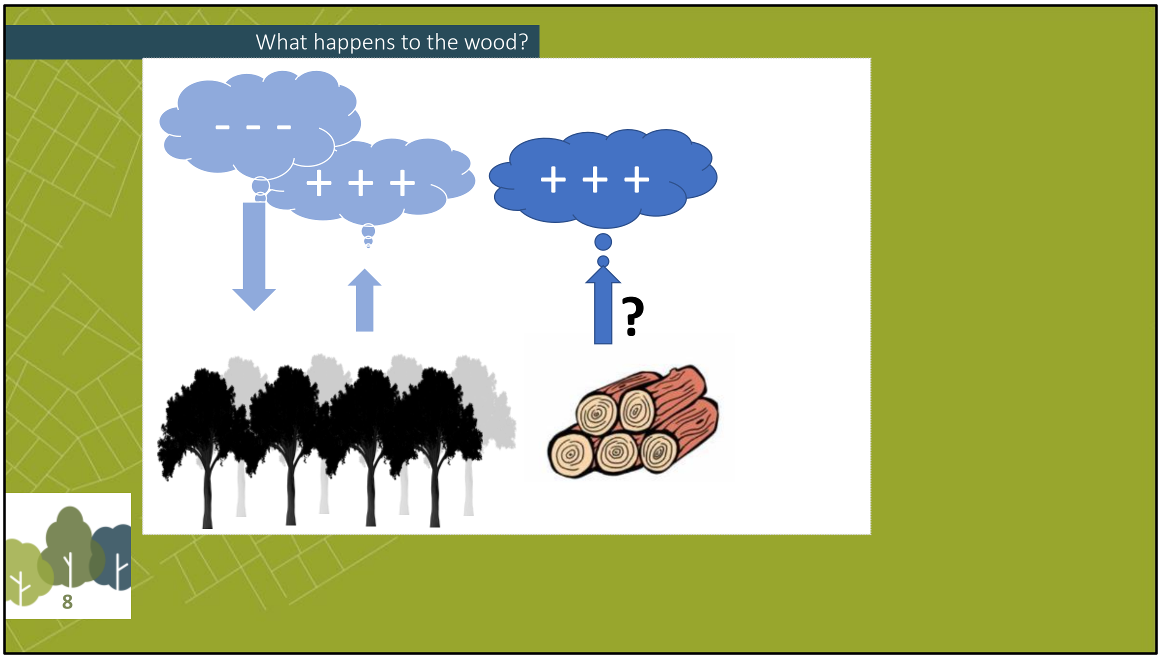
Make sure you keep track of everything

If the plot is not **reforested** after harvest and its **use is changed**, for example, replaced by agriculture, emissions **will increase significantly**, because, as we know, agricultural practices emit greenhouse gases, which will add to the carbon balance.



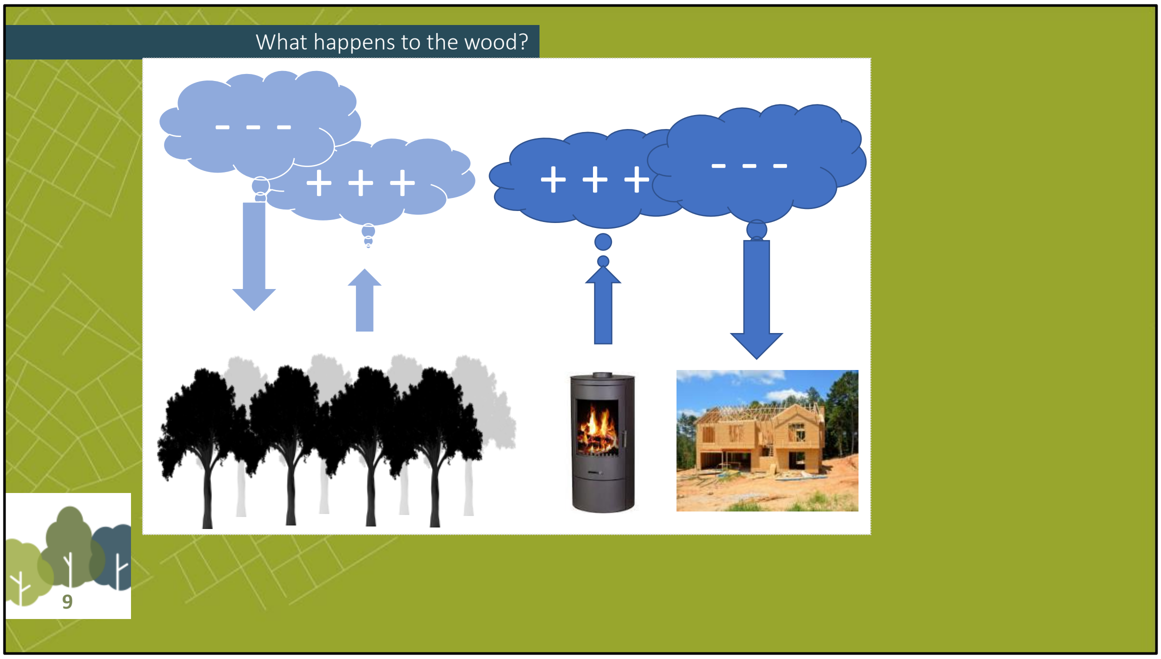
When the forest grows back

If we **regenerate the forest**, as it grows, it will act as a **carbon sink** by absorbing CO2 from the atmosphere. The balance will be more negative.



Now let's look at what happens to the wood harvested from the forest.

If we are hasty in our thinking, we might think that since it came out of the forest, it must have emitted GHGs,



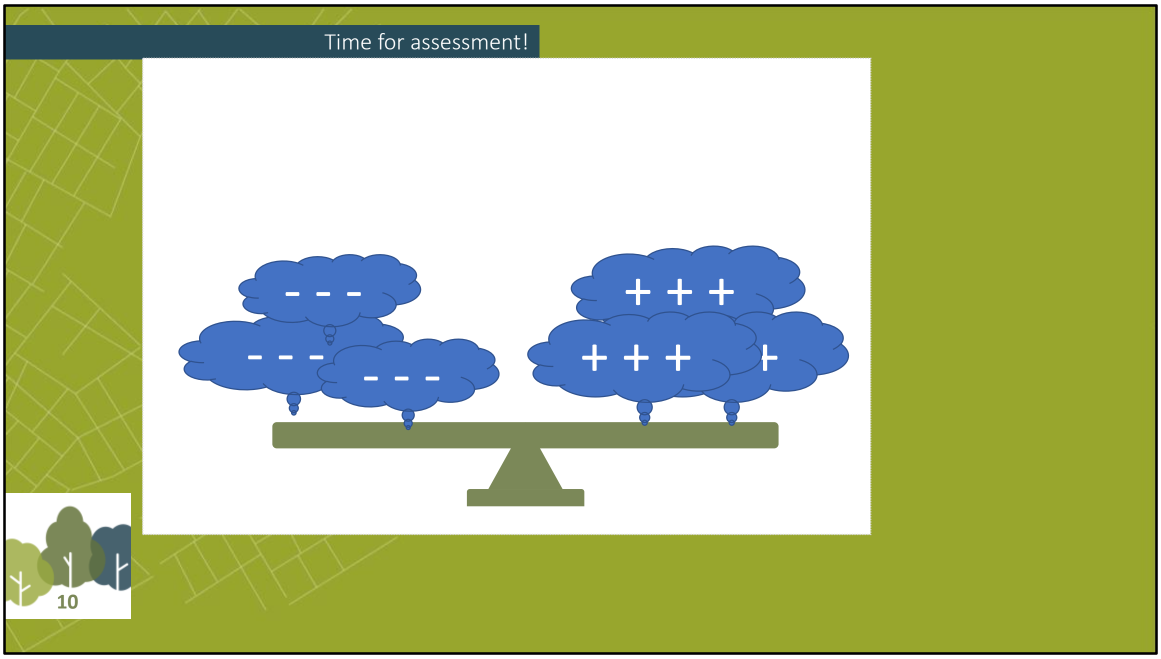
What happens to the wood?

This is obviously true if it is used directly and entirely as firewood.

However, if not all of it is burned, but the wood is used to make long-lasting products, the CO2 will be stored in the product.

Please note that this is carbon storage, not sequestration! Wood products, like this house, are incapable of photosynthesis!

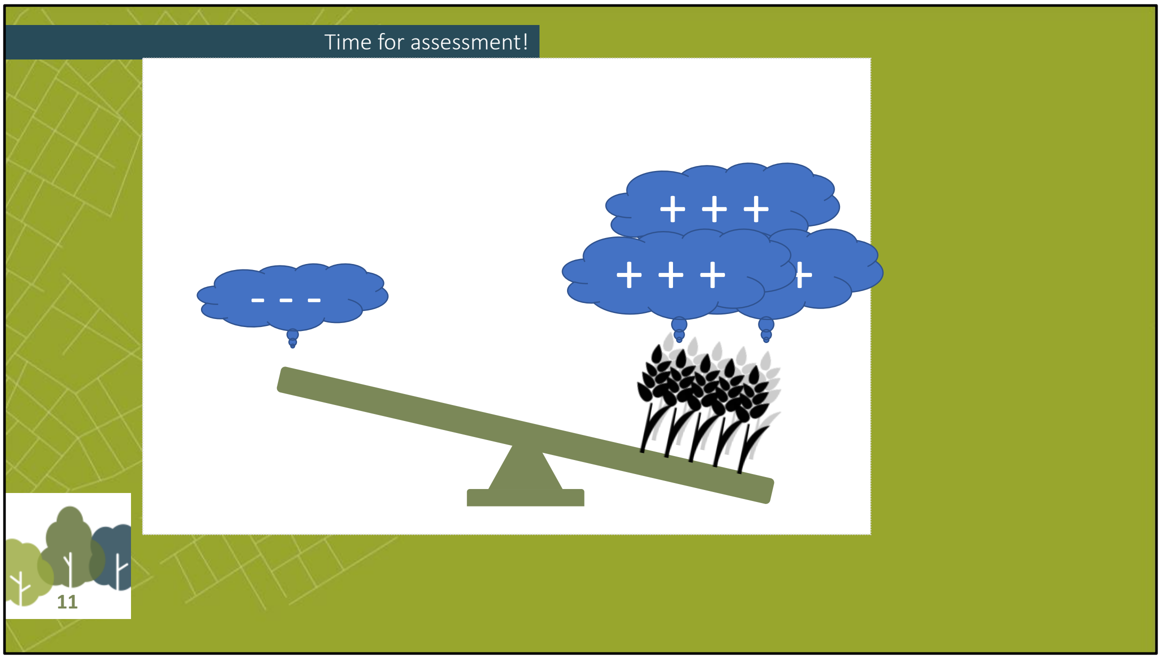
The arrow that goes towards the house is there to show that, from our pile of harvested wood, a part of the carbon is stored in the house, as it would be in the forest, and that we can therefore count it as negative.



Time for assessment!

Let's now look at all the CO2 bubbles:

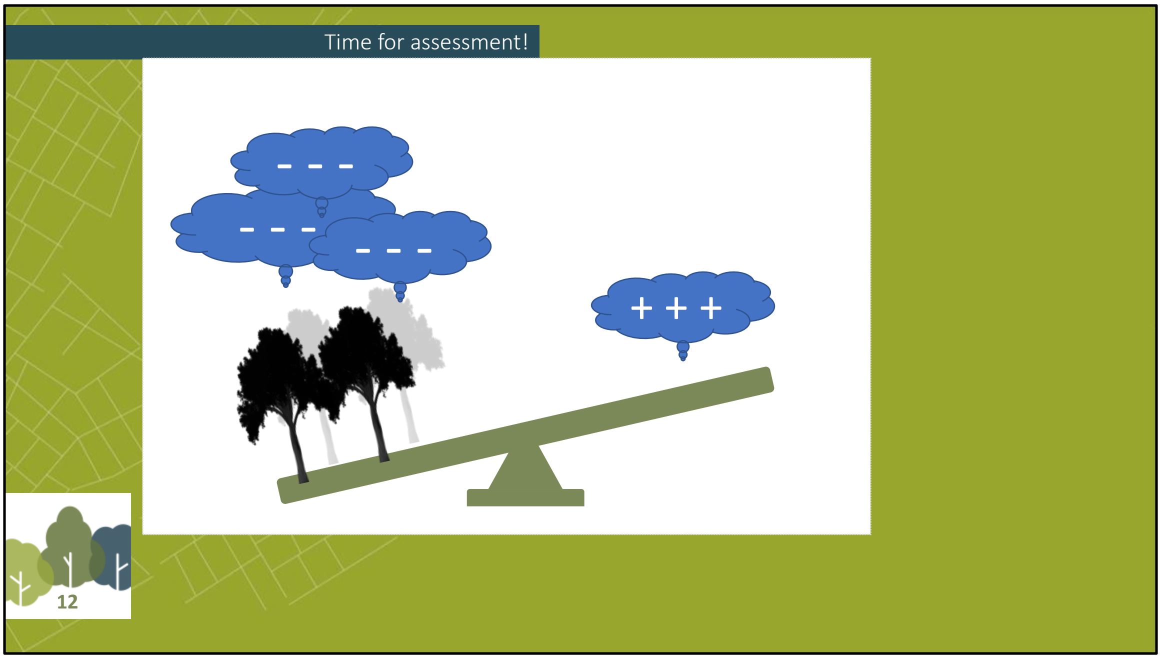
- Those that enter the atmosphere: positive emissions.
- Those that leave the atmosphere and enter the forest, the carbon sink that will try to compensate for the emissions.



Time for assessment!

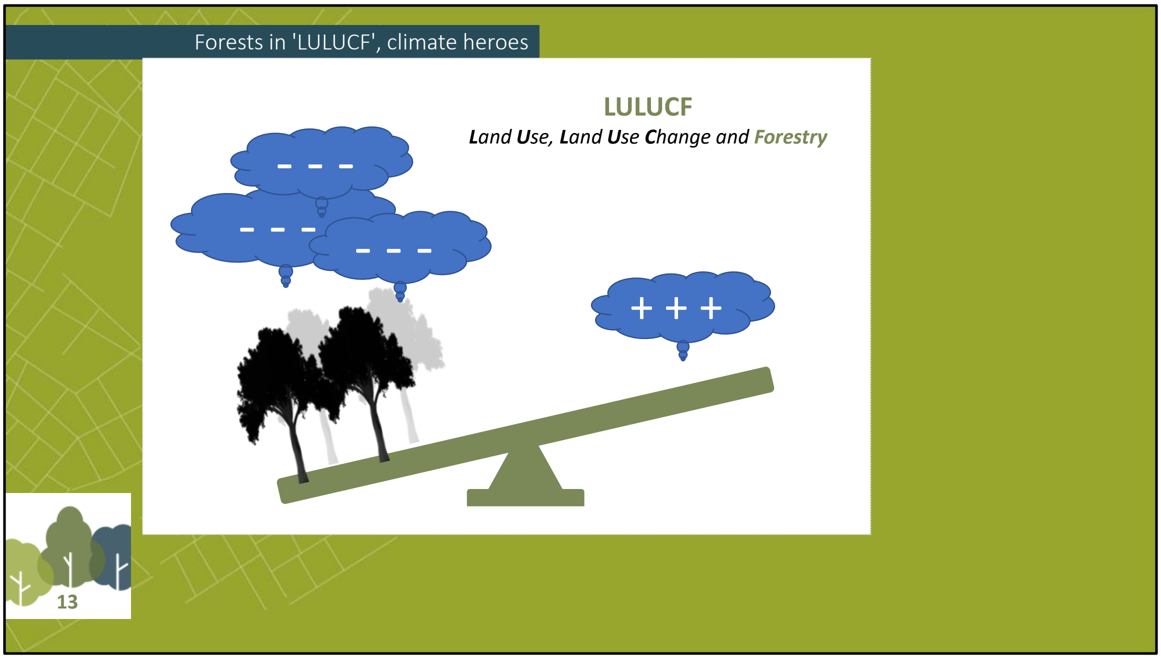
Emissions can be higher, as is often the case with deforestation.

In this case, the balance is positive and the impact on the climate is therefore negative.



Time for assessment!

But forests can also have a positive impact on climate.



Forests in 'LULUCF', climate heroes

LULUCF

Land Use, Land Use Change and Forestry

In this case, the LULUCF (Land Use, Land Use Change and Forestry) sector is a carbon sink.

It is the only sphere of human activity that manages to have negative emissions thanks to the forest.

Kyoto Protocol

VIDEO / 01 MAR, 2015

COP21 - Ensemble nous pouvons ecrire l'histoire

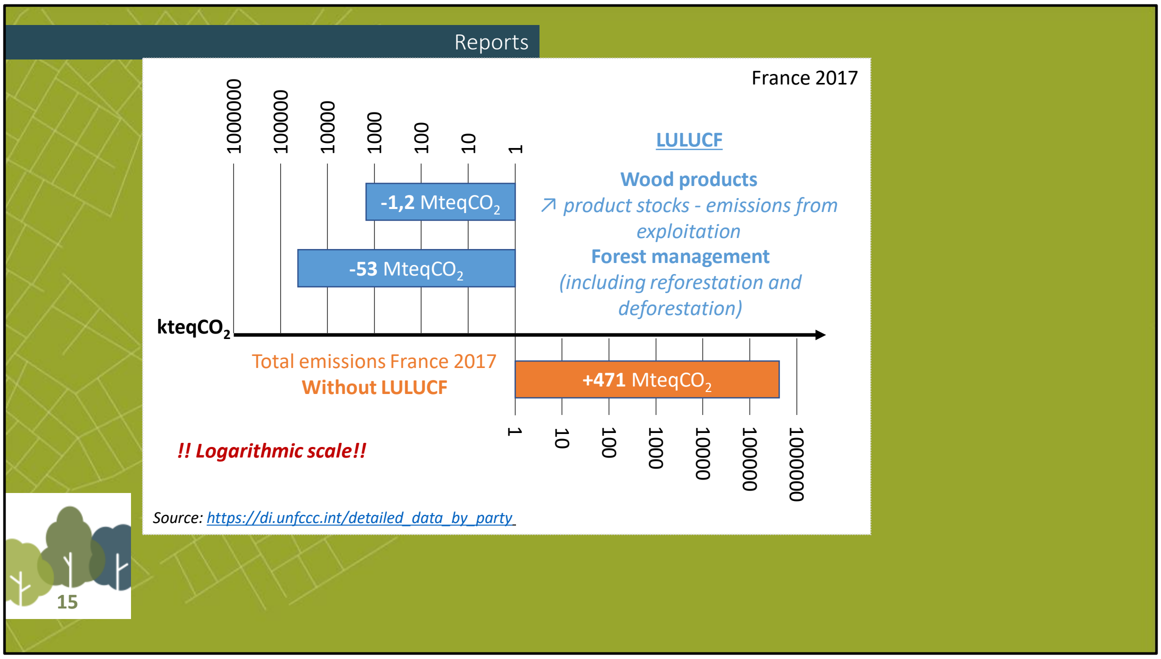
“Together we can make history”

Why is it so important to quantify our emissions?

Because there is an urgent need to reduce them; to do so we need to know what to reduce.

In the **Kyoto Protocol**, and now in the **Paris Agreement**, we committed to **reducing our emissions**, and we also committed to **reporting them**.

Every year, countries that are signatories to these agreements report their emissions in all sectors, including LULUCF. This translates into **national accounting systems.**



Reports

France 2017

-1,2 MteqCO_2

-53 MteqCO_2

+471 MteqCO_2

LULUCF

Wood products

↗ product stocks - emissions from exploitation

Forest management

(including reforestation and deforestation)

Total emissions France 2017

Without LULUCF

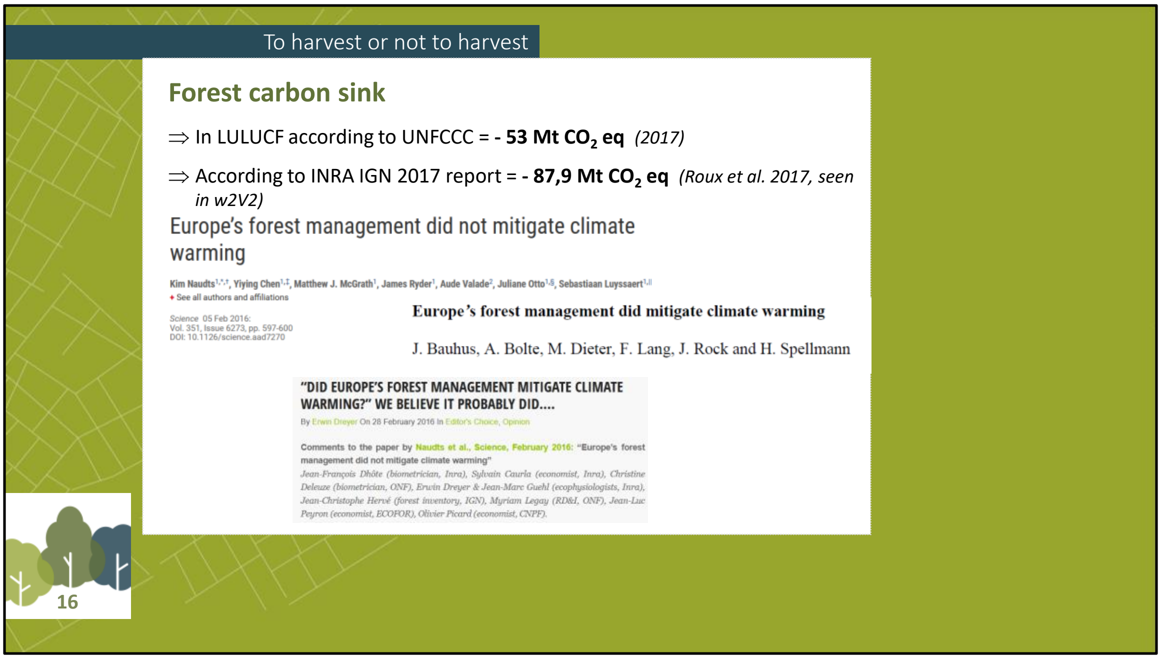
!! Logarithmic scale!!

Source: https://di.unfccc.int/detailed_data_by_party

Since 1990, France, like all committed countries, has reported its GHG emissions balance from all sectors, including forests, every year.

This 2017 data shows that **forest management is a huge carbon sink**.
Carbon stocks in wood products are also increasing, enough to offset emissions from forest harvesting.

Please note that this is a log scale graph, as the carbon storage in wood products is tiny compared to the balance of forest management.
However, the graph also shows the magnitude of the forest and wood products carbon sink relative to the overall emissions of all other sectors: transportation, industry, energy... this sink represents 11% of their emissions. Don't think that the forest exempts you from living more sustainably, you have to reduce this big orange bar of emissions.



To harvest or not to harvest

Forest carbon sink

⇒ In LULUCF according to UNFCCC = **- 53 Mt CO_2 eq** *(2017)*

⇒ According to INRA IGN 2017 report = **- 87,9 Mt CO_2 eq** *(Roux et al. 2017, seen in w2V2)*

Europe's forest management did not mitigate climate warming

Kim Naudts[1,*,†], Yiying Chen[1,‡], Matthew J. McGrath[1], James Ryder[1], Aude Valade[2], Juliane Otto[1,§], Sebastiaan Luyssaert[1,||]
+ See all authors and affiliations

Science 05 Feb 2016:
Vol. 351, Issue 6273, pp. 597-600
DOI: 10.1126/science.aad7270

Europe's forest management did mitigate climate warming

J. Bauhus, A. Bolte, M. Dieter, F. Lang, J. Rock and H. Spellmann

"DID EUROPE'S FOREST MANAGEMENT MITIGATE CLIMATE WARMING?" WE BELIEVE IT PROBABLY DID....

By Erwin Dreyer On 28 February 2016 In Editor's Choice, Opinion

Comments to the paper by Naudts et al., Science, February 2016: "Europe's forest management did not mitigate climate warming"
Jean-François Dhôte (biometrician, Inra), Sylvain Caurla (economist, Inra), Christine Deleuze (biometrician, ONF), Erwin Dreyer & Jean-Marc Guehl (ecophysiologists, Inra), Jean-Christophe Hervé (forest inventory, IGN), Myriam Legay (RD&I, ONF), Jean-Luc Peyron (economist, ECOFOR), Olivier Picard (economist, CNPF).

As we see, in 2017, France reported a forest carbon sink of -53 M tons of CO2 equivalent.
In fairness, other data showed an estimate of -88 M tons of CO2 equivalent absorbed by French forests.

The remaining 35 M tons show that the accounting rules are very complex and that the methodological choices can lead to scientific controversies.
Here, three scientific papers debate the role of forests in global warming.

The underlying and unresolved question is:

« **Should we collect more wood or let forests store carbon instead?** »

Substitution

OIL

WOOD

PVC

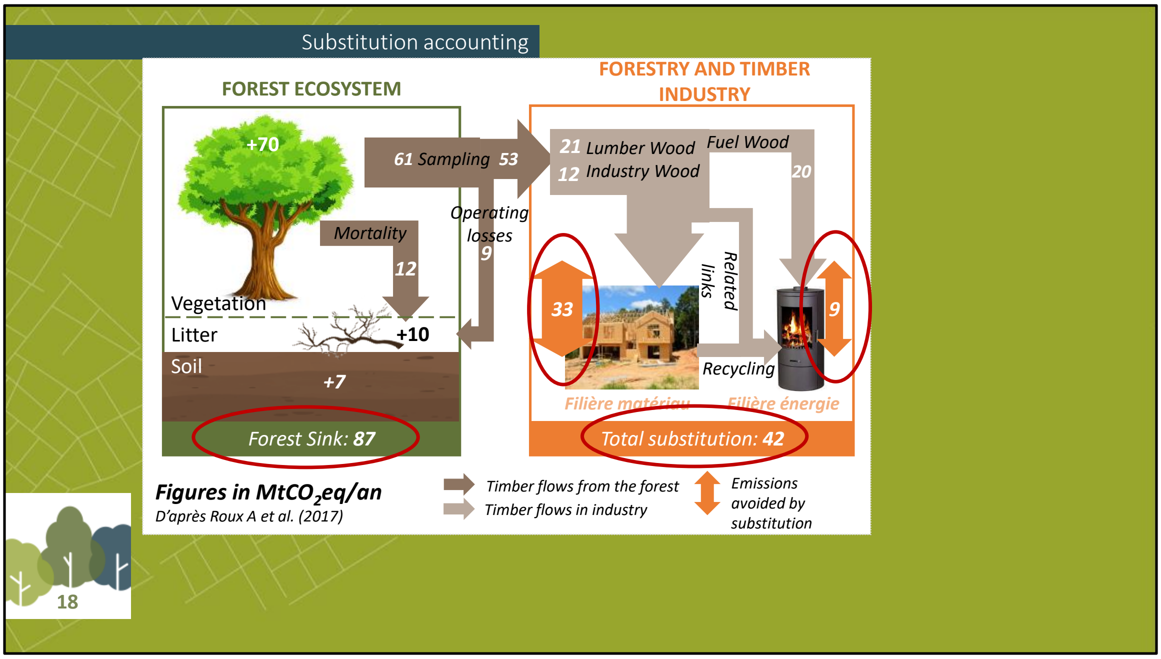
WOOD

This is where the substitution effect comes in and adds complexity to our reasoning. Yet, this is what will make the use of wood very interesting for the climate.

Using fossil fuels such as coal or oil removes carbon from the subsoil and releases it into the atmosphere. This destocking is responsible for global warming.

Using wooden products, fuel wood, or wooden materials instead of similar requiring more fossil fuels, avoids emissions, and is called substitution.

Installing a wooden window, instead of a PVC one, or heating homes with wood instead of fuel, is good for the climate.
And thus, as we keep count of the emissions of each product, we can thus calculate and compare the amount of avoided emissions.



Substitution accounting

Figures in $\boldsymbol{MtCO_2eq/an}$

D'après Roux A et al. (2017)

This substitution effect is quite significant.

The graph here, which you saw in week 2, shows the global carbon accounting of French forests from IGN-INRAe's 2017 report.

On the right hand side, the **forest sink**, which amounts to **87,9 Mt eq** $\mathbf{CO_2}$ **/ year**.

On the left hand side, we can see the **avoided fossil emissions** thanks to wood products: **fuelwood** saved **9,1 Mt eq** $\mathbf{CO_2}$ and overall **32,8 Mt eq** $\mathbf{CO_2}$ were avoided thanks to **material substitution,** that is from lumber and industry wood.

CONCLUSION

Forests **sequester carbon,**
+ timber usage **stores it in the materials**
+ avoids emitting carbon by substituting **less environmentally friendly energy and materials**

Carbon accounting is a complex science.
Rigorous (and constantly improving) methods allow countries committed to the Kyoto Protocol and the Paris Agreements to keep track of what they emit.

The forestry sector is the only one working as a carbon sink.

Deciding on the best management and harvesting scenario to optimize the carbon service offered by European forests is a debate**, with scientific controversies**

On a global scale, **countering deforestation** continues to be a **key challenge.**

Sources

Lien sur les données UNFCCC sur les émissions :
https://di.unfccc.int/detailed_data_by_party

Une vidéo (en anglais) sur LULUCF :
www.youtube.com/watch?v=NOU1bJqfmoQ

Site web UNFCCC
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Roux A et al. 2017 Quel rôle pour les forêts et la filière forêt-bois françaises dans l'atténuation du changement climatique? Une étude des freins et leviers forestiers à l'horizon 2050. Rapport d'étude pour le Ministère de l'agriculture et de l'alimentation, INRA et IGN, 101 p. + 230 p. (annexes).

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Photographies

Nicolas BILOT Prosilva

www.youtube.com/watch?v=NOU1bJqfmoQ

https://unfccc.int/fr/process-and-meetings#:0c4d2d14-7742-48fd-982e-d52b41b85bb0:adad877e-7830-4b8b-981a-5cdd34249c9d

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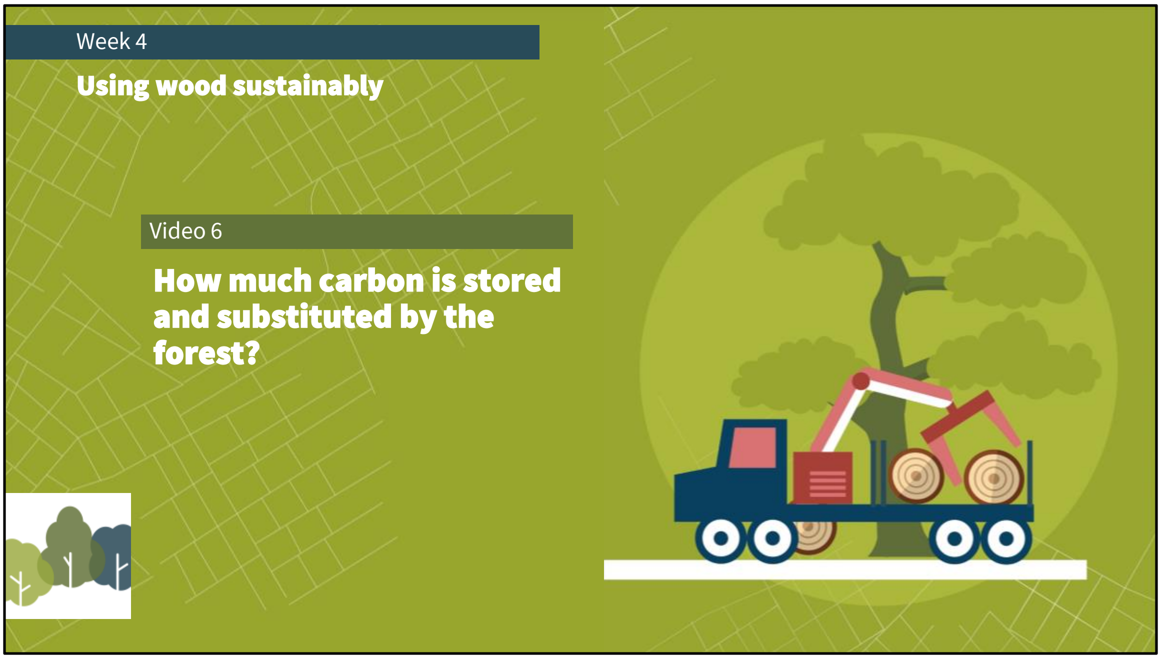


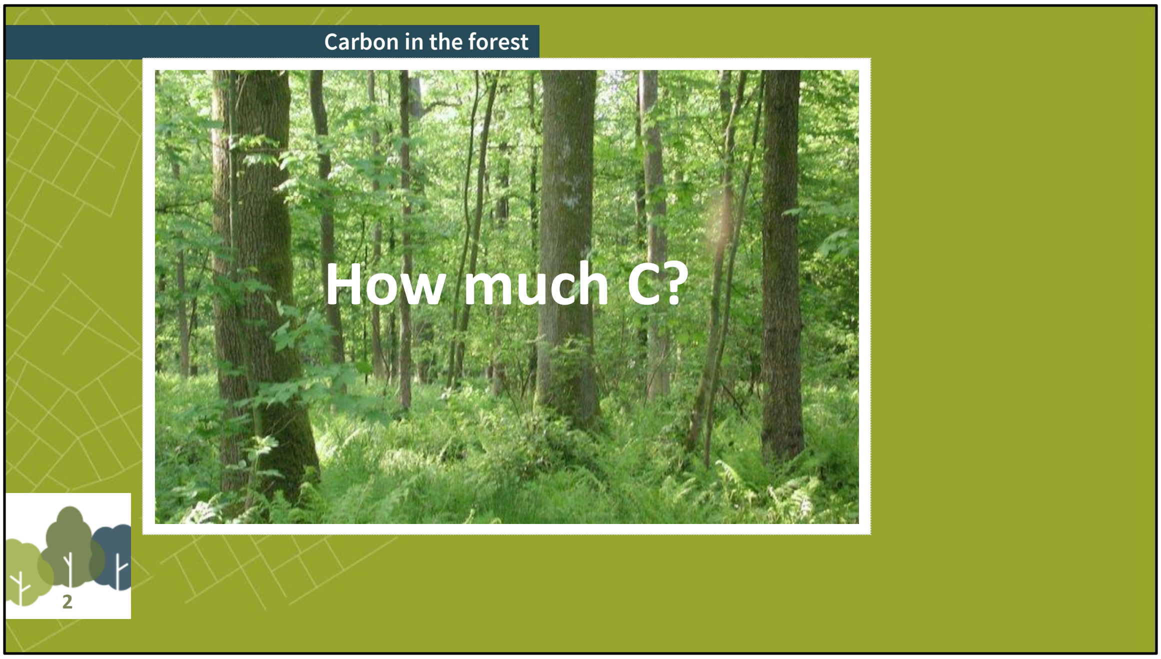
Week 4

Using wood sustainably

Video 6

How much carbon is stored and substituted by the forest?

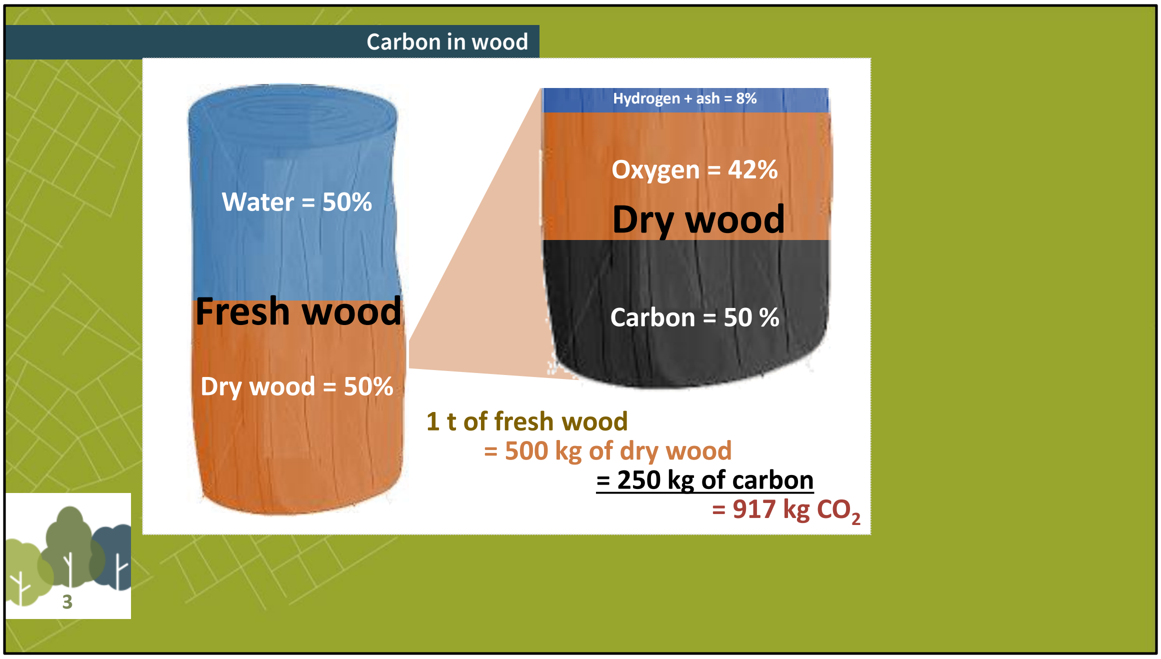
In this video, after discussing carbon inventory at the scale of annual forest sector emissions, we will go into detail about the carbon contained in a growing and harvested forest to compare different management approaches.



Carbon in the forest

How much C?

I present you this forest. How many tons of carbon does it contain?



Carbon in wood

Water = 50%

Fresh wood

Dry wood = 50%

Hydrogen + ash = 8%

Oxygen = 42%

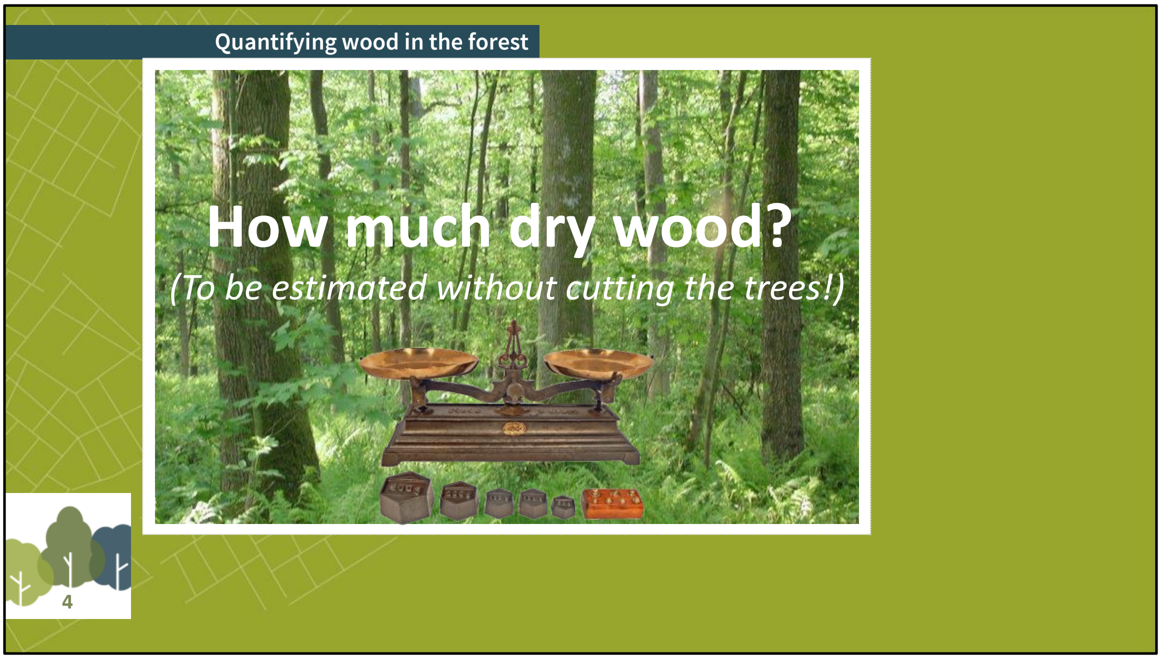
Dry wood

Carbon = 50 %

1 t of fresh wood
= 500 kg of dry wood
= 250 kg of carbon
= 917 kg CO_2

Here’s a first clue. A ton of fresh wood is about 50% water and 50% dry wood. And dry wood is 50% carbon.

So for one ton of fresh wood, you have 250 kg of carbon.



Quantifying wood in the forest

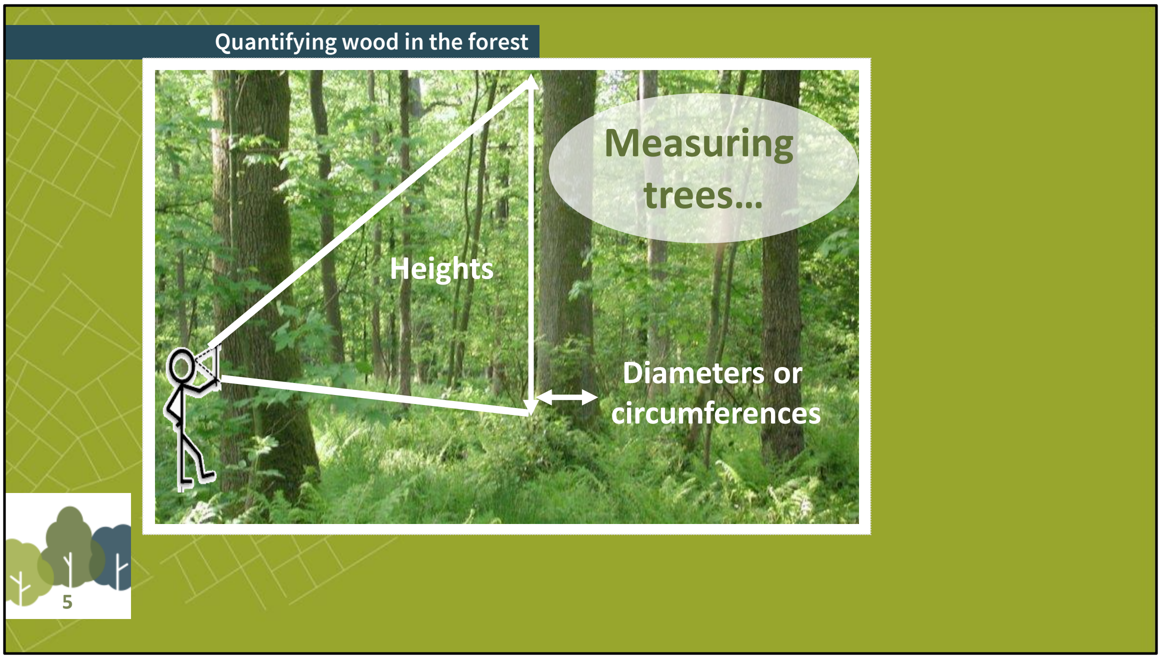
How much dry wood?

(To be estimated without cutting the trees!)

So the challenge is to figure out how many tons of dry or fresh wood are in my forest.

Let's cut all the trees in this forest, dry them and weigh them, what do you think?

This is of course ridiculous and out of the question.



Quantifying wood in the forest

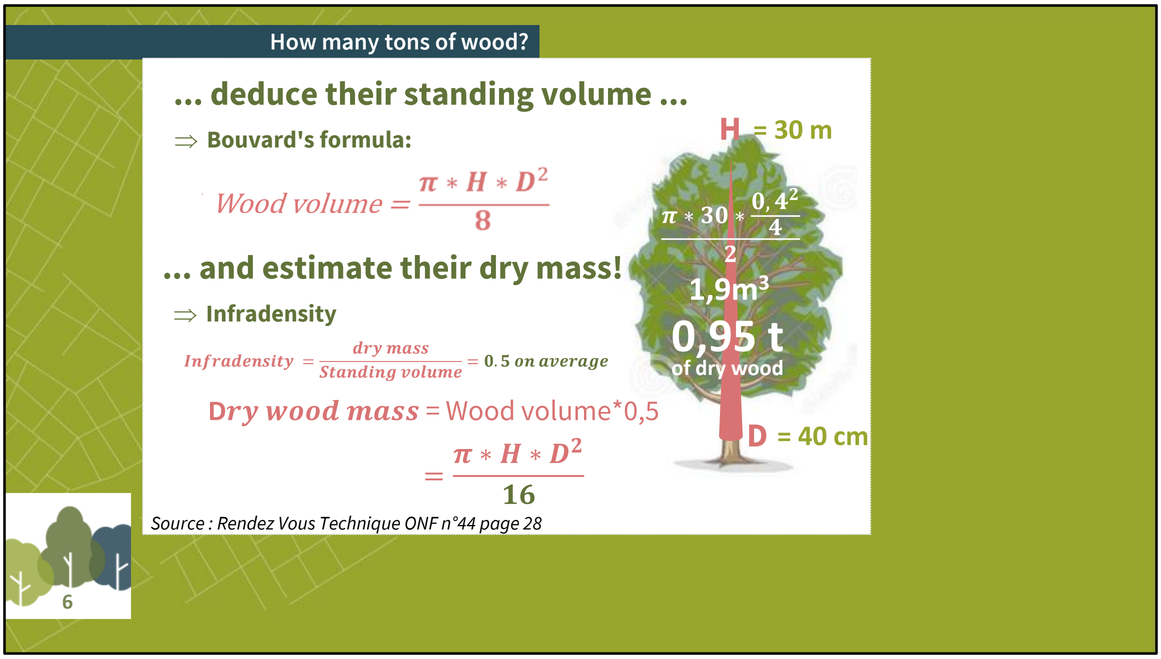
Measuring trees…

Heights

Diameters or circumferences

I’m not allowed to cut these trees so, what should I measure?

Well, remember week 1? I can measure: heights, diameters or circumferences, basal areas.



How many tons of wood?

... deduce their standing volume ...

⇒ **Bouvard's formula:**

$$Wood\ volume = \frac{\pi * H * D^2}{8}$$

... and estimate their dry mass!

⇒ **Infradensity**

$$Infradensity = \frac{dry\ mass}{Standing\ volume} = 0.5\ on\ average$$

$\mathbf{Dry\ wood\ mass}$ = Wood volume*0,5

$$= \frac{\pi * H * D^2}{16}$$

Source : Rendez Vous Technique ONF n°44 page 28

H = 30 m

$$\frac{\pi * 30 * \frac{0,4^2}{4}}{2}$$

1,9m³

0,95 t

of dry wood

D = 40 cm

We will now move on from the dimensions to the total volume of aboveground wood, branches and trunks.

Here is a tree whose diameter and height are known

I can calculate the volume of the cylinder that has this height and diameter.

It's π*H*D^2/4 (that's just math, not forestry!).

Question now. This cylinder which has the same diameter at breast height as the trunk and the total height of the tree, does it represent a larger or smaller volume than the trunk and branches of the tree?

Not necessarily intuitive; some think it is more because of the branches, while others that it is less because of the trunk which is conical.

Well it is less, and we can even show that it is on average quite exactly half. Don't forget that the trunk is very conical, the diameter decreases a lot when you climb and the branches don't compensate.

And so: total aboveground volume = π*H*D^2/8 .

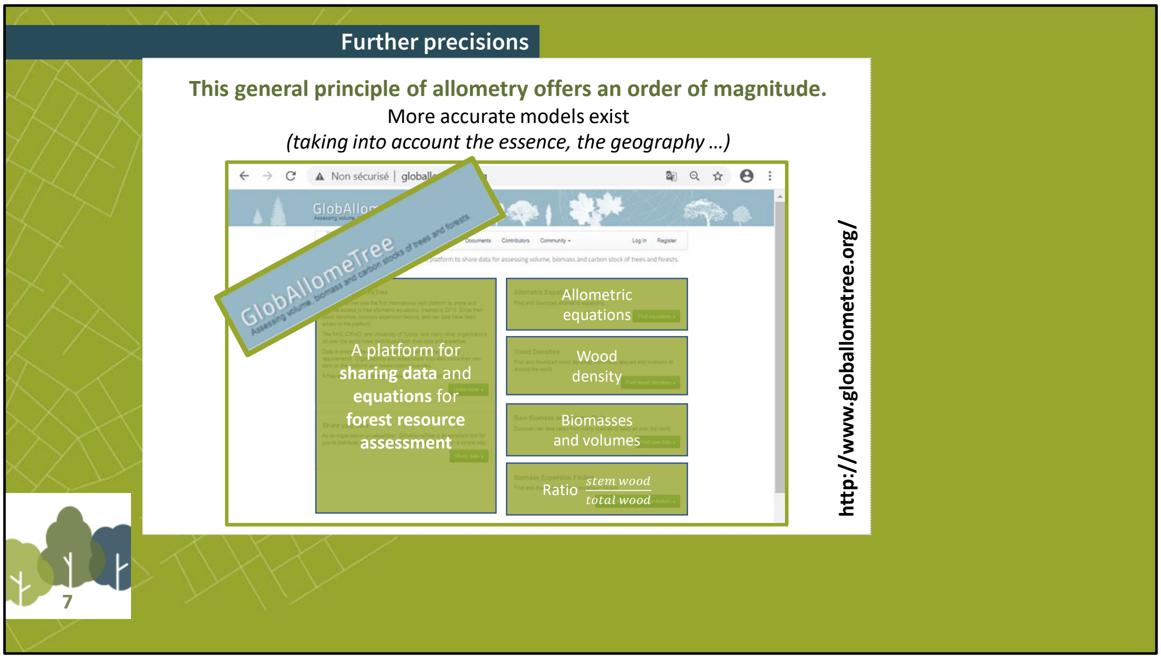
This formula is called an **allometric equation**. It was formulated by a forester, Mr. Bouvard.

Once the volume is obtained, to move on to the mass of dry wood, we need to know how much this volume weighs in terms of dry wood.

This is called the **infradensity**, which is the mass of dry matter in a unit volume of fresh wood, a sort of water-free density compared to the density of water (above 1, dry wood does not float).

The infradensity of wood is generally considered to be about 0.5 (although it varies greatly from species to species).

To obtain the mass of dry wood in tons, the total volume in m3 is multiplied by 0.5. A small numerical example on this slide for a tree of 30m in height and 40cm in diameter, there will be 1.9 m3 of wood and 0.95 tons of dry wood.



Further precisions

This general principle of allometry offers an order of magnitude.

More accurate models exist

(taking into account the essence, the geography …)

A platform for **sharing data** and **equations** for **forest resource assessment**

Allometric equations

Wood density

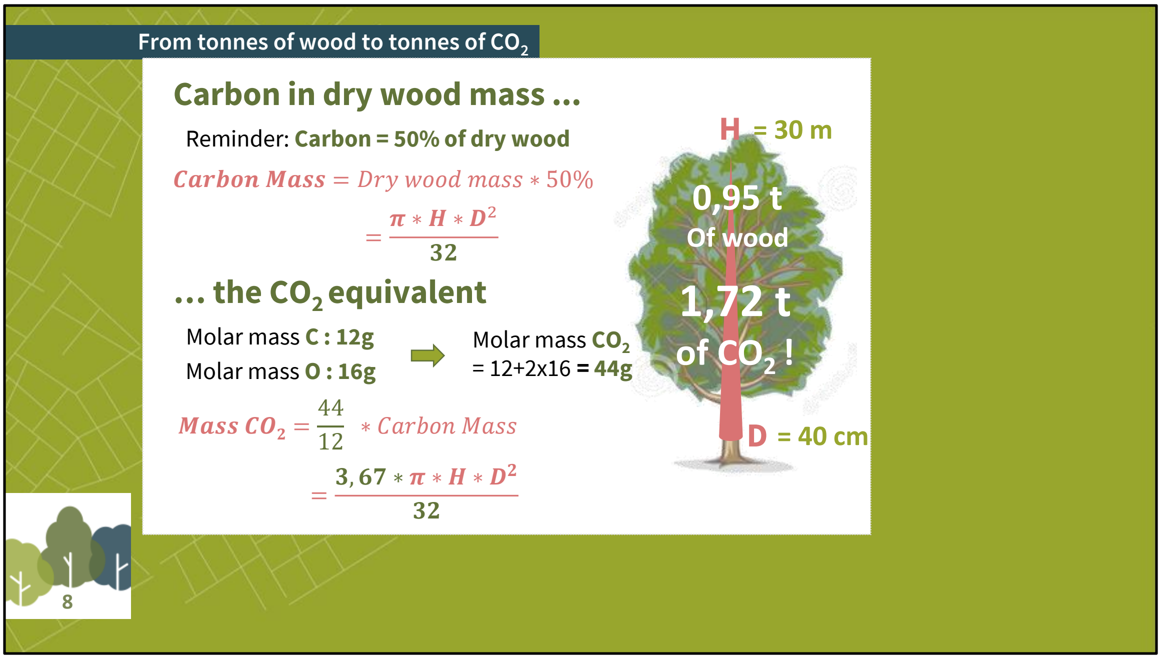
Biomasses and volumes

Ratio $\frac{stem\ wood}{total\ wood}$

http://www.globallometree.org/

These simple formulas (the volume of the cylinder divided by 4) provide a pretty good estimate, whatever the species.

However, if you want to make more precise calculations, to differentiate an oak from a chestnut of the same diameter and height, or an oak in France and in Germany, you can get them from the Globallometree site.



From tonnes of wood to tonnes of CO_2

Carbon in dry wood mass ...

Reminder: **Carbon = 50% of dry wood**

$$Carbon\ Mass = Dry\ wood\ mass * 50\%$$

$$= \frac{\pi * H * D^2}{32}$$

... the CO_2 equivalent

Molar mass **C : 12g**

Molar mass **O : 16g**

➡ Molar mass CO_2 = 12+2x16 = **44g**

$$Mass\ CO_2 = \frac{44}{12} * Carbon\ Mass$$

$$= \frac{3,67 * \pi * H * D^2}{32}$$

H = 30 m

0,95 t Of wood

1,72 t of CO_2 !

D = 40 cm

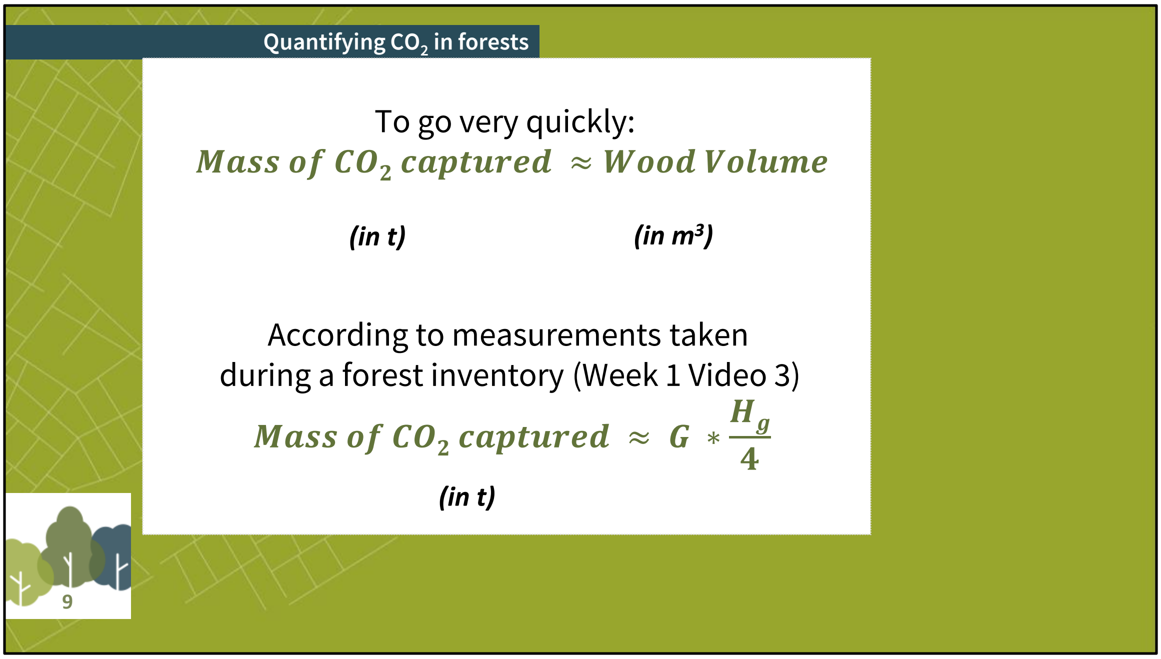
8

You have the mass of dry wood, and you know that the carbon concentration is 50%. You can determine the amount of carbon in a tree of height H and diameter D as follows: π*H*D^2/32.

Now you also know that greenhouse gas emissions are measured in carbon dioxide. How much carbon dioxide is bound by this volume? If you've done any chemistry... you know that in 44 g of CO2, there are 12 g of C. In other words, 1 ton of C from the forest bounds 44/12 = 3.67 tons of CO2.

In the end the amount of CO2 is 3.67 π*H*D^2/32.

And since this coefficient of 3.67, which is almost 4, compensates for the previous divisions by 2, finally the quantity of CO2 in tons is equal to the volume of wood (π*H*D^2/8) in m3.



Quantifying CO_2 in forests

To go very quickly:

$$\text{Mass of } CO_2 \text{ captured} \approx \text{Wood Volume}$$

(in t) ***(in m^3)***

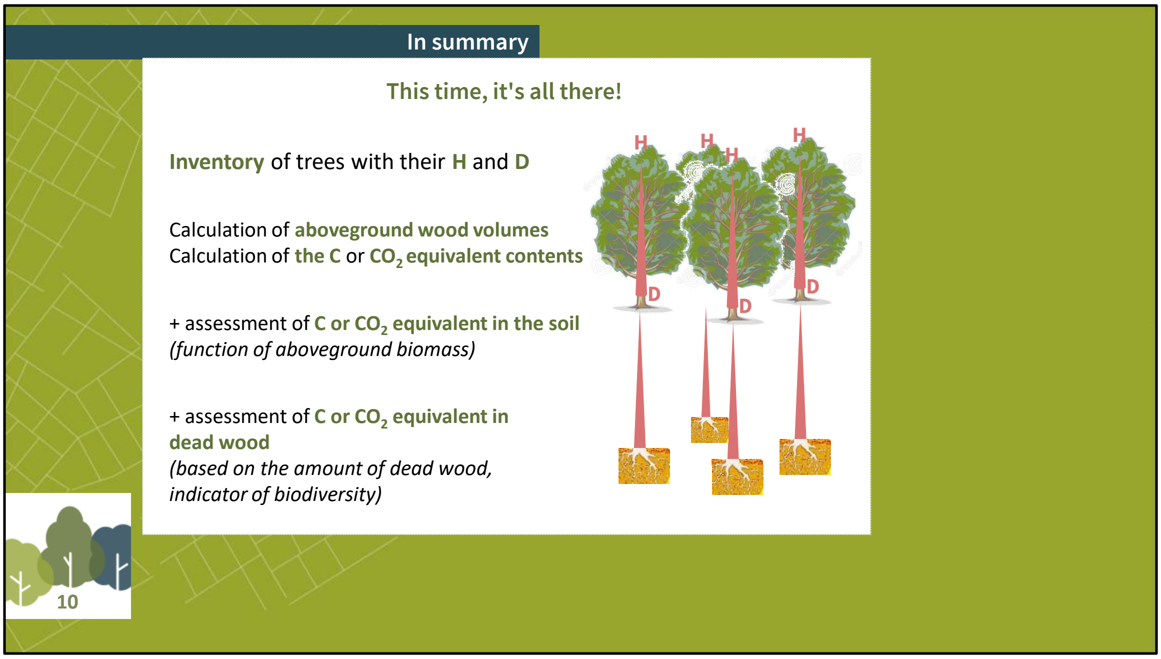
According to measurements taken during a forest inventory (Week 1 Video 3)

$$\text{Mass of } CO_2 \text{ captured} \approx G * \frac{H_g}{4}$$

(in t)

If the calculations make your head hurt, you have the right to remember only that. The volume of wood inventoried in m3 gives you directly the mass of CO2 captured in tonnes.

And if you remember the measurement of basal area G in m2, that basal area multiplied by the stand height divided by 4, it is also a good quick assessment of the volume and CO2 captured at stand level (without the need to measure all the trees and add them up).



In summary

This time, it's all there!

Inventory of trees with their **H** and **D**

Calculation of **aboveground wood volumes**
Calculation of **the C** or **CO_2 equivalent contents**

+ assessment of **C or CO_2 equivalent in the soil**
(function of aboveground biomass)

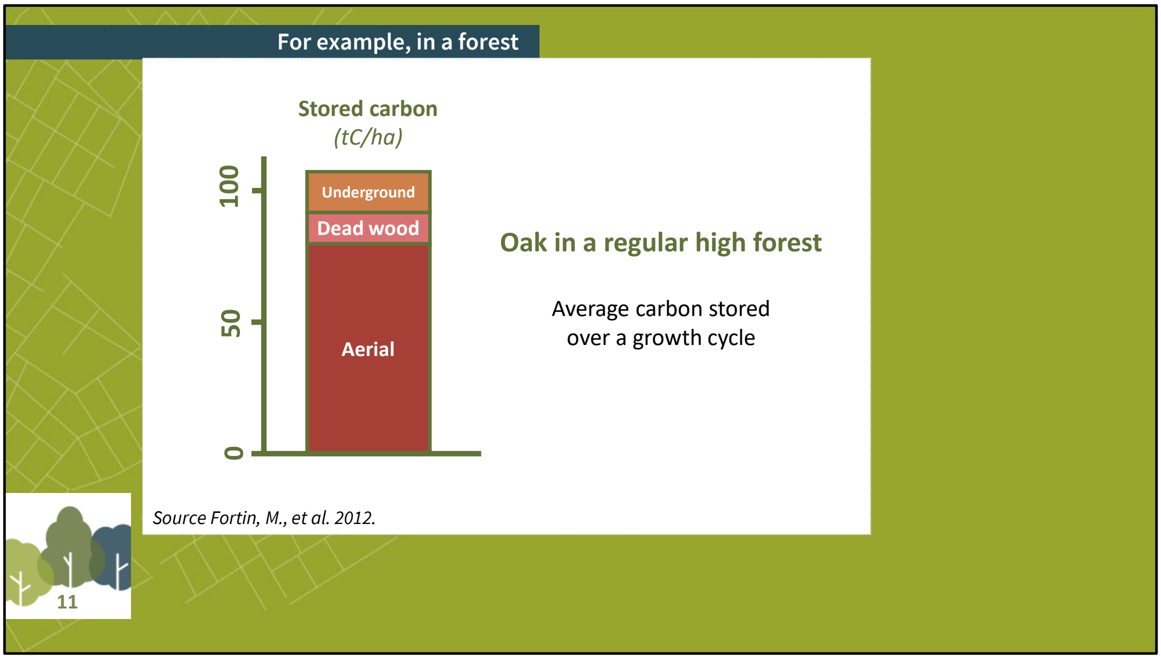
+ assessment of **C or CO_2 equivalent in dead wood**
(based on the amount of dead wood, indicator of biodiversity)

Well, this time, everything is there to evaluate the carbon contained in a forest:

From the trees inventoried in the forest, we can calculate aboveground carbon.

It is necessary to add an evaluation of the carbon contained in the soil (belowground). For lack of better, it is considered as a fraction of the aboveground carbon.

Similarly, the carbon contained in dead wood on the ground is increasingly evaluated in inventories as an indicator of biodiversity.



For example, in a forest

Oak in a regular high forest

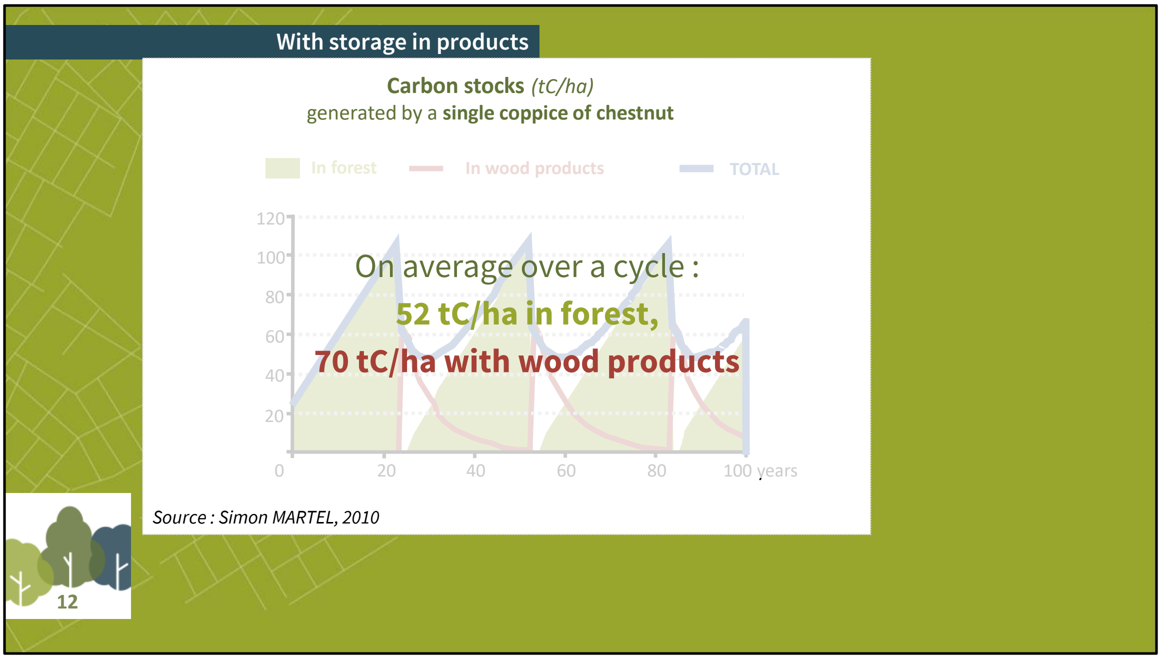
Average carbon stored
over a growth cycle

Source Fortin, M., et al. 2012.

This is an example of a typical oak forest.

The values are an average over the growth cycle.

A small note not included in the video course: the proportion of soil carbon may seem low to you, in fact, what is taken into account is the increase in soil carbon stock linked to the growth cycle of the trees, knowing that the soil, even at the stage of regeneration where the aboveground carbon is almost at zero, continues to be a carbon reservoir.



With storage in products

Carbon stocks *(tC/ha)*
generated by a **single coppice of chestnut**

On average over a cycle :

52 tC/ha in forest,

70 tC/ha with wood products

Source : Simon MARTEL, 2010

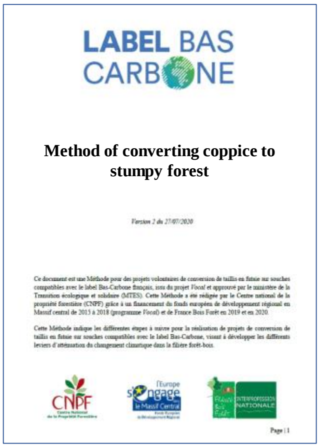
Now an example where we follow the evolution of the stocks in the forest (as the trees grow), but also in the wood products.

Here, we follow a simple chestnut coppice from which parquet, posts, panels and firewood are made.

- In green, the C in the forest including the different compartments.
- In red, the wood products, which represent a certain C storage after harvest and the storage decreases over time as products reach the end of their lifespan.
- In blue the total forest + wood products carbon stock.

On average over a cycle: 52t/ha of carbon stored in the forest (average of the green curve) and 70tC/ha with wood products (average of the total curve in blue)

Change in forestry



LABEL BAS CARBONE

Method of converting coppice to stumpy forest

Version 2 du 27/07/2020

Ce document est une Méthode pour des projets volontaires de conversion de taillis en futaie sur souches compatibles avec le label Bas-Carbone français, issu du projet *Vocal* et approuvé par le ministère de la Transition écologique et solidaire (MTES). Cette Méthode a été rédigée par le Centre national de la propriété forestière (CNPF) grâce à un financement du fonds européen de développement régional en Massif central de 2015 à 2018 (programme *Vocal*) et de France Bois Forêt en 2019 et en 2020.

Cette Méthode indique les différentes étapes à suivre pour la réalisation de projets de conversion de taillis en futaie sur souches compatibles avec le label Bas-Carbone, visant à développer les différents leviers d'atténuation du changement climatique dans la filière forêt-bois.

Page | 1

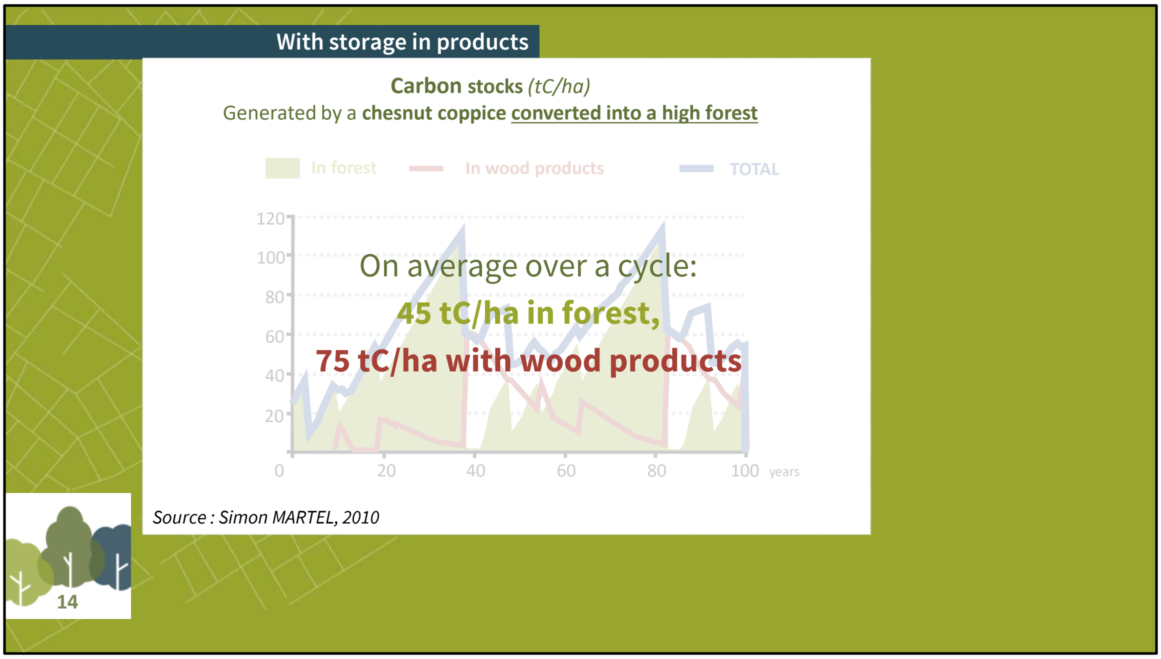
Thierry Néquier © CNPF

Now let's see what happens when we change the management of the forest.

We have just seen a chestnut coppice, what would happen if it were a high forest?

Although the transition is complicated, foresters know which techniques can lead to this type of forest.

But does the change in management allow for more carbon storage?



With storage in products

Carbon stocks *(tC/ha)*

Generated by a **chesnut coppice** **converted into a high forest**

On average over a cycle:

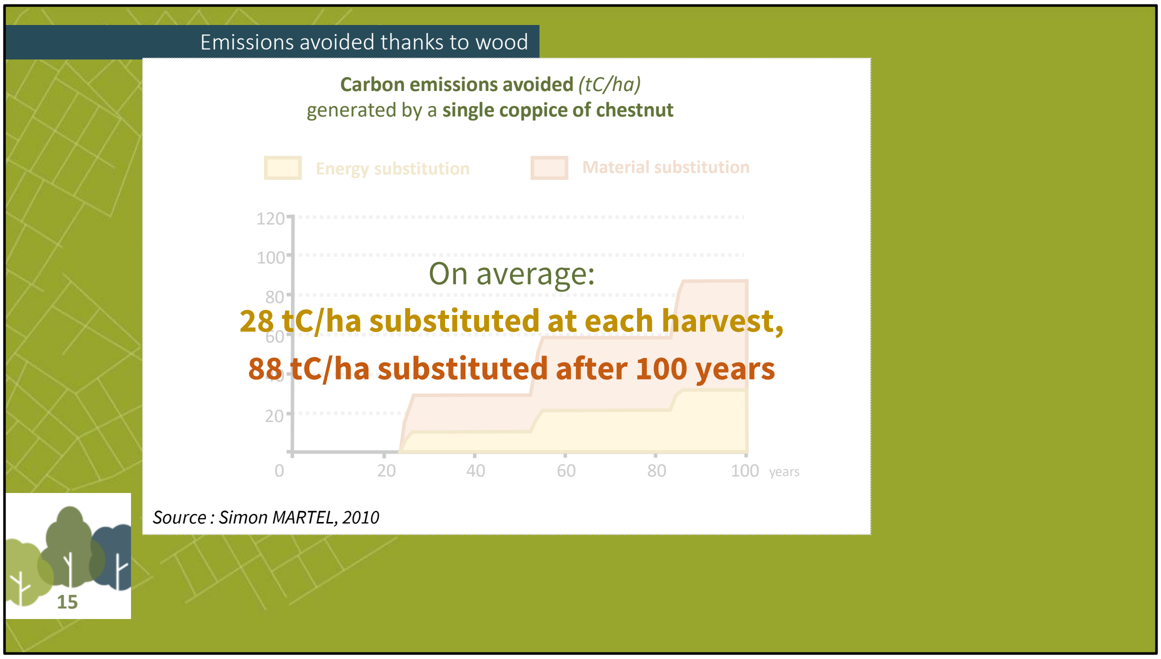
45 tC/ha in forest,

75 tC/ha with wood products

Source : Simon MARTEL, 2010

This is the result of the carbon inventory. We harvest less often over a longer cycle. The reason for this is that we now thin out the trees and do not take out all the wood at once at the final cut.

On average over a cycle, stocks are estimated at **45 t C/ha** in the forest; **75 t C/ha** if wood products are included.



Emissions avoided thanks to wood

Carbon emissions avoided *(tC/ha)*
generated by a **single coppice of chestnut**

On average:

28 tC/ha substituted at each harvest,

88 tC/ha substituted after 100 years

Source : Simon MARTEL, 2010

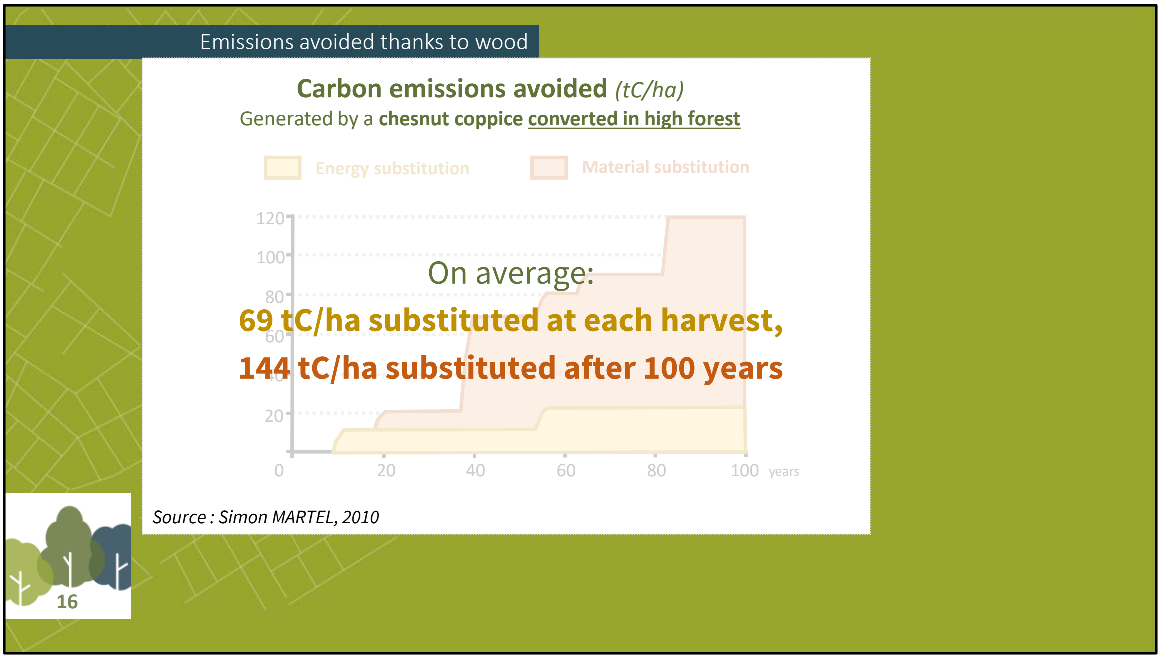
But remember the substitution effect, i.e. the emissions avoided by the use of wood.

Simon Martel's work has also calculated them, both the energy substitution and the material substitution.

For simple coppicing, here are the results. Note that the avoided emissions are cumulative.

Every time we avoid emitting a ton of C, we avoid destocking fossil fuels that will never go into the atmosphere and will remain in the subsoil. As the stock of C in the forest rises and falls.

On average: 28 tC/ha (avoided emissions) at each harvest, 88 tC/ha (avoided emissions) after 100 years.



Emissions avoided thanks to wood

Carbon emissions avoided *(tC/ha)*

Generated by a **chesnut coppice converted in high forest**

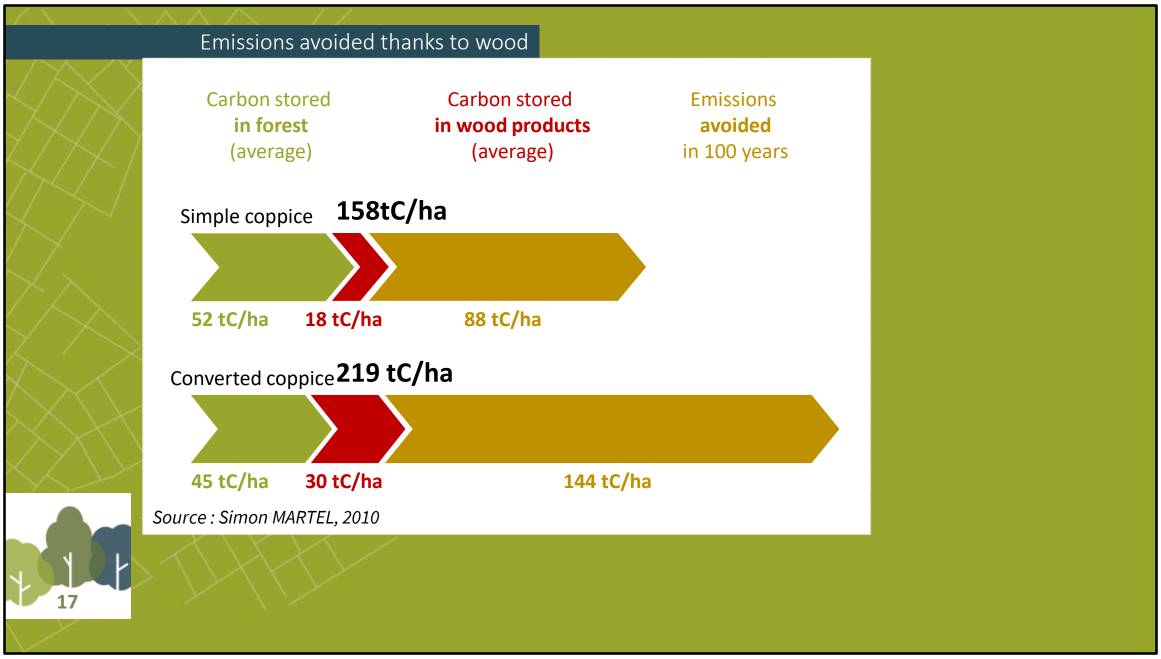
On average:

69 tC/ha substituted at each harvest,

144 tC/ha substituted after 100 years

Source : Simon MARTEL, 2010

For coppice converted to high forest, 69 tC/ha of emissions avoided at each harvest; 144 tC/ha after 100 years.



Emissions avoided thanks to wood

Carbon stored **in forest** (average)

Carbon stored **in wood products** (average)

Emissions **avoided** in 100 years

Simple coppice **158tC/ha**

52 tC/ha **18 tC/ha** **88 tC/ha**

Converted coppice **219 tC/ha**

45 tC/ha **30 tC/ha** **144 tC/ha**

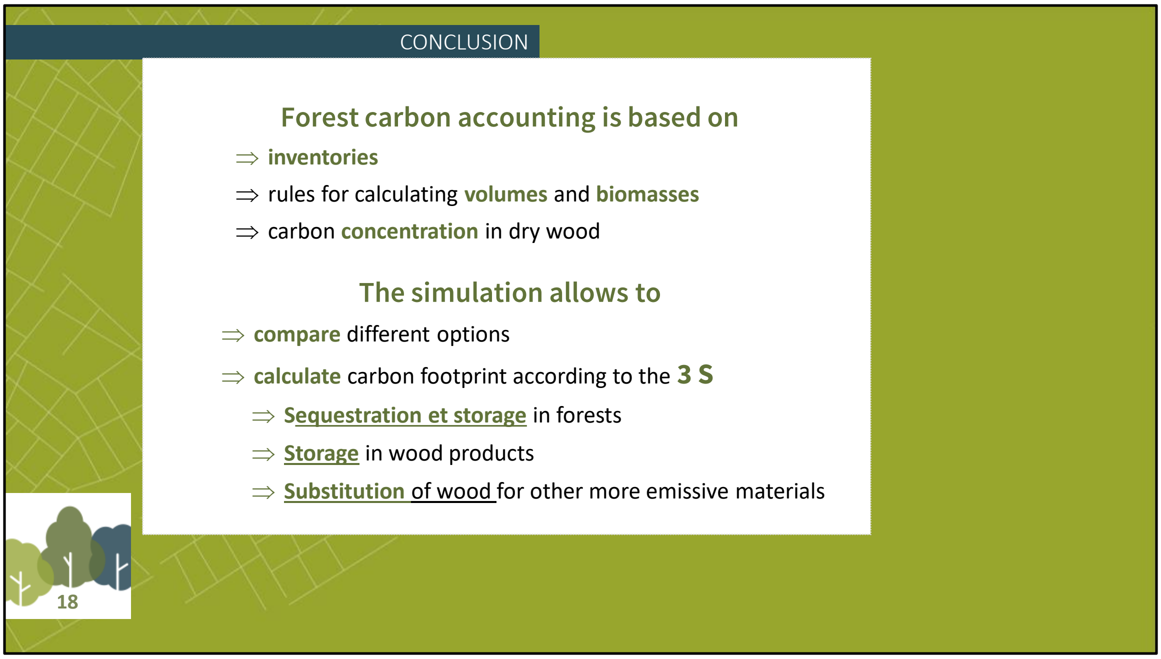
Source : Simon MARTEL, 2010

If we consider only the carbon stored in the forest, the simple coppice seems superior.

If we add the wood products, the reverse is true; coppice converted to high forest is superior. In reality, the figures are not significantly different and given the uncertainties of the data used, we cannot really claim that there are differences.

On the other hand, the emissions avoided by coppice conversion through material substitution are much higher.

This result has been found quite often when considering the increase in carbon stocks that can be expected from a change in silviculture, the differences are not very large, but material and energy substitution ends up resulting in huge savings in terms of emissions since non-renewable energy and materials are not used.



CONCLUSION

Forest carbon accounting is based on

⇒ **inventories**

⇒ rules for calculating **volumes** and **biomasses**

⇒ carbon **concentration** in dry wood

The simulation allows to

⇒ **compare** different options

⇒ **calculate** carbon footprint according to the **3 S**

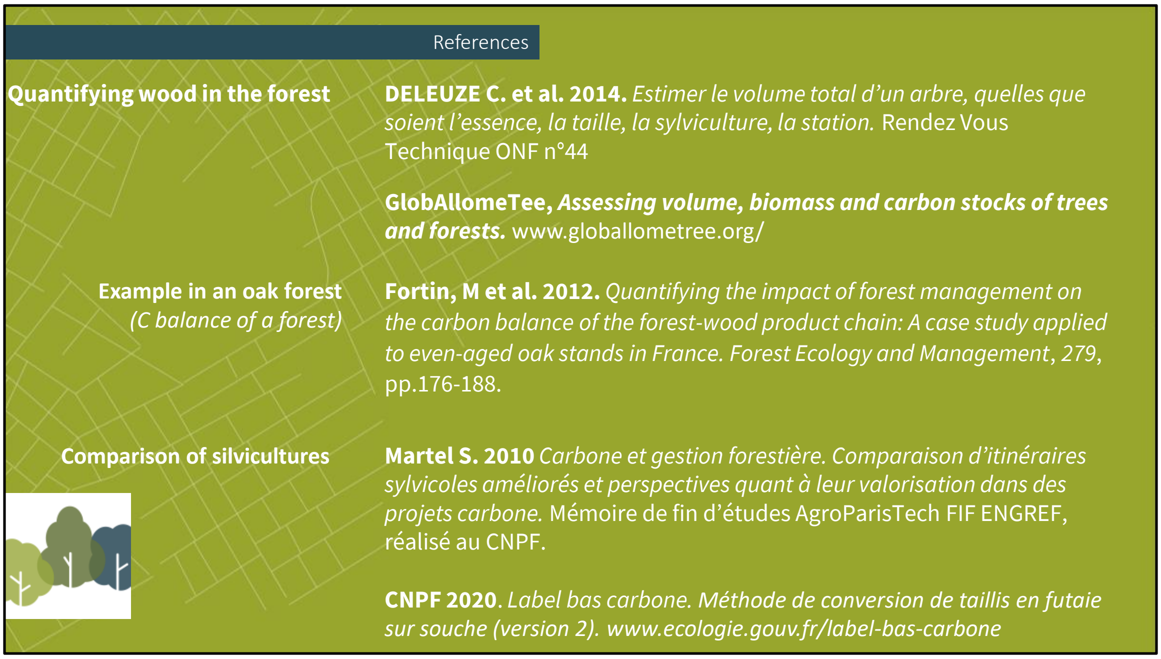
  ⇒ **Sequestration et storage** in forests

  ⇒ **Storage** in wood products

  ⇒ **Substitution** of wood for other more emissive materials

In conclusion, this lesson presented the basics of carbon inventory in forests based on dendrometric measurements and then the results of the study of the carbon balance of different types of forests taking into account the three levers of global warming mitigation: sequestration and storage in the forest, storage in wood products, and substitution of wood to avoid emissions.

Let's remember that the last lever, even if it is the most complicated to calculate, is very important and links forest management to wood use in terms of carbon balance. The carbon balance of the forest depends ultimately on what we do with the wood products.



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Photographers

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Acknowledgements

Week 4

Using wood sustainably

Video 7

Is my wood boiler sustainable?

Here is the last video of week 4 "Using wood sustainably".

I've often been asked if wood energy is good or bad.

In this last video of the week, we will see that it is not possible to answer this question in such a binary way, but that the sustainable use of a wood product can be reasoned on different criteria.

Did you say sustainable development?

OUR
COMMON
FUTURE

The United Nations Global Commission on Environment and Development

Introduction of Gro Harlem Brundtland

Éditions LAMBDA

Alternatives

Society
Health, education, employment, equity, justice

Economy
Creating wealth

Environment
Preserving resources and biodiversity

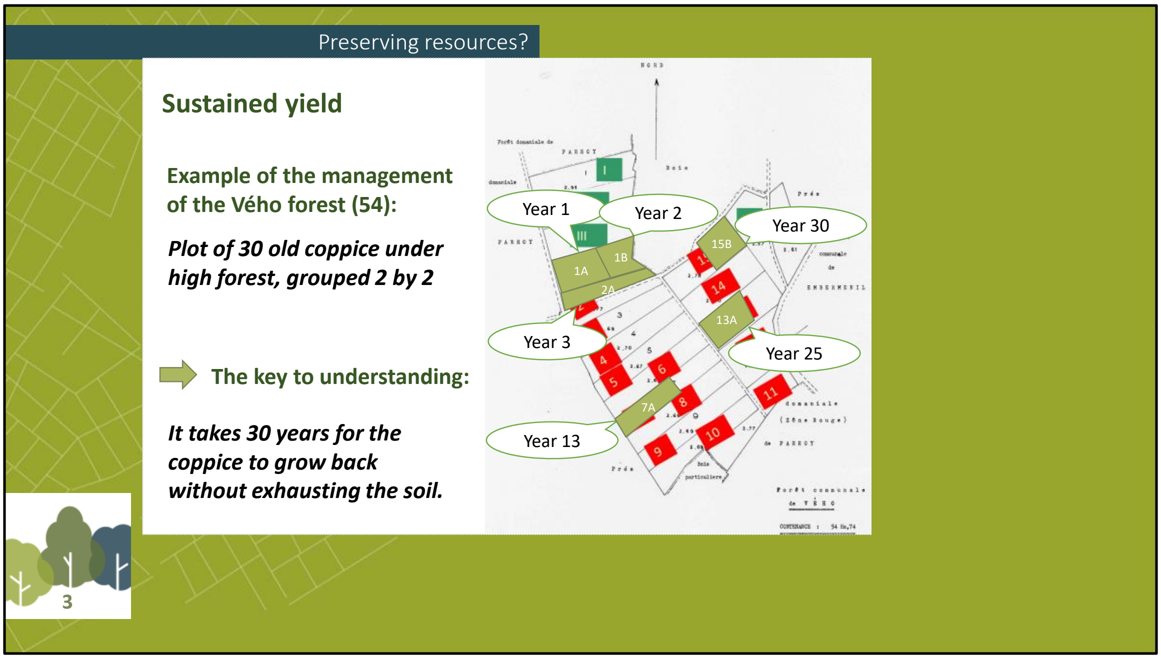
Brundtland's report 1987

Sustainable use? Sustainable development?

What is sustainable development?

Since the Brundtland report of 1987, it is defined as a mode of organization of the society which allows it to exist in the long term. And it is specified that it is built at the crossroads of 3 pillars: economic development which creates wealth, but which must be combined with the preservation of resources and biodiversity to be viable, and also with the expectations of society in terms of health, education, employment, social equity and justice.

Let's try to apply these three main classes of criteria to the analysis of the sustainability of wood energy use.



Preserving resources?

Sustained yield

Example of the management of the Vého forest (54):

Plot of 30 old coppice under high forest, grouped 2 by 2

The key to understanding:

It takes 30 years for the coppice to grow back without exhausting the soil.

Wood energy is wood fuel for heating, cooking or, at the time of the industrial revolution, for powering steam engines. It has been used since the dawn of time. Have we ever thought about not depleting resources? Of course, the ancients did not wait for us, they formalized the notion of sustained yield. This means collecting without damaging the forest capital.

We have known since Colbert that we should not take more than the forest can give or grow back and this is very concretely visible in the way our old forests are divided into blocks.

Here is the Vého forest in Meurthe-et-Moselle, which shows 30 cuts grouped 2 by 2 in 15 plots, formerly treated as coppice under high forest.
Why this division? Because it takes 30 years for the coppice to recover. And each year, one of the 30 cuts is harvested before returning to the first one after 30 years.
This is the principle of sustained yield, we divide the forest spatially so that we can continuously collect fuel wood in different blocks, and by the time we return to the first block, the forest will have grown back.

Obviously, if you want to come back to plot 1 after 10 years, it won't work.

Unless you use a faster growing species ? But be careful, a fast-growing species can exhaust the soil, and maybe that forest area, exploited over 30 years was enough for the people’s needs.

We have seen in previous weeks that it is the basis of management combined with silviculture not to deplete the potential of a forest. NOT IN AUDIO

Preservation of resources?

CONFERENCE
DE
L'ORDONNANCE
DE LOUIS XIV
Du mois d'Août 1669.
SUR LE FAIT DES EAUX ET FORÊTS.
Avec les Édits, Déclarations, Coutumes; Arrêts, Réglemens, & autres Jugemens, rendus avant & en interprétation de ladite Ordonnance, depuis l'an 1115 jusqu'à présent.
CONTENANT
LES LOIX FORESTIERES DE FRANCE.
Nouvelle Edition, augmentée des Observations de M. Simon, Avocat Général, & M. Segauld, Procureur Général à la Table de Marbre de Dijon.
TOME I.

A PARIS, RUE SAINT JACQUES.
Chez Bernard Brunet, Imprimeur-Libraire, vis-à-vis la rue des Mathurins.
M. DCC. LII.
AVEC APPROBATION ET PRIVILEGE DU ROI

Philip VI of Valois
Ordinance of Brunoy 1349

Ordinance of Louis XIV 1669
(under the impetus of the minister COLBERT)

So, when we use firewood today, is it always managed according to the principle of sustained yield? It should be because the rules and regulations that govern the exploitation of wood in the forest today are designed to do just that, ever since the kings of France began to monitor the supposed plundering of ignorant populations.

This also exists in other countries, where people have understood that they should not damage their resources and let the forest grow back.

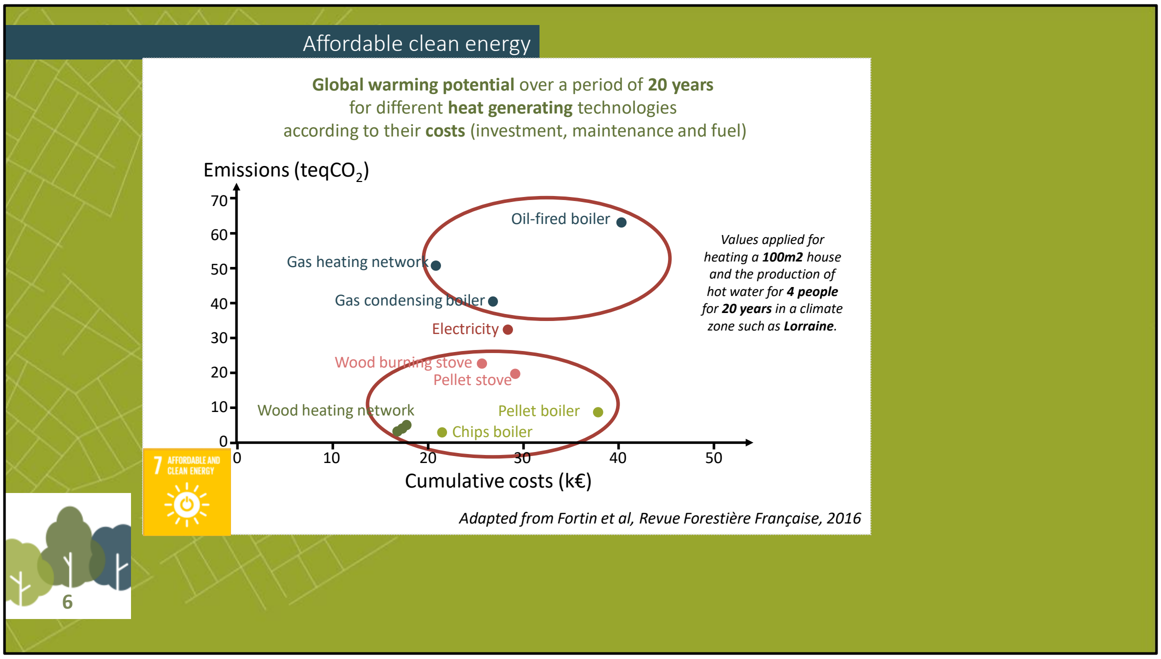
Affordable clean energy

Sustainable development is obviously much more complicated than simply not depleting the wood in the forests and giving the trees time to grow and the soil time to renew itself. In 2015, the UN defined 17 Sustainable Development Goals (SDGs) for 2030. You can see that the 7th one is "Clean and affordable energy”.

We saw that fuel wood is a renewable energy, an interesting substitute to other sources of energy. It is currently the leading renewable energy in France, far ahead of solar energy and wind turbines.

Obviously, for it to be clean, it must respect the forests but also be produced in well-controlled processes. Not all methods of heating with wood are equal: open fireplaces are energy sinks, whilst stoves, boilers and heat networks all vary in efficiency.

Finally, in order to be sustainable, energy must be accessible to all and therefore affordable



Affordable clean energy

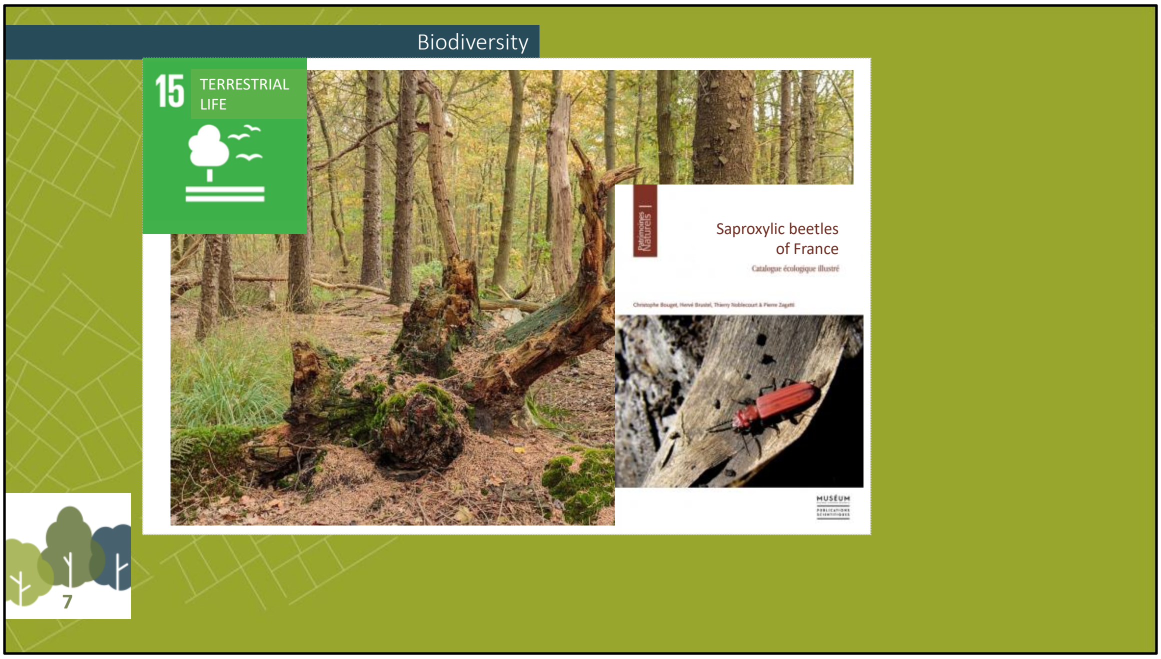
Global warming potential over a period of **20 years**
for different **heat generating** technologies
according to their **costs** (investment, maintenance and fuel)

*Values applied for heating a **100m2** house and the production of hot water for **4 people** for **20 years** in a climate zone such as **Lorraine**.*

Adapted from Fortin et al, Revue Forestière Française, 2016

This graph is the result of a study on the sustainability of several heating and hot water options for a 100 m2 house. For each option, the greenhouse gas emissions produced, including the impact on global warming, and the costs generated in terms of investment, maintenance, and fuel purchase were evaluated.

I guess you already knew that oil and gas were less climate-friendly than wood, even with the latest condensing boilers. But there is still a big difference between a stove, a boiler, or a heat network. And the individual solution is not the most interesting for the climate or for your wallet. Of course, people don't always have a choice.



Biodiversity

15 TERRESTRIAL LIFE

Patrimoines Naturels

Saproxylic beetles
of France

Catalogue écologique illustré

Christophe Bouget, Hervé Brustel, Thierry Noblecourt & Pierre Zagatti

MUSÉUM

Does my wood boiler have an impact on biodiversity?

It depends on the origin of the wood. If it comes from wood that was left in the forest, it can affect the biodiversity of all the living organisms that decompose the wood, the "saproxylic" organisms - beetles, fungi, lichens, and mosses. It also has an impact on birds, reptiles, amphibians, and some rodents...

Biodiversity experts tell us that harvesting can also have positive effects on biodiversity. It can increase the amount of dead wood left in the forest, which provides good habitat for these beetles. Harvesting changes the environment and it is also known that some beetles prefer sunny surfaces. The stumps in the plots after felling (higher temperature) are favorable to their development.

The basic rule of thumb is to avoid removing too much wood from the forest, and especially to leave a diversity of dead wood on the ground. However, it is not easy to define the right thresholds of "what is too much" or "what is an optimal diversity of dead wood".

Soil fertility

Practical guide

For soil- and forest- respectful forestry "PROSOL"

Coordination : Didier Pischedda

FCBA

Office National des Forêts

Does the use of firewood have an impact on the soil?

Again, it depends on where the wood comes from. It may come from a forestry operation that does not respect the soil, that uses heavy machinery that compacts the soil, that does not respect the partitions, and above all that strips the organic matter and removes the minerals contained in large quantities in the branches and small wood.

In this case, the use of firewood is of course detrimental to the proper functioning of the soil. But if practices are controlled, the impact can be minimal. And most importantly, sustainable firewood, as you remind us in Video 2, should remain a by-product of the wood harvest.

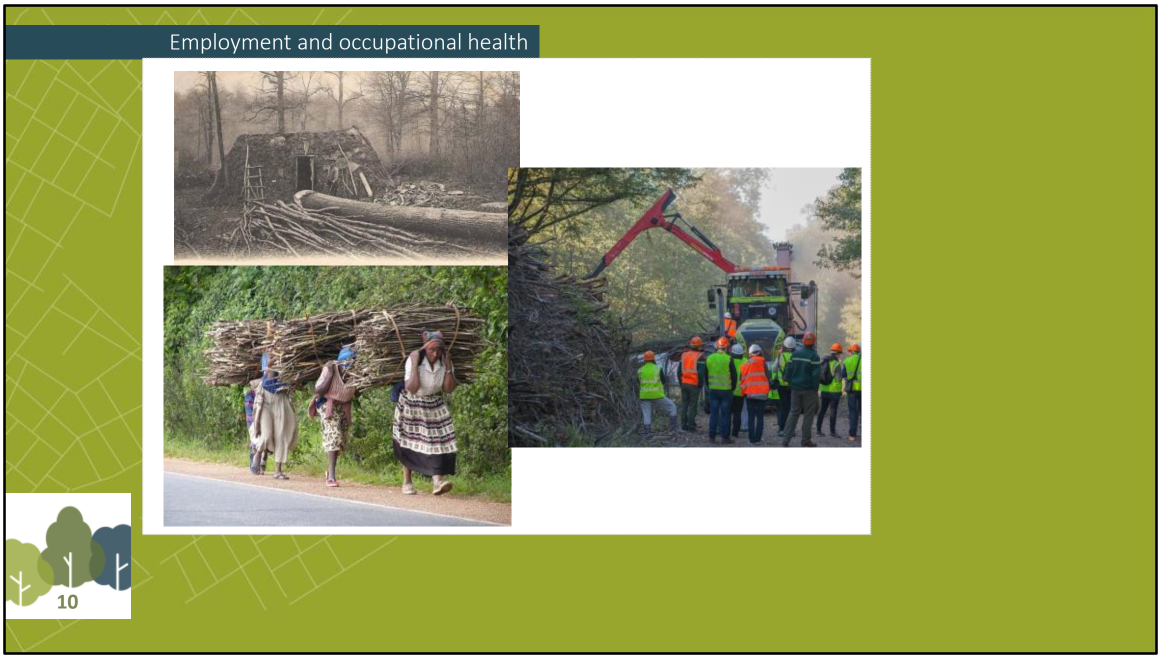
Fire hazard

Forest fire

It may also be thought that harvesting wood for energy purposes may reduce the risk of fire by limiting the fuel mass in the forest.

However, past experience in the Mediterranean region has tempered this idea, as the wood harvested is not that which would serve as flammable and combustible biomass.

(Eric Rigolot, Forêt Méditerranéenne t. XXXI, n° 2, June 2010).



Employment and occupational health

There are many other issues that call into question the sustainability of firewood collection.

What is the impact on employment and occupational health, for example?

Traditional forestry work is hard work!

Mechanization reduces drudgery, but if poorly managed, it leads to excessive strain and stress.

Does firewood create stable and well-paid jobs? On the contrary, does it threaten other sectors by competing with them? Does it support rural activities that are essential to maintain life in our countryside?

This is a dimension of sustainability that is rarely addressed.

What else?

There are many other elements that can call into question the sustainability of the use of this wood pile. For the forest owner who grows wood in his or her forest (and there are many), it goes without saying that this is an essential activity for the value he or she gives to his or her forest and is enhanced by the pleasure he or she gets from walking in it.

But for mountain bikers and hikers, is there a difference between collecting or not collecting firewood in the forests they visit?

Industrialisation

Gardanne power plant

I hope that you will now ask yourself many questions about logs or pellets, or about a biomass power plant and that you will carry out real investigations before deciding whether it is good or not.

The energy demand of our urban societies is a mass demand. We have already seen that fewer and fewer citizens of the developed world are willing to spend their days chopping and gathering wood for heat.

Resource conservation is easier to ensure in a village like Veho, when the end user of the firewood is also the one who harvests it from his forest, than for our developed urban world that gets its energy from power plants located on industrial sites.

To answer your questions, we need to document all the criteria we have mentioned, to follow and evaluate the production and value chain.

Forest certification

PEFC™
10-1-1

GUARDIAN OF THE
FOREST BALANCE

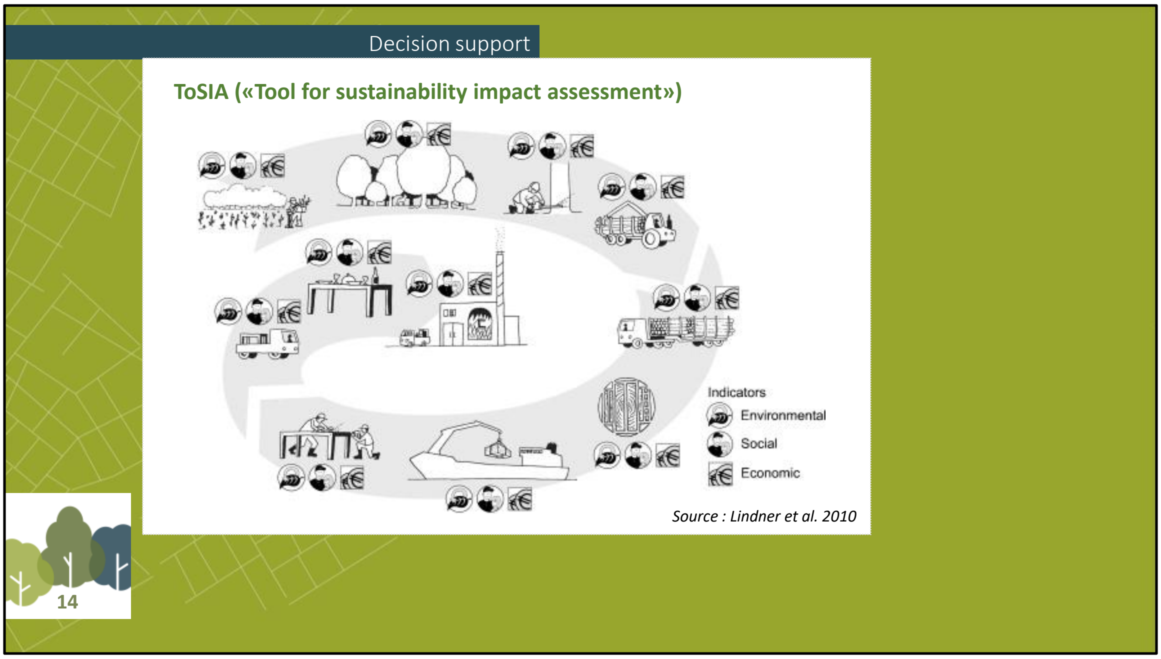
FSC®
www.fsc.org
FSC® A000507

The mark of
responsible forestry

13

Forest certification aims to guarantee the sustainable management of the forests that supply the wood.

There are two systems in the world, PEFC and FSC, which are not well known by the general public. It is obvious that certification only works if consumers demand and value it. It must be based on transparent and informative criteria. Collecting and disseminating information has a cost that wood consumers must be willing to pay. As consumers, we are probably more willing to pay for organic food than for organic heating.



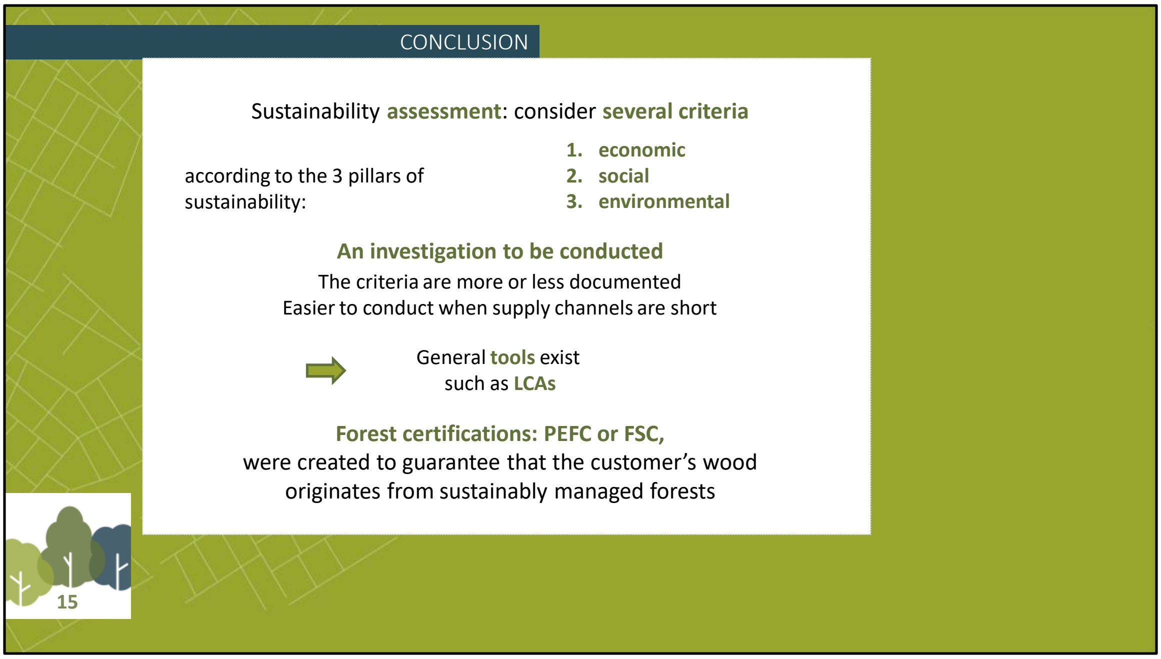
Decision support

ToSIA («Tool for sustainability impact assessment»)

Source : Lindner et al. 2010

Life Cycle Assessment (LCA) is a standardized evaluation method (ISO 14040 and 14044) that allows a multi-criteria and multi-stage environmental assessment of a product over its entire life cycle.

This is how the environmental quality of products and processes can be compared, including wood products.



CONCLUSION

Sustainability **assessment**: consider **several criteria**

according to the 3 pillars of sustainability:

1. **economic**
2. **social**
3. **environmental**

An investigation to be conducted

The criteria are more or less documented
Easier to conduct when supply channels are short

⇨ General **tools** exist
such as **LCAs**

Forest certifications: PEFC or FSC,
were created to guarantee that the customer’s wood
originates from sustainably managed forests

There are tools such as ToSIA, which assess the overall environmental, social, and economic impacts of changes in the forest sector at European, national, regional, and even territorial levels. These tools are designed to provide policymakers with objective information on the impacts of changes in the forest sector. For example, how an increase in the use of industrial wood or fuelwood will simultaneously affect our greenhouse gas emissions, employment or biodiversity. It is probably a pity that these tools are not used more to anticipate the impact of decisions.

To decide whether the use of wood is sustainable, several criteria must be taken into account, because sustainability is based on three pillars: economic development, preservation of the environment, and meeting society's expectations.

It is a real survey to be conducted, some criteria are well documented, others less so. The survey is easier to carry out when the circuits are short between the forest owner and the finished product.

Life cycle assessments, or LCAs, are tools that allow surveys to be carried out and results to be drawn from them, on the scale of the wood product or the territory. Forest certifications, PEFC or FSC, were created to guarantee to the consumer that the wood he uses comes from sustainably managed forests.

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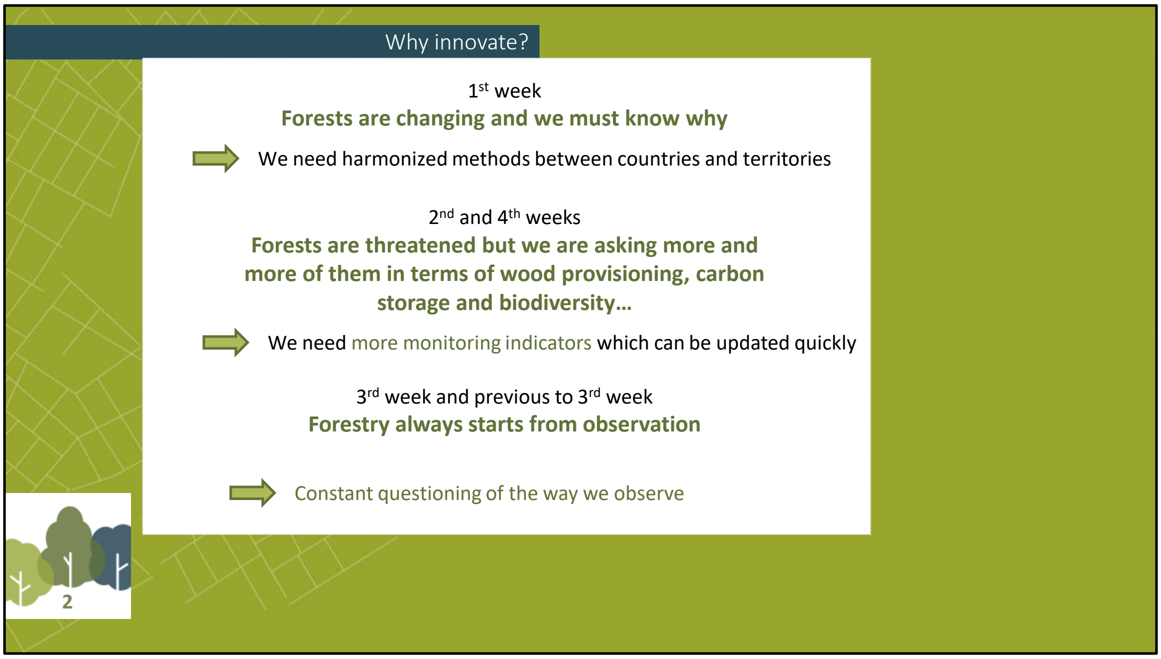
Week 5

Innovations and forest management

Video 1

Improving monitoring and information available on forests

Hello everyone, it's week five and we are going to talk about innovation in forest management. In this first video, we will look at improving forest monitoring and information.



Why innovate?

1st week

Forests are changing and we must know why

➡ We need harmonized methods between countries and territories

2nd and 4th weeks

Forests are threatened but we are asking more and more of them in terms of wood provisioning, carbon storage and biodiversity…

➡ We need more monitoring indicators which can be updated quickly

3rd week and previous to 3rd week

Forestry always starts from observation

➡ Constant questioning of the way we observe

1**) Forests are changing** and we need to have the means to know their evolution on a large scale through national forest inventories (e.g. FRA reports in Europe).

- We need to harmonize our methods between countries in Europe and the world, and between territories.

2) **Forests are under threat and yet more and more is being asked of them** (in terms of wood, carbon and biodiversity, calm, and services of all kinds).

- The indicators needed for forest inventories are increasingly diverse and complex, and it is not just a question of knowing the surface area of forests, but also the quality of wood, biodiversity, carbon, etc. And we need to know how to update these indicators more quickly and more frequently.

3) **Forest management** shapes the forest. It is an art as much as a science, and it is an art that always starts with observation (of trees, soils, environment).

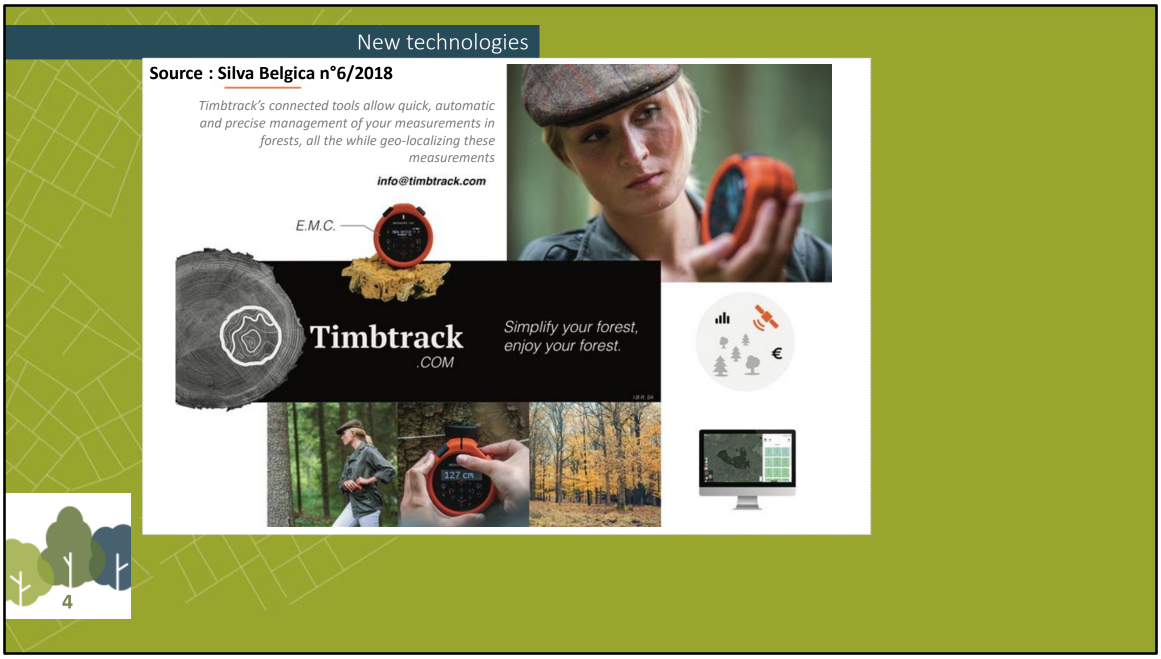
- We can/should question our modes of observation, which can evolve with improved knowledge and tools.

The first issue: gathering data

Photos : Vosges Matin

The first challenge facing innovation is the collection of information and data.

With the day-to-day tools of the forester - compasses, dendrometers, telemeters, weather stations, GPS



New technologies

Source : Silva Belgica n°6/2018

Timbtrack's connected tools allow quick, automatic and precise management of your measurements in forests, all the while geo-localizing these measurements

info@timbtrack.com

New digital technologies can facilitate the lives of those who work collecting data. GPS and laser telemetry are obvious technologies of this kind.

New professional tools will succeed if they are ergonomic and easily adapted to the work organization. This is as important as whether or not they measure more precisely or faster.

It's not so much the new technology itself which will attract the forester, but rather how he/ she will be able to use it. Here, we have an article from the Belgian forest journal on a new tool created by a start up which is receiving numerous prizes.

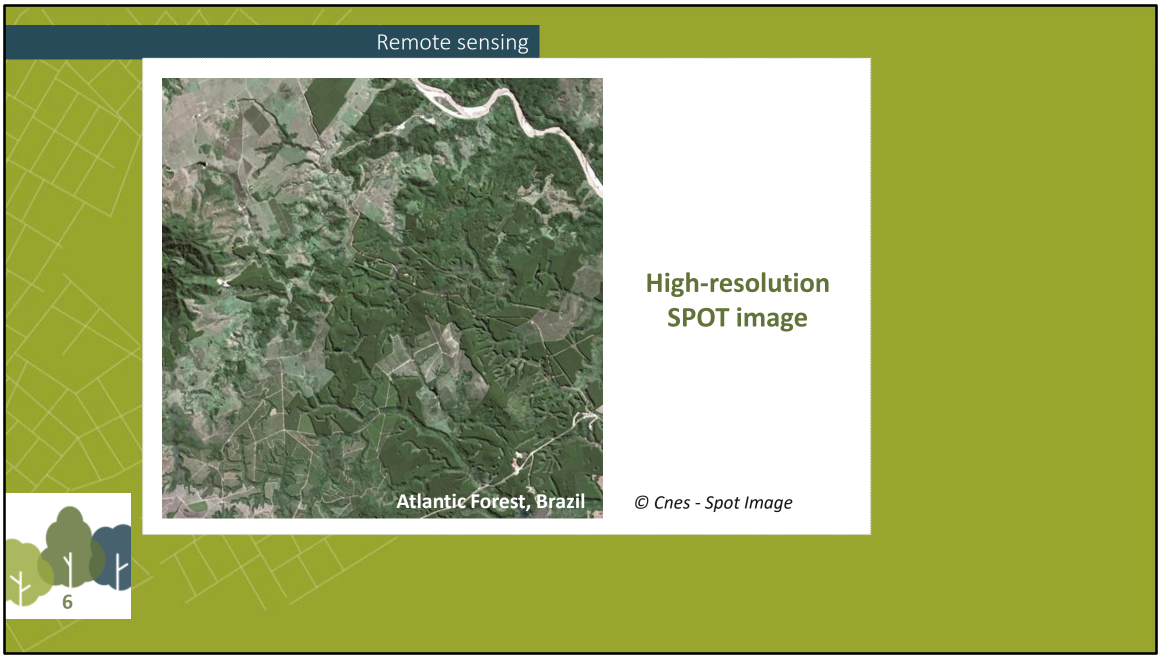
Everything on my smartphone!

http://www.moti.ch/

Smartphones, which fit in your pocket, have a phenomenal computing power, allowing the measurement of angles, distances, positions, with the added benefit of quick communication. They certainly have great potential.

The MOTI app, developed in Switzerland, measures basal area, the number of stems per hectare and the height of trees.

MOTI (just like other such tools) is free, but in order to use it, we must be trained to this kind of measurement.



Remote sensing

High-resolution SPOT image

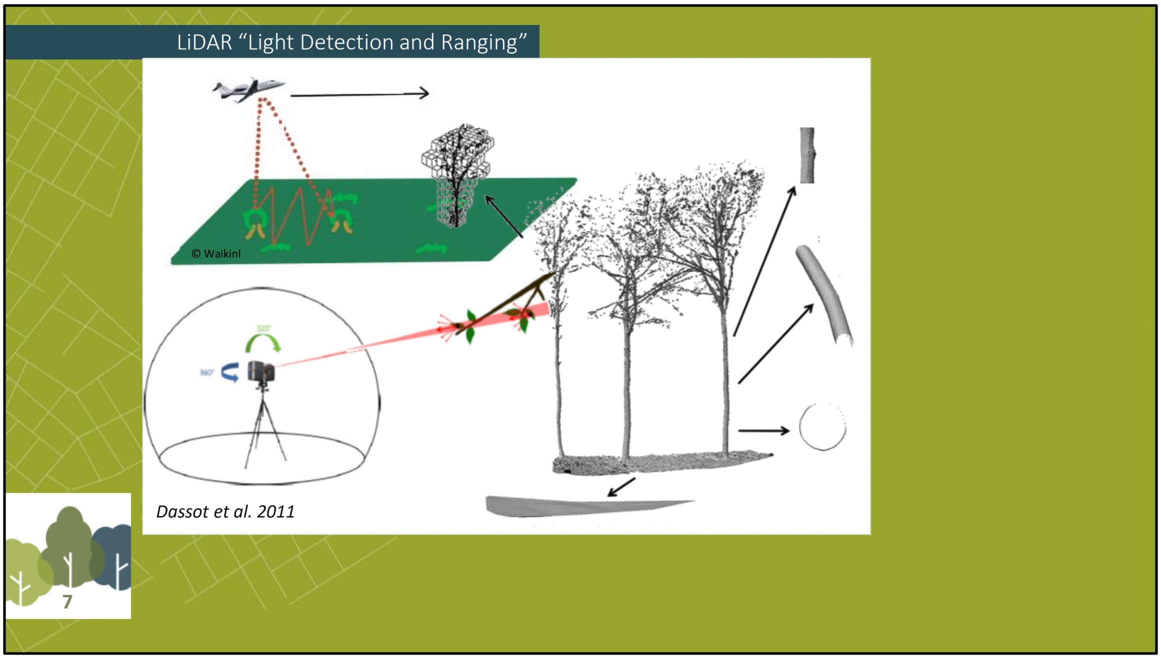
Atlantic Forest, Brazil

© Cnes - Spot Image

Remote sensing has been used in forests for a long time now, with aerial imagery.

Satellite remote sensing is now opening up new possibilities.

For example, high-resolution SPOT images can be used to monitor forest cover and land-use changes, with up-to-date data.



LiDAR “Light Detection and Ranging”

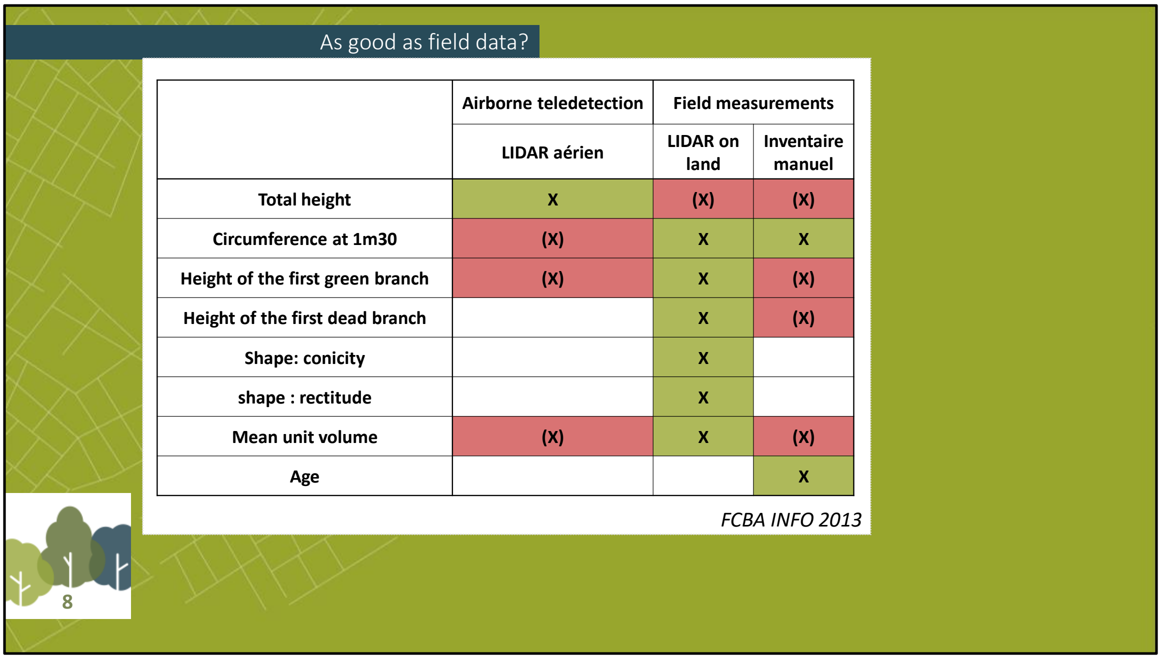
Dassot et al. 2011

LIDAR (Light Detection and Ranging) is a remote sensing tool based on the analysis of a laser signal which emits and then receives a laser signal.

This tool can be used on land (TLS) or it can be airborne (ALS) **(aéroporté)**

The information it provides is revolutionizing forestry.

More information, including a video, on :
https://www.wikiwand.com/en/Lidar
And:
https://www.youtube.com/watch?v=-wQvIJvpcvM



As good as field data?

	Airborne teledetection	Field measurements	
	LIDAR aérien	LIDAR on land	Inventaire manuel
Total height	X	(X)	(X)
Circumference at 1m30	(X)	X	X
Height of the first green branch	(X)	X	(X)
Height of the first dead branch		X	(X)
Shape: conicity		X	
shape : rectitude		X	
Mean unit volume	(X)	X	(X)
Age			X

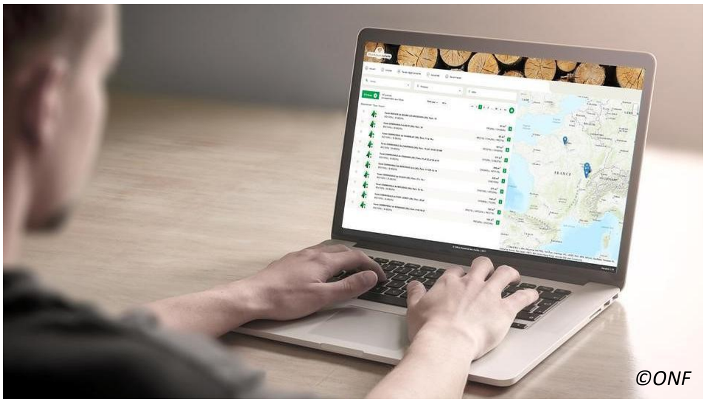
FCBA INFO 2013

Here, you can see a comparison between what can be done by the airborne LIDAR (carried by an airplane)(ARS), the land based LIDAR on a tripod in a forest parcel and the standard forest inventories in the field.

You can see that the two LIDARs, terrestrial and airborne, are complementary. You can also see that LIDAR can do almost everything, except measuring a variable which is often essential, the age of trees.

The issue with all of these methods is that they are based on physical principles which do not interpret information as well as the human eye. Once we know their potential (what they could do), there is a lot of work between forest specialists and technology specialists to obtain relevant indicators on forests from raw data.

Organizing data in order to use it

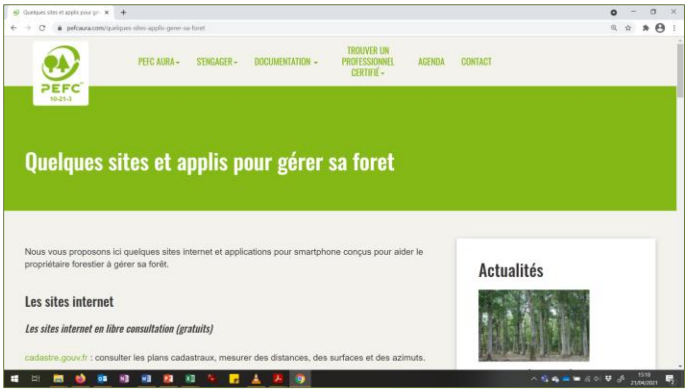


©ONF

The second and equally important challenge of innovation is therefore not only to obtain data with increasingly sophisticated tools but also to know how to analyze the data in order to use it.

SV2

The connected forest owner



Quelques sites et applis pour gérer sa foret

Nous vous proposons ici quelques sites internet et applications pour smartphone conçus pour aider le propriétaire forestier à gérer sa forêt.

Les sites internet

Les sites internet en libre consultation (gratuits)

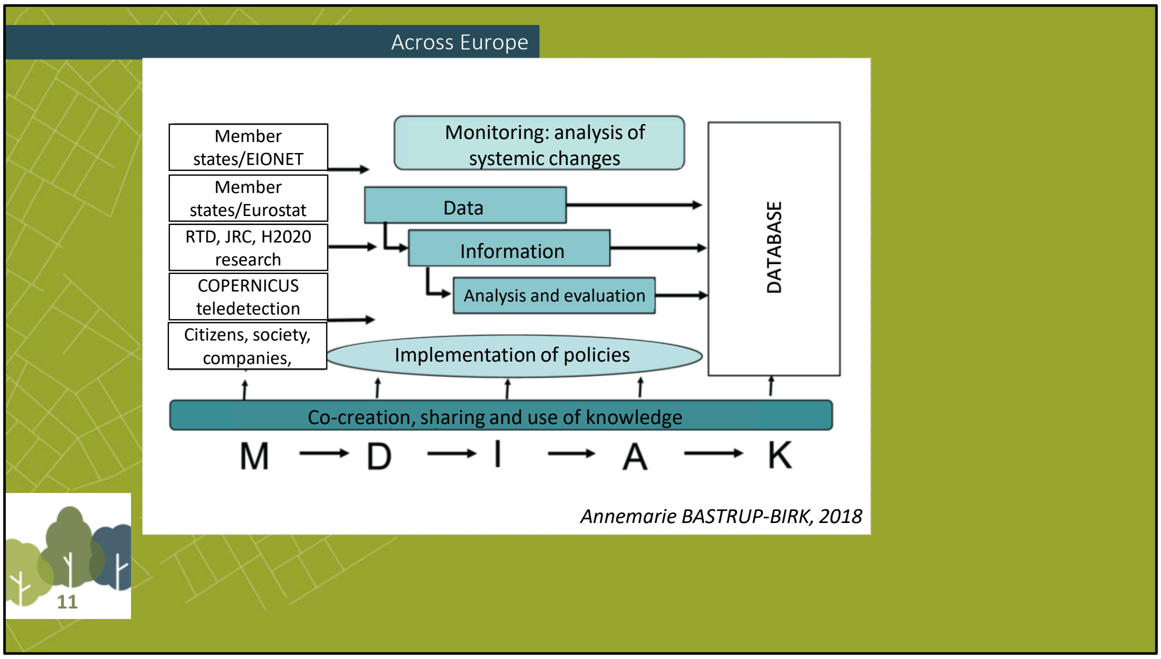
cadastre.gouv.fr : consulter les plans cadastraux, mesurer des distances, des surfaces et des azimuts.

Actualités

Website of the PEFC Auvergne Rhône Alpes

Here, the PEFC (Programme for the Endorsement of Forest Certification) Rhône Alpes's website presents many apps and websites which provide forest managers with more tools to better manage their forests.

This is complicated: we can see that there are many tools and choosing the ideal one is not necessarily easy.



Across Europe

Member states/EIONET

Member states/Eurostat

RTD, JRC, H2020 research

COPERNICUS teledetection

Citizens, society, companies,

Monitoring: analysis of systemic changes

Data

Information

Analysis and evaluation

Implementation of policies

DATABASE

Co-creation, sharing and use of knowledge

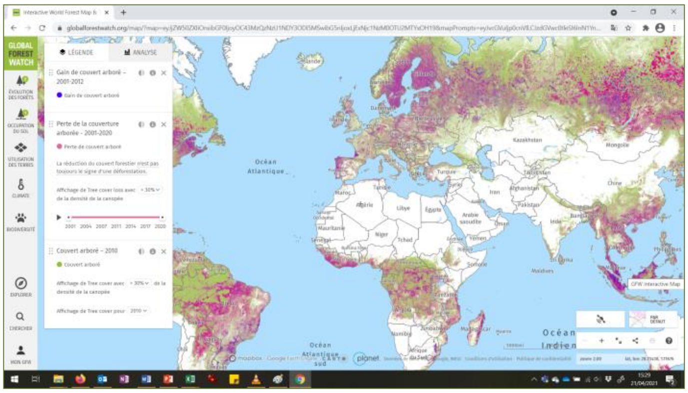
M → D → I → A → K

Annemarie BASTRUP-BIRK, 2018

Forestry information in Europe is also complicated. Data are organized in information and knowledge systems.

Here you can see the proposal of the European Environment Agency in 2018 at a conference celebrating 25 years of an observation system called RENECOFOR. In this proposal, data sources are to be organized in a classical and formalized way:
Monitoring: raw data are obtained regularly and frequently, well distributed in space for monitoring purposes.
Data: this information is integrated into a database
Information: databases are interpreted to produce information relevant to those who need it
Analysis: reports and assessments on topics of interest for European forests are produced
Knowledge database: this is the compilation of all these dimensions.

Global Forest Watch



Gain de couvert arboré – 2001-2012

● Gain de couvert arboré

Perte de la couverture arborée - 2001-2020

● Perte de couvert arboré

La réduction du couvert forestier n'est pas toujours le signe d'une déforestation.

Affichage de Tree cover loss avec > 30% de la densité de la canopée

Couvert arboré – 2010

● Couvert arboré

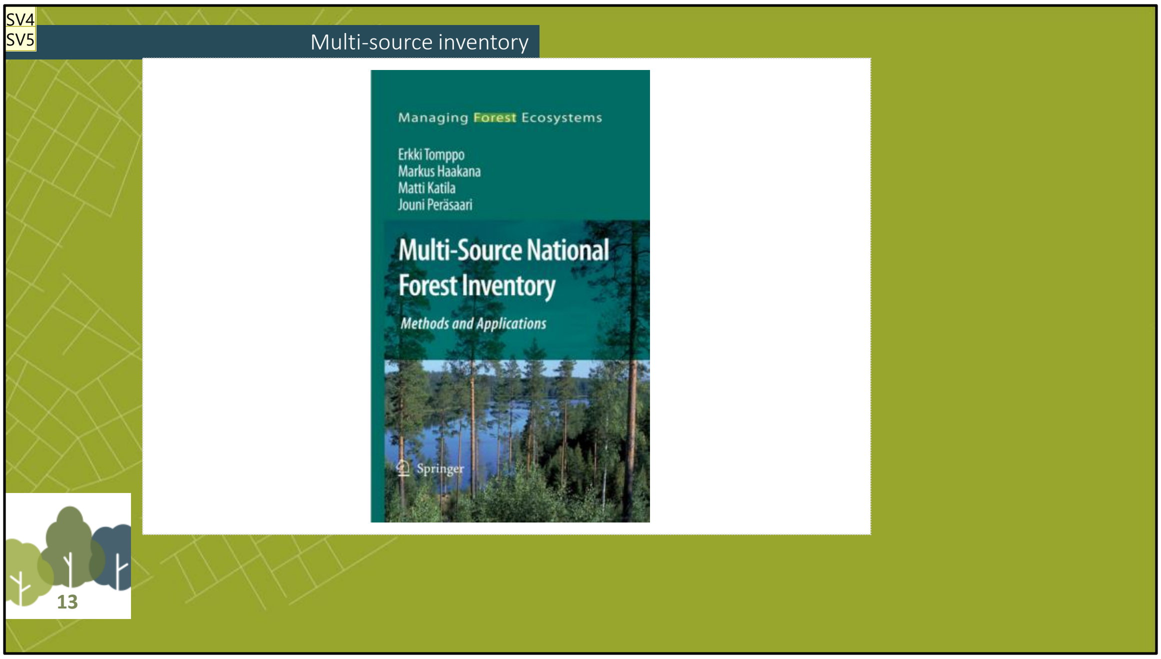
Affichage de Tree cover avec > 30% de la densité de la canopée

Affichage de Tree cover pour 2010

www.globalforestwatch.org

The “multisource forest inventory” is the technical word for “using data of diverse origins” – remote sensing, national forest inventories based on systematic sampling, local data … to have the best possible information

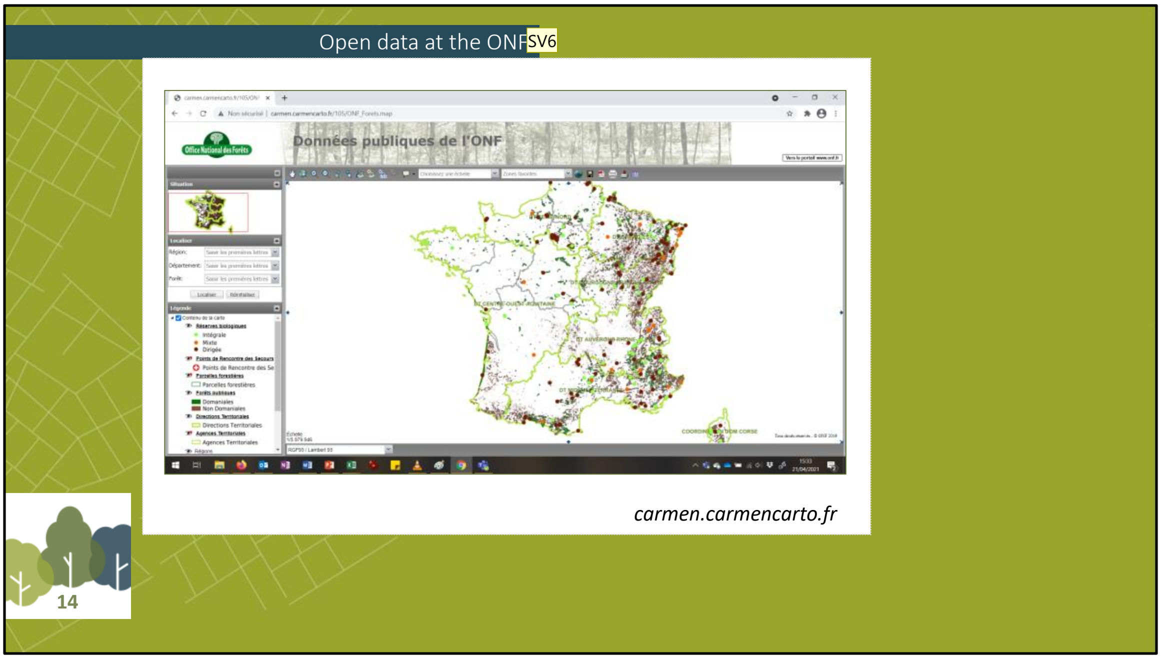
Global Forest Watch is an online platform which was launched in 1997 by the World Resources Institute (www.wri.org) which provides data and tools to track global deforestation. With this advanced technology, GFW allows anyone to access real time information to know where and how forests are evolving all over the world.



SV4
SV5

Multi-source inventory

In France, at the national level, specialists from IGN (Institut national de l'information géographique et forestière) and ONF (Office national des forêts) are working on this, and their work benefits from the advances and resources of the Nordic countries, where forests are somewhat simpler. We have here a methodological manual, published in 2008 by Finnish authors.



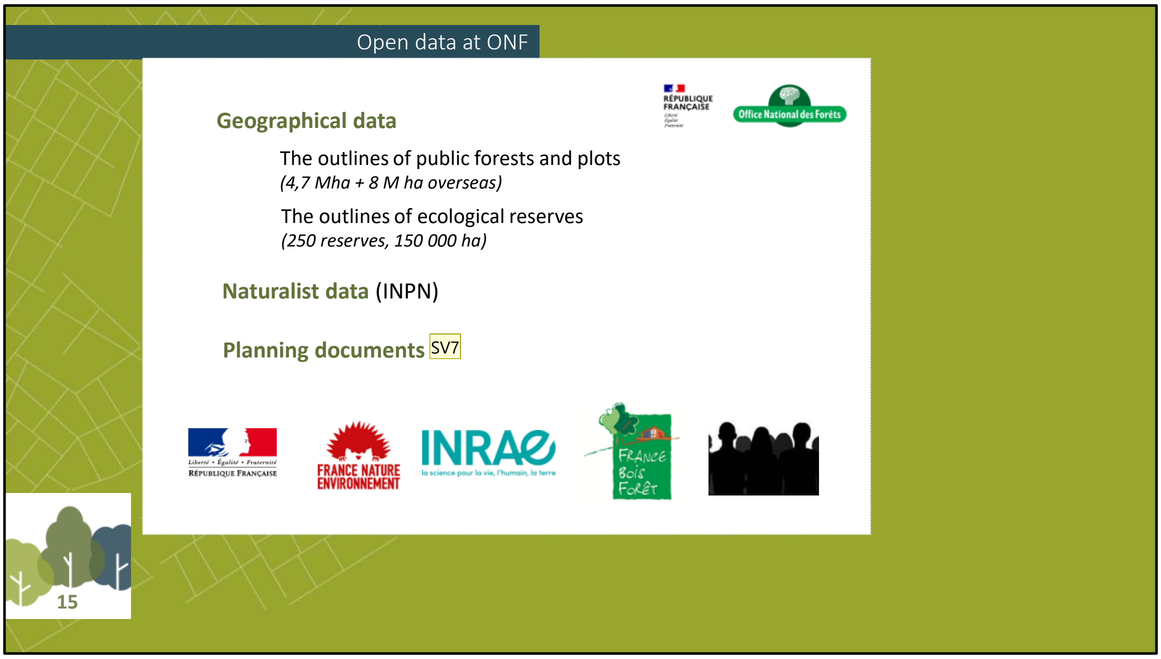
Open data at the ONFSV6

carmen.carmencarto.fr

In order to draft forest planning documents, provide information for inventories and manage public spaces, the ONF produces data about public forests in France.

These provide a wealth of information for the public as well as for administrations and practitioners.

The ONF is fully in line with the French digital republic law’s ambitions, the “biodiversity” law of 2016 and the Open Data movement as a whole. This commitment was taken as early as the start of this millennium, before the implementation of European directives on access to public environmental data.



Open data at ONF

Geographical data

The outlines of public forests and plots
(4,7 Mha + 8 M ha overseas)

The outlines of ecological reserves
(250 reserves, 150 000 ha)

Naturalist data (INPN)

Planning documents SV7

In practical terms, what data is provided by the ONF?

Foresters of the ONF and experts of six naturalist networks (entomology, mycology, flora, mammals, avifauna and herpetofauna) feed information to ONF's naturalist database.

These mainly concern public forests and species from forests and associated environments (moors, ponds, forest borders…).

This data is shared with the National Inventory of Natural Heritage (Inventaire national du patrimoine naturel (INPN)) as part of the system of information on nature and landscapes (Système d'information sur la nature et les paysages (SINP)). ONF also provides access to the planning documents of public forests.

SV8

Participatory systems?

naturae

2019 • 9

Les apports des sciences participatives
à la connaissance naturaliste : le cas de l'enquête
participative « Lichens forestiers du Massif central »

Théo MARECHAL, Sylvain MARSY, David HAPPE,
Thomas DARNIS, Jacques-Henri LEPRINCE, Philippe ANTONETTI,
Christian HURTADO & Rémy PONCET

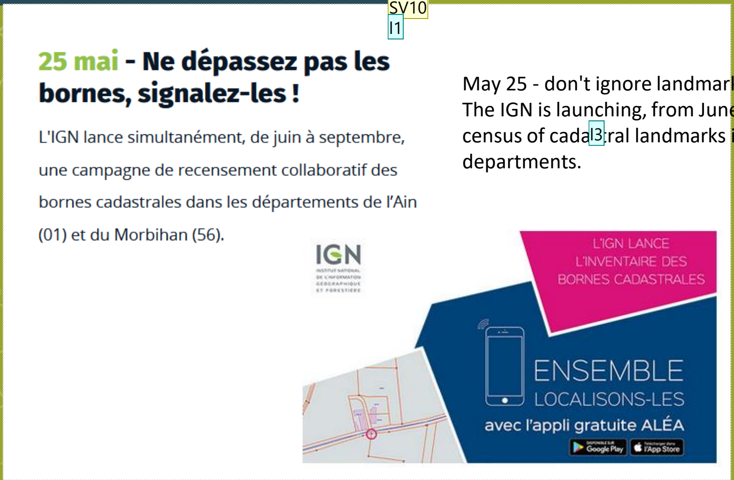
Can you, citizens, contribute to forest information?

The French Natural History Museum (MNHN) and the Regional Office for the Environment, Development and Housing (direction régionale de l'environnement, de l'aménagement et du logement Dreal) launched a participatory inventory of forest lichens in the Massif Central, in Central France.

Over the course of one year, 200 individuals and professionals were trained to recognize 8 species of lichen. They then traced the location and distribution of these eight species.

This provided valuable information on biodiversity, which experts would not have been able to gather alone.

Participatory systems?



25 mai - Ne dépassez pas les bornes, signalez-les !

L'IGN lance simultanément, de juin à septembre, une campagne de recensement collaboratif des bornes cadastrales dans les départements de l'Ain (01) et du Morbihan (56).

IGN

L'IGN LANCE L'INVENTAIRE DES BORNES CADASTRALES

ENSEMBLE LOCALISONS-LES

avec l'appli gratuite ALÉA

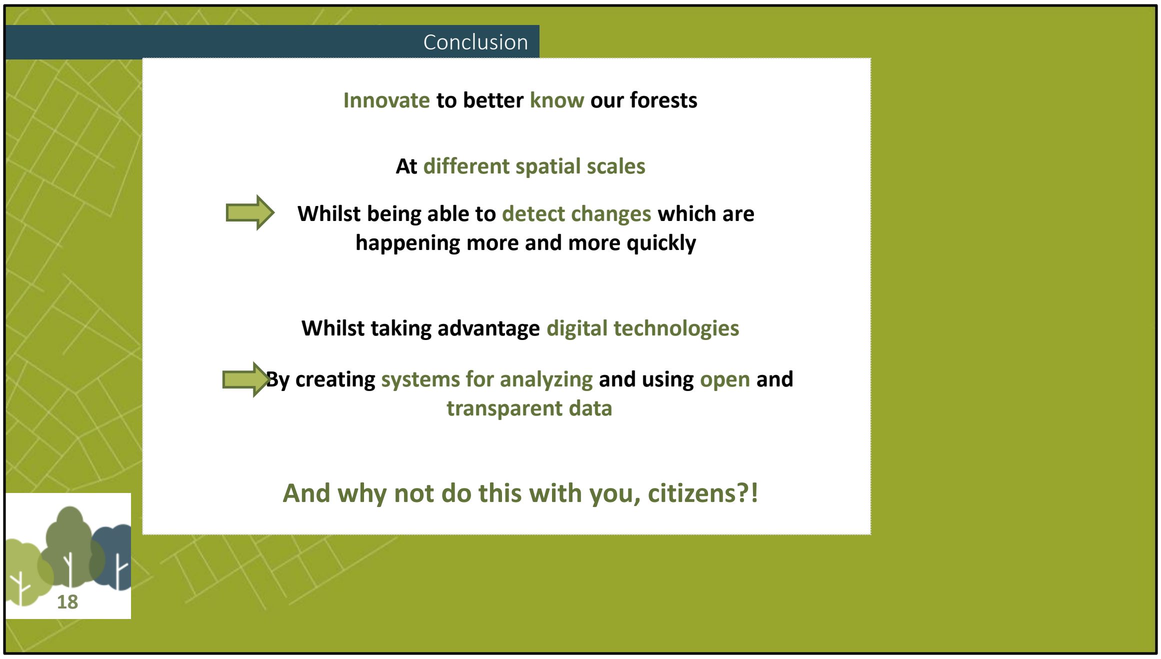
Google Play | l'App Store

May 25 - don't ignore landmarks, mark them!
The IGN is launching, from June to September, a collaborative census of cadastral landmarks in the Ain and Morbihan departments.

Made from stone or from other materials (metal, plastic…), cadastral landmarks are "precious markers which can be several centuries old".

Yet "the mark of many landmarks has been lost", and some are buried in the ground or are deteriorated. As a consequence, we no longer know the limits of some forest plots, even though this is basic information.

In 2020, the IGN launched a participatory inventory of cadastral landmarks. The institute invited forest owners, elected officials and walkers to contribute to the census.



Conclusion

Innovate to better know our forests

At different spatial scales

⇨ **Whilst being able to detect changes which are happening more and more quickly**

Whilst taking advantage digital technologies

⇨ **By creating systems for analyzing and using open and transparent data**

And why not do this with you, citizens?!

Bibliographic references

Tools

Moti www.moti.ch
TIMBTRACK : https://www.timbtrack.com/press
Websites et apps to manage one's forest : https://pefcaura.com/quelques-sites-applis-gerer-sa-foret

LIDAR

Dassot et al. 2011 *The use of terrestrial LiDAR technology in forest science: application fields, benefits and challenges*, Annals of Forest Science 68
https://hal.archives-ouvertes.fr/hal-00930668

FCBA INFO 2013 : *Evaluation du LIDAR et de solutions innovantes pour la chaîne d'approvisionnement du bois : les résultats du projet européen FlexWood*
https://www.fcba.fr/wp-content/uploads/2020/09/fcbainfo_16_allevet_lidar_flexwood.pdf

Knowledge sources

Annemarie BASTRUP-BIRK, 2018
Questionnements et enjeux actuels pour le monitoring forestier à l'échelle européenne
Colloque 25 ans Renecofor https://www.youtube.com/watch?v=FNEsYWvhpUo

Multisource inventories

Book : Tomppo et al. 2008, *Multi-Source National Forest Inventory*, Springer
https://link.springer.com/book/10.1007%2F978-1-4020-8713-4

Data

Global Forest Watch : www.globalforestwatch.org
Public data from the'ONF : http://carmen.carmencarto.fr/105/ONF_Forets.map

Participatory initiatives

Study of the MNHN-DREAL on lichens in the Massif Central
⇒ Study website : http://enquetelichensauvergne.mnhn.fr/
⇒ Article on the study : https://sciencepress.mnhn.fr/fr/periodiques/naturae/2019/9
IGN inventory on cadastral landmarSV11ttps://www.ign.fr/ensemble-localisons-les-bornes-de-propriete

Photos

Vosges Matin
Forestiers ONF en martelage public pour la Journée Internationale des Forêts
https://www.vosgesmatin.fr/economie/2021/03/22/l-onf-lance-une-operation-de-communication-dans-le-massif-de-darney-la-voge

Wikimedia commons
Cnes - Spot Image
Waikinl

ONF

Week 5, video 2: improving harvesting, an interview with Didier Pischedda

Introduction by Meriem Fournier:

In this video, we are going to look at how we can improve harvesting practices in the forest. To do so, we will interview an expert on innovations for sustainable harvesting, that is to say harvesting which is economically profitable, socially acceptable and which protects the environment.

Didier Pischedda: Hello everyone, my name is Didier Pischedda, I work in the timber sales department of the National Forestry Office (ONF). My tasks are based on three main themes:

- the first one concerns everything related to establishing contracts with forestry companies. These contracts exist because the National Forestry Office is a public establishment, and recently, it has become subject to the public procurement code which requires a lot of communication and organisation with our service providers.
- the second theme concerns these compagnies’ quality: interventions in the forest, our relationships with machine manufacturers, organisation our work sites, and drafting of the specifications which must be respected by our service providers.
- the third theme concerns digital data, since mechanisation is expanding our ability to collect and manage forest data.

Meriem Fournier: the general public often perceives engines in the forest as a form of violence against nature. Could you explain why mechanised harvesting is a good thing?

Didier Pischedda: First of all, we must look into the history of this mechanisation. It all started with the Second World War, when most machines were military machines. Their use in forestry was to improve the working conditions of foresters, since working in the forest means working in a harsh natural environment with rocks, slopes, branches, stumps and so on. At the time, there was already a manpower shortage, with fewer and fewer loggers.
Mechanisation has boomed in the last 20 years, in particular after the 1999 storm, a turning point in mechanisation: there was a huge volume of wood that fell to the ground in three days. This wood had to be harvested quickly. Again, it was not possible to manually harvest in these sites for ergonomic reasons and for safety reasons. As a result, harvesting machines were even more used and developed.

Source gallica.bnf.fr / Bibliothèque nationale de France

A Renault tank in the Chaville forest in 1920

Source gallica.bnf.fr / Bibliothèque nationale de France

The *Rol tank*, used for wood transport in in Vélizy (Yvelines region).

17 avril 1943, démonstration de tracteurs RENAULT à chenille HI-1921 (photo) et LATHIL © RENAULT

Forests following the storm of 1999

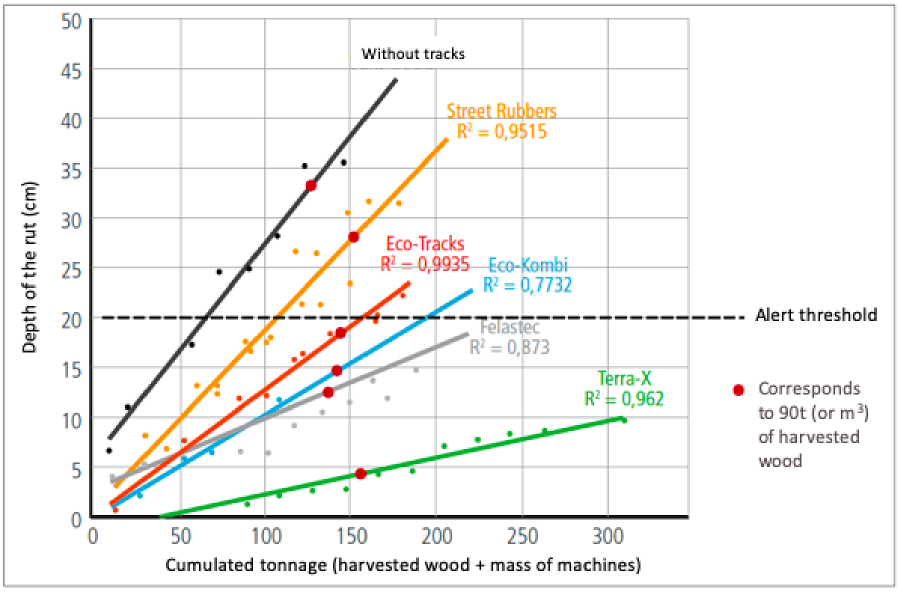
Meriem Fournier: Harvesting machines have a reputation of compacting the soil. During week 4, we saw that they operate in specific ways which are not haphazard, but how do we innovate to control their impact on the soil?

Didier Pischedda: They have a bad reputation because they are very heavy machines. Here too, we must put ourselves in the context of the harsh natural environment which requires sufficiently strong machines. Sturdiness is somewhat related to the machine's weight. One factor that increases the empty mass of these machines is compliance with motorisation regulations, such as the Stage standards in Europe and the Tier standards in the USA, which control pollution levels in terms of hydrogen sulfide and fine particles.

The same applies to our cars: if you take the same model from the 1980s or from today, you can see that the mass of our cars has increased, and the same goes for forestry machines. What's more, safety conditions, whereby a machine must protect its operator in case of a rollover or of a tree falling on the cabin, further increase the machine's weight.

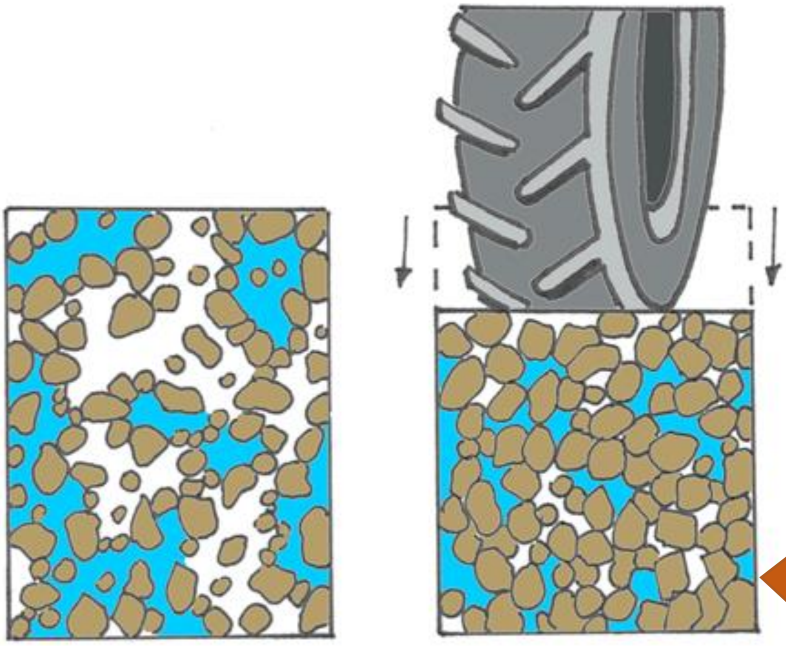
This is a fact that we must accept. As managers, we then have two options to deal with this:

- One is to consult with manufacturers so that they distribute this weight as well as possible, via contact with the soil. We used to have four-wheel machines, then we developed six-, followed by eight-wheel machines, so the pressure on the ground for the same weight has dropped considerably in recent years. We have also developed semi-rigid track systems which contribute to reducing pressure on the ground and therefore reducing forest soil compaction.
- The second way to address these problems is to better organise the work sites, in particular to direct the movement of harvesting machines in the forest. We don't let them drive everywhere. For the past 20 years, we have been putting in place what we call secondary permanent skid tracks. These are 4-metre wide openings every 18 to 20 meters, and our service providers have to circulate on these partitions only, rather than on the entire plot. The partitions are compacted, but the rest of the plot is less impacted. This is included in the contract we have with our service providers. In the event of non-compliance, we sometimes have to apply penalties, suspend interventions, and even suspend our contracts if rules are not respected.



Source : Heubaum et Padberg 2014

Efficiency of different tracks for soils with little to no bearing strength: the best results are obtained with the largest tracks (Terra X: 1m large)

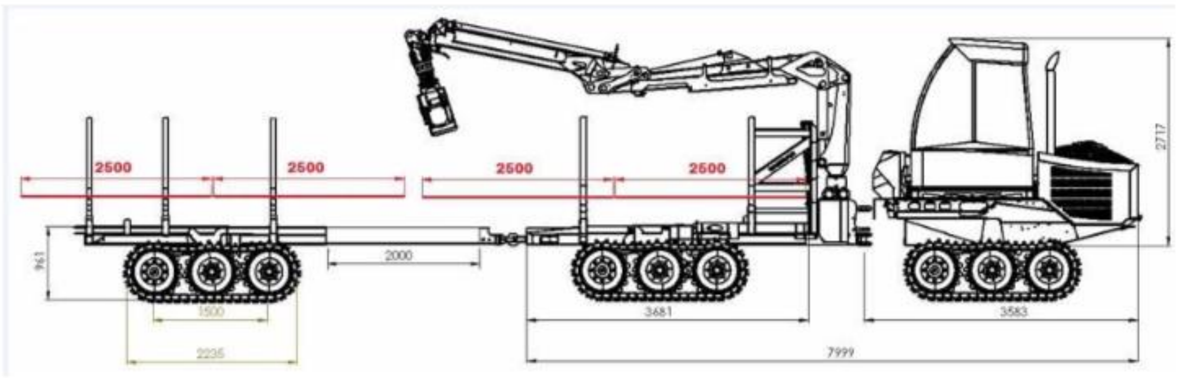


from: https://sol.environnement.wallonie.be/home/sols/autres-menaces/compaction.html

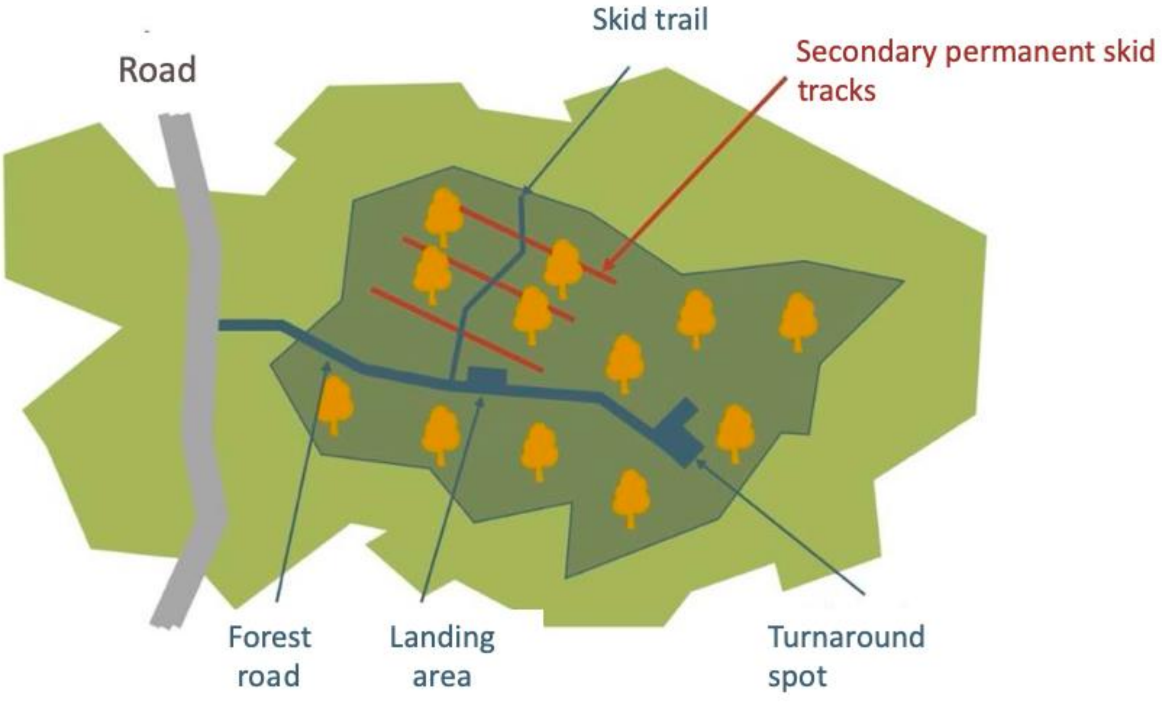
BE CAREFUL
80% of soil compaction occurs between the 1st and the 3rd intervention

Main consequences:
→ significant decrease in macropores
→ destruction of soil structure
→ large increase in soil bulk density
→ no natural ventilation of the soil

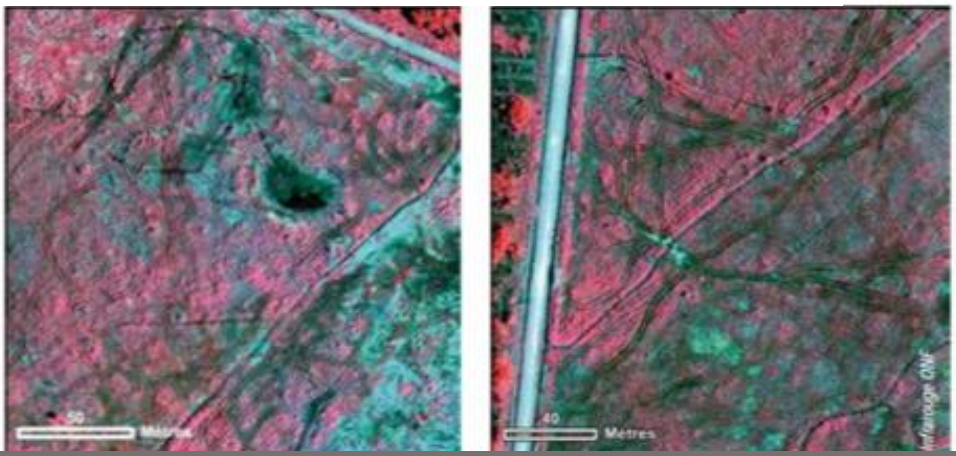
Forwarders with 4, 6 and 8 wheels



Timbrear’s LightloggC was very promising in terms of reducing impacts on soils, because it spread load over two frames. It was tested in France in 2011-2012, and many foresters found it interesting. Unfortunately, however, it did not succeed for economic reasons, and production has now stopped.



WITHOUT HARVESTING PARTITIONS
→ the surface impacted by machines can be as high as 60% !



Tracks from the use of machines. Infrared photos, Vierzon forest (France)

Images from the Pratic'sols Guide

Meriem Fournier: In week 4, we saw a fairly standard worksite with a harvester and a forwarder. Besides improving the machines and work sites' organisation, are there situations in which you completely change your methods, with what we would call breakthrough innovations?

answer: Another system, which is not fully innovative in mountainous regions, is what we call aerial cable skidding. What is somewhat innovative in recent years with climate change is to see that these techniques can also be used in flat lowlands. The majority of forestry operations are undertaken in winter, but, with climate change, there is more and more rain in winter (and less frost) and this makes forest soils even more sensitive and vulnerable.
Using such systems in flat lowlands is an interesting alternative. Combinations of systems can also be used, typically land-based systems with forwarders, tractors and horses. The horse does the skidding until the partition, covering a distance of 80 to 100 m. At the partition, the forwarder brings the wood to the log landing area. The combination of systems is often a win-win situation for everyone.

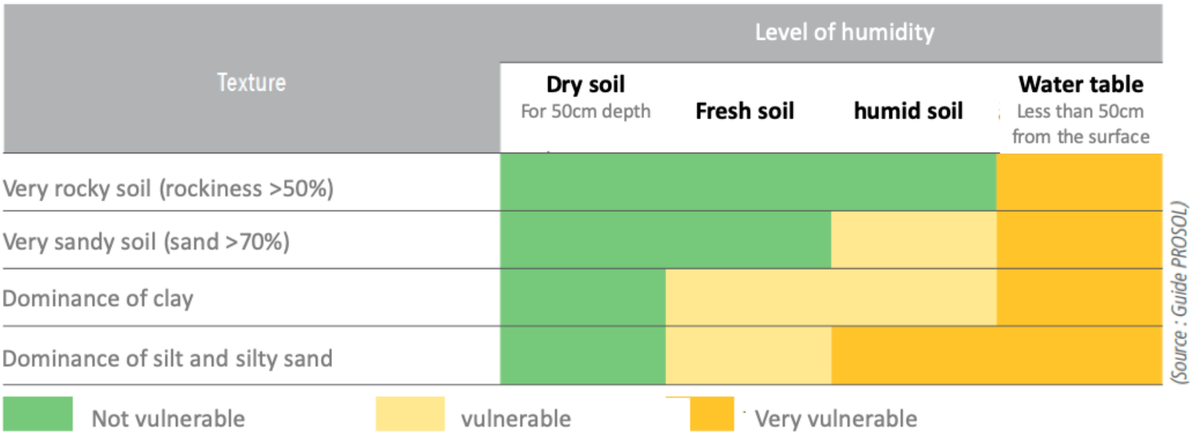
We are also working on systems based on exoskeletons, for the moment mainly for foresters who do forestry work (clearing, cleaning ...) and who for example carry brush cutters. This type of aid already exists in the construction industry or in the cinema industry, for example, for cameramen. It is going to arrive for loggers and is an innovation that we will hear about in the next 5 to 10 years.


EXHAUSS
EXOSQUELETTES
Gamme
Sxstem.
Modulaire.
Puissante
Durable.

Meriem Fournier: In week 1, we taught our MOOC listeners that an important skill for foresters is to know how to observe soils. We explained that you have to know how to look at the humus, the texture, the acidity, the water reserve and that this information is used to know which trees should be grown in each location. Could you explain how such characteristics are also used to diagnose soil vulnerability?

E. Ulrich

Profiles of forest soils with different textures and stone content



Texture	Level of humidity			
	Dry soil For 50cm depth	**Fresh soil**	**humid soil**	**Water table** Less than 50cm from the surface
Very rocky soil (rockiness >50%)	🟩	🟩	🟩	🟧
Very sandy soil (sand >70%)	🟩	🟩	🟨	🟧
Dominance of clay	🟩	🟨	🟨	🟧
Dominance of silt and silty sand	🟩	🟨	🟧	🟧

🟩 Not vulnerable 🟨 vulnerable 🟧 Very vulnerable

(Source : Guide PROSOL)

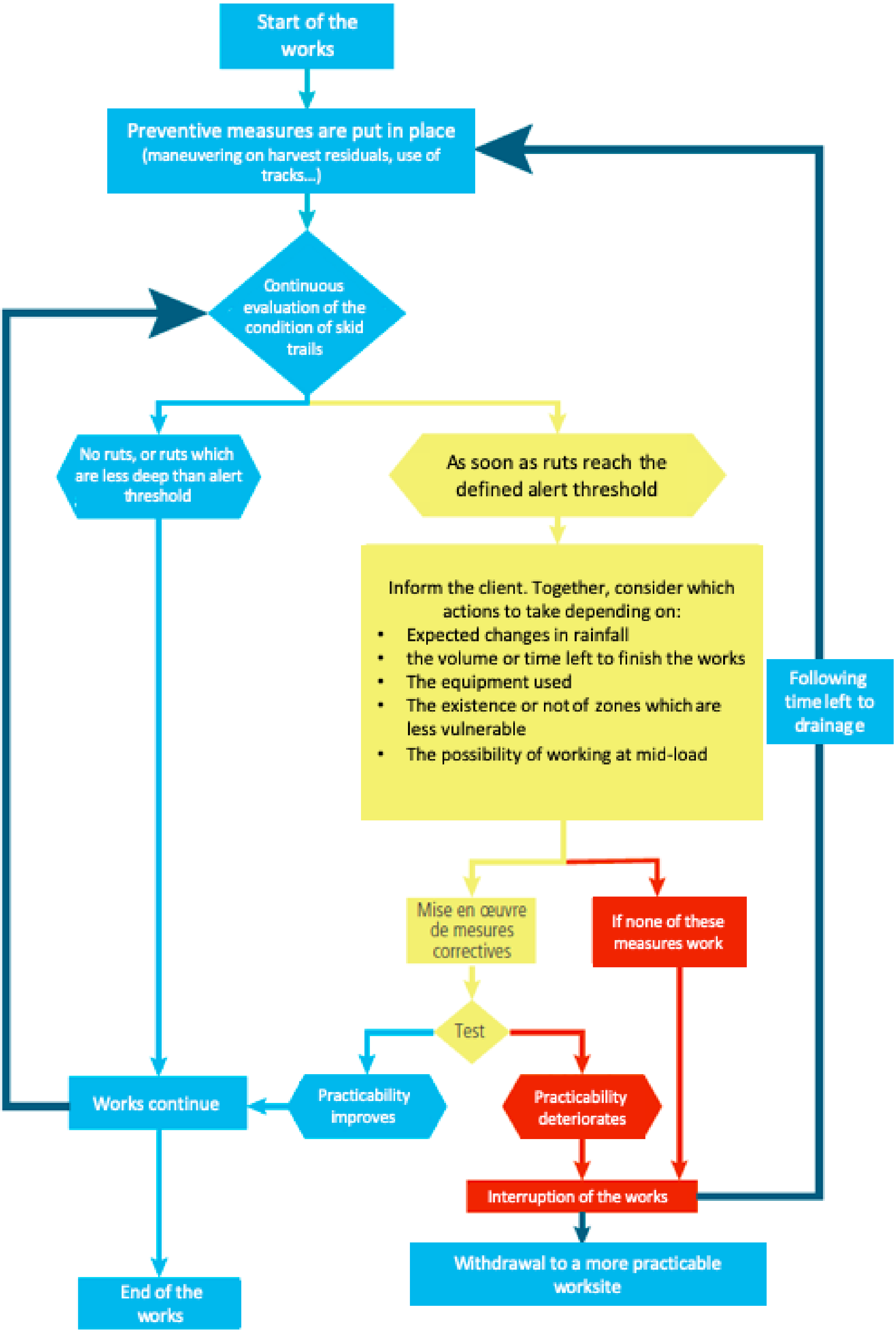
Exerpt from the Pratic'sols Guide

Didier Pischedda : During forestry interventions, ground-based machines ride on the forest floor which is a natural system. The vulnerability of a forest soil can be a function of two criteria:

- The first is the texture of the soil: is it sandy, silty, clayey or with a coarse texture (with stones) ?
- The second is its moisture content. This moisture content varies with rainfall, which is not the same from one day to the next and which varies during an intervention.

Here, we talk about potential vulnerability. Such diagnoses are tools that we have developed over the last 20 years and that we include in our special requirements for contractors, to warn them that they may be operating on soils that are more or less vulnerable, and that they will have to be careful in the event of rainy episodes that may impact the vulnerability of the soils. This is described in our specifications with all our contractors.

The second factor is to ask ourselves how much we can intervene. We recently wrote a guide called *Praticsols*, on the practicability of forest soils: we know that the soil can be more or less vulnerable, but not necessarily when we start interventions. It can become so if it starts to rain. This means that before interventions, we have to agree on what can bring interventions to a stop. We set a rule. For example, when the operator notices that his machine is creating ruts which are more than 20cm deep, he or she has to contact the manager to see how to manage the end of the intervention. If there are only a few round trips left, these can be acceptable, but if there are several hundred cubic meters left, we have to stop. At the National Forestry Office, we are also identifying fallback sites for these companies, to enable them to work all year round and prevent them from being out of work.



Exerpt from the Pratic'sols Guide

Meriem Fournier: What about wood transportation? I lived in French Guiana, where transportation was a problem, because once the wood was brought to the log landing area, there were still dozens of kilometers or more to bring it to the sawmill. We went to places where there were no roads, so it was necessary to build forest tracks for the transport of wood. Building such tracks is expensive and it has an environmental impact.

First of all, the road itself destroys the forest it replaces, but more importantly, it creates opportunities for surrounding people to implement other land uses, including agriculture, mining or housing. Such land uses lead to permanent and irreversible deforestation. I know that in France, this problem is not crucial, but I was wondering what your problems were with the transport of wood?

Didier Pischedda: Indeed, transporting wood, especially in the mountains, entails building new infrastructures. These infrastructures are an important investment for the foresters and, in communal forests, for the public bodies that own them.

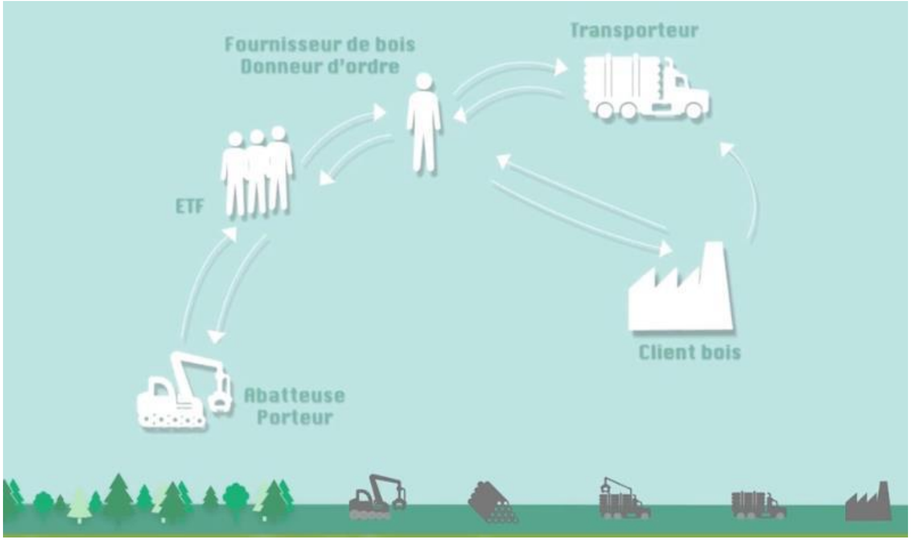
Transport infrastructures require regular maintenance, especially in the mountains where water runs down these structures. We recently received a proposal from a French start-up (Flying Whales) to remove wood from the forest via an airship, which can then bring it to a logistics platform or even directly to the wood processor. To date, we are studying the organizational methods for this type of equipment which does not exist yet and remains a concept. We don't have sufficiently reliable technical data yet to be able to choose this solution over another, nor do we have the economics data which could inform us on the cost of this system. But it's an interesting innovation to look into and it would allow us to stop using machines in the forest, especially in mountains where the risk is the greatest, and it would avoid road transport between the forest and the customer.

Meriem Fournier: Great! I have one last question, given that you began by telling us that your mandate also involves topics of data management and processing. In this week’s first video, which is dedicated to innovations, we saw that one issue was to improve both information on forests and the way this information is shared between all stakeholders. How do you see harvesting participating in this effort, given that it is the link between wood products and the forest?

Didier Pischedda: All forestry machines are equipped with a computer and they take continuous measurements, for the driver obviously, but also production data for the machine owner, and data concerning maintenance. This data has been standardised in recent years by our Swedish colleagues, the Skogforsk forestry research centre, and the resulting standard has been adopted by all machine manufacturers regardless of their origin. Today, the challenge is to be able to use this data as a client or as a customer. This involves accepting that the data be passed from the machine owner to the person who mandated the intervention. Several things must be done for data to be shared.

First, we must guarantee that the data, which concerns all the trees that have passed through the machine, have been calibrated and controlled. We had a project with the operators to carry out these tasks properly. It is then necessary to transfer this data to stakeholders who do not own the machine. Here, we have the same issues as when you access your bank account via your smart-phone: you need minimum security to guarantee that you are consulting your data and not that of your neighbour. We are currently designing systems to standardize these exchanges, with a French project called EMOBOIS, which is based on an international exchange standard which is being set up called PapiNet. Once this is done, we will be able to compare data that is continuously taken on our forests, that are georeferenced, so we will know exactly where the tree with such and such characteristics was taken, and will be able to compare this information with our timber volume table[1], or with the growth models[2] that exist for each species, in order to be able to better organise our future work sites. This topic, called big data, will be increasingly present over the next 10 years. At the National Forestry Office, we have also started recruiting people who are not foresters at all, but rather who specialize in processing these databases.

A driver in a cabin with a computer ©Castagnet Duméou, et on the ground measurements allowing for calibration © FCBA



The Emobois system

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[1] A timber volume table is based on a formula used to estimate the volume of the tree (the total volume, as seen in week 4 during the carbon assessment, or commercial volumes following different specifications) according to its measured characteristics: diameter, height ... Traditionally, they are established from a sample of felled trees which are then precisely measured.

[2] Growth models are computer-based tools that rely on observations of inventory plots or on ecophysiological considerations (photosynthesis etc.) to evaluate how the volume of wood in the forest increases over time as a function of the environment and of silvicultural practices. We saw several examples of this during weeks 1, 2 and 3.

Thank you, and goodbye!

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Cahier National des Prescriptions d’Exploitation Forestière (validé par PEFC) : https://www.onf.fr/produits-services/+/63f::cahier-national-des-prescriptions-dexploitation-forestiere-cnpef.html

Mechanization :

Débardeur à grue et à câble https://www.youtube.com/watch?v=yp9OLpGRpug

Débardeur à grue (on voit les phases de débusquage et de débardage) https://www.youtube.com/watch?v=Aubr0nwdlEA

Système de commande de grue intelligent (IBC) pour les grues de porteur https://www.youtube.com/watch?v=L1CQqKasg9U

Expérience d’un ETF français avec cette innovation : https://www.youtube.com/watch?v=XKkrPbqxHBA

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Vidéo 1 FNEDT ONF : Les atouts du débardage par câble : https://www.youtube.com/watch?v=ctoENATjbBA

Vidéo 2 FNEDT ONF : Les atouts du débardage par câble aérien en 56 secondes : https://www.youtube.com/watch?v=cpEovJhrhcc

Autre article site ONF : https://www.onf.fr/+/4df::cable-mat-que-retenir-de-ce-debardage-aerien.html

Opération de débardage par câble-mât à Hostens / Gât-Mort : https://www.youtube.com/watch?v=zNqGXBNgy6E
Début 2019, le Département de la Gironde et l'ONF ont réalisé un grand chantier de débardage par câble-mât à Hostens / Gât-Mort. Cette technique innovante permet de préserver les milieux naturels.

Forêt girondine : débardage par câble pour protéger les milieux sensibles et les espèces rares https://www.youtube.com/watch?v=rxCBRRpG_8Y

Les Ecouges : le débardage par câble aérien : https://www.youtube.com/watch?v=qKypP678izg
Le débardage par câble est une technique d'exploitation forestière vertueuse et respectueuse de l'environnement. Le câble qui transporte le bois est démonté à la fin de l'exploitation. Exemple dans la forêt des Ecouges, un Espace Naturel Sensible isérois géré par le Département de l'Isère.

Le bûcheron des cimes : https://www.youtube.com/watch?v=gbhu_Xd6LpU
Un film documentaire de Gilles Perret pour Chroniques d'en haut. Une Co-production Mécanos productions/ France Télévisions

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Deux sources utilisées lors de la rédaction du guide PROSOL :

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PISCHEDDA D., BRÊTHE A., RANGER J., 2009. Enjeux et gestion du risque de tassement des sols en forêt. Colloque INRA - Le tassement un risque majeur pour les sols ? SIMA 2009 http://www.accac.eu/decouverte_aigoual/Docs/Enjeux_et_gestion_du_risque_de_tassement.pdf

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Lien guide Clefs pour agir : Récolte durable de bois pour la production de plaquettes forestières ADEME 2020

Projet Européen EFFORTE: Efficient forestry for sustainable and cost-competitive bio-based industry
https://www.luke.fi/efforte/

Innovations machinisme pour protéger les sols

- Porteur forestier à 10 roues

https://www.youtube.com/watch?v=giLWZCVOATk
https://www.youtube.com/watch?v=TKBImtv8l_M

- Prototype de porteur avec des chenilles Prinoth (chenilles de dameuse)
  https://www.youtube.com/watch?v=DFj4QPQlYXE

Porteur à deux paniers https://www.youtube.com/watch?v=BMT_RY1eu8I

Data collection in forests and data processing

Fiabiliser l'utilisation de systèmes de mesure des machines de bûcheronnage. Projet FCBA FACILACHANTIER. 2019

eMOBOIS : site internet : https://emobois.fr/

Videos

Présentation eMOBOIS : https://www.youtube.com/watch?v=X6fT4y2Sjus
eMOBOIS - Au service de l'industrie et du bois :
https://www.youtube.com/watch?v=1BomfA_7IE0
eMOBOIS - Au service du transport du bois :
https://www.youtube.com/watch?v=6z6zpU6f3Nw
eMOBOIS - Au service de la filière bois énergie : https://www.youtube.com/watch?v=Tbj-3lctazY

Canada :

Projet « Foresterie 4.0 » https://www.youtube.com/watch?v=1bpYfrJWA14

This video outlines the Forestry 4.0 initiative as well as a vision of what forest operations could look like in the near future. Several emerging technologies such as the Internet of Things, automation and robotization, massive data analysis systems, artificial intelligence, augmented reality, etc., are converging towards a 4th industrial revolution. The forestry sector will also be influenced by the emergence of these technologies.

Week 5

Forest management and innovation

Video 3

Experimenting with new species in response to climate change

Introduction

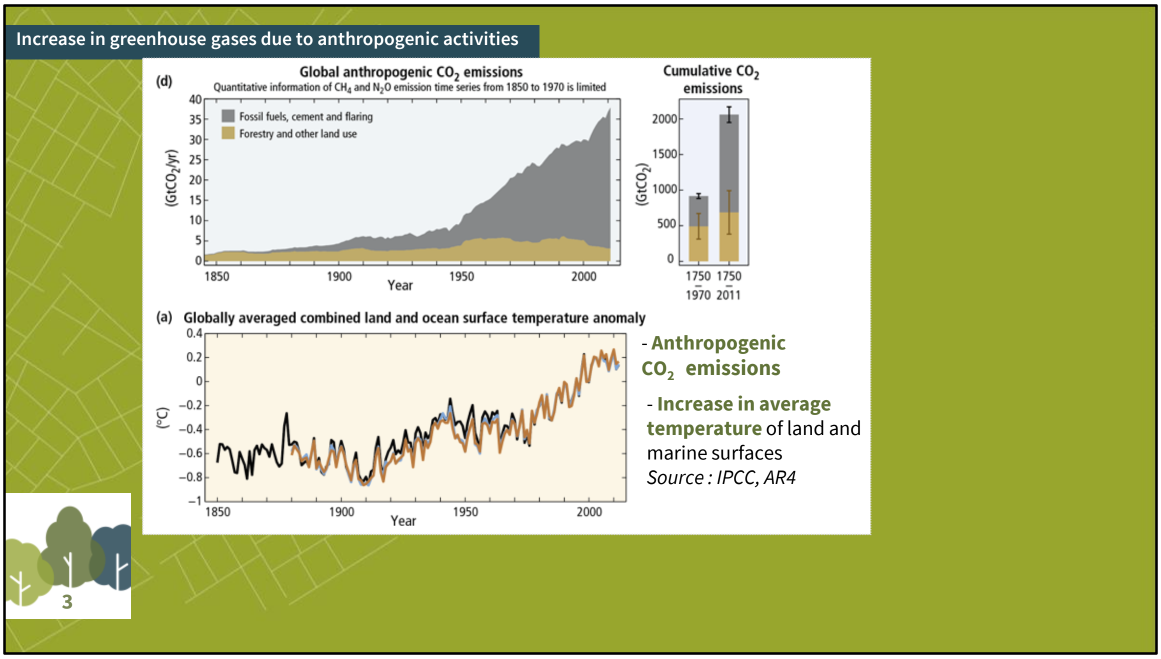
Climate change seriously **threatens**
our forests

One way to adapt is to
look for new tree species

Over the course of these 5 weeks, we have regularly hinted at the fact that climate change seriously threatens our forests. By modifying the growing conditions of trees and their associated species in forest ecosystems, climate change challenges the circumstances of forest management.

In doing so, it forces foresters, researchers and forest managers to actively seek solutions to adapt.

One of the possibilities for adaptation consists in looking for new forest species. This is what we will focus on today.



Increase in greenhouse gases due to anthropogenic activities

- **Anthropogenic CO_2 emissions**
- **Increase in average temperature** of land and marine surfaces

Source : IPCC, AR4

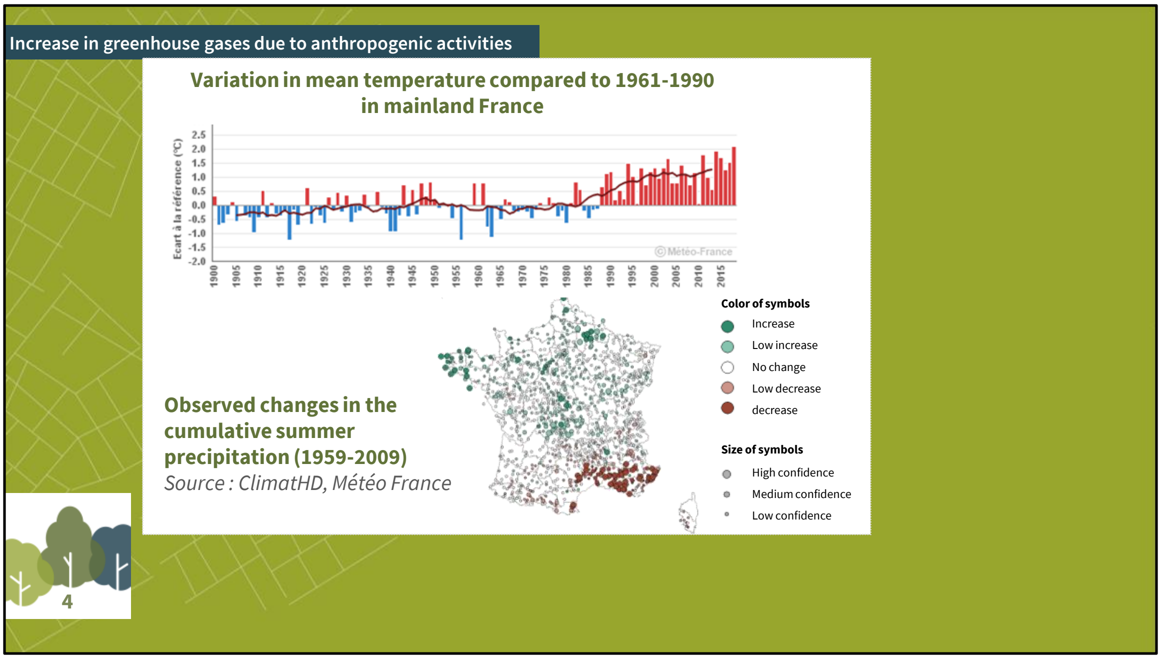
First, this is a brief reminder that global warming results from the increase in greenhouse gas effect resulting from human activity. This considerably accelerated in the 20th century, mainly due to CO2 emissions, whose increases are shown on the graph at the top of this slide.

These CO2 **emissions** mainly come from burning **fossil fuels** (coal and petrol, in grey on the graph) and from **deforestation** (in brown on the graph).

In both cases, carbon stored in the form of coal, petrol or wood is released into the atmosphere in the form of carbon dioxide, or CO2. Human activities (industry, agriculture, transport) also emits other greenhouse gases, particularly **methane**.

Such changes in composition increase the atmosphere's capacity to retain infrared radiation reemitted by the earth, which is itself heated by the sun. This change translates into **a global warming of the climate**, represented in the graph on the bottom of the slide, and into a change in climate variability depending on the region.

It's important to understand that this warming does not depend on today's emissions, but rather on the **accumulation of past emissions** up to today. This means that considerable efforts will be required to reverse the current trend.



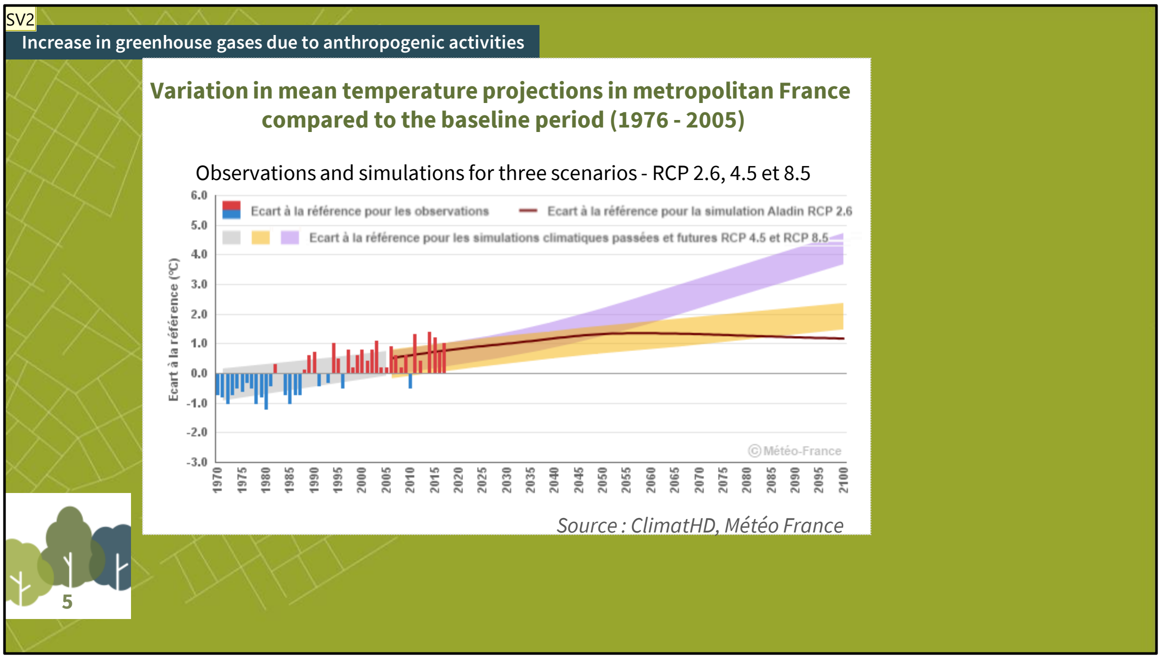
Increase in greenhouse gases due to anthropogenic activities

Variation in mean temperature compared to 1961-1990 in mainland France

Observed changes in the cumulative summer precipitation (1959-2009)

Source : ClimatHD, Météo France

In France, these changes have already resulted in a warming of **1.5°C since the start of the 20th century**, and in a decrease in precipitations around the Mediterranean region.



SV2

Increase in greenhouse gases due to anthropogenic activities

Variation in mean temperature projections in metropolitan France compared to the baseline period (1976 - 2005)

Observations and simulations for three scenarios - RCP 2.6, 4.5 et 8.5

Source : ClimatHD, Météo France

Future changes, both globally and in France, will depend on the decisions we take and will take, but warming will continue at least until 2050, and temperatures could reach an additional 4°C compared to the end of the 20th century in the worst case scenario.

This change in temperatures could be combined with a decrease in summer precipitations, especially in the South of France.

Warming increases plants’ water requirements in summer.

Thus, this decrease in summer precipitations exacerbates water scarcity. Drought and heat episodes will become more frequent and more intense.

SV3

Visible changes

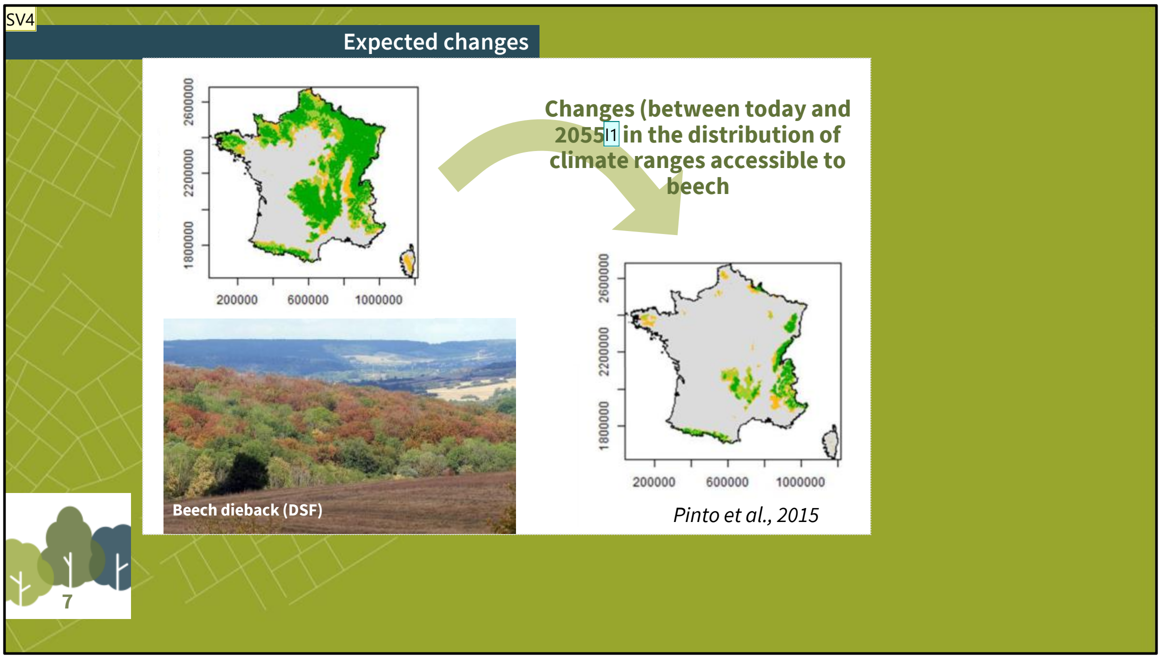
From the works of C. Robinet et A. Roques
Illustration : www.developpement-durable.gouv.fr/Front-d-expansion-de-la-chenille.html

6

This change in temperatures impacts the functioning of trees, which unfurl their leaves earlier and suffer from drought.

It opens up new areas for insects or diseases that threaten forest trees, whether these pests are naturally present in our territories or accidentally introduced by human activity, as is increasingly the case.

In this illustration, we can see how the pine processionary caterpillar colonized new areas in France between the eighties and in 2009, thanks to increased warming.



SV4

Expected changes

Changes (between today and 2055I1 in the distribution of climate ranges accessible to beech

Beech dieback (DSF)

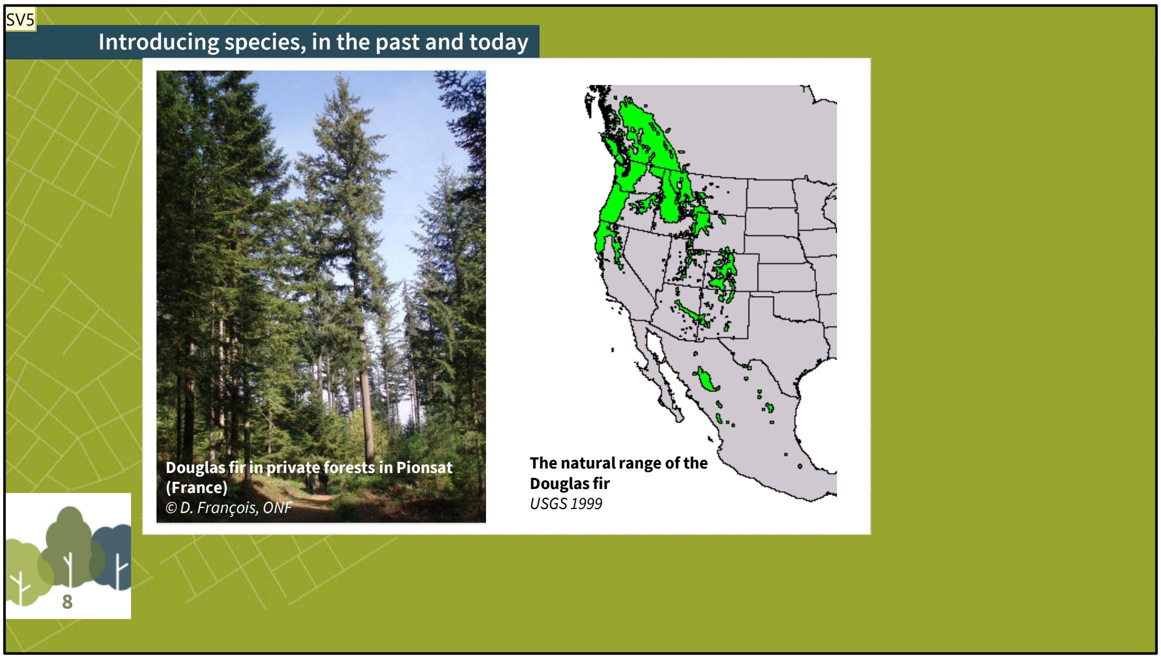
Pinto et al., 2015

You now know that forests and their tree species are intimately tied to climate. **3°C of warming corresponds to several hundred kilometers of lowland movement !** On the long term, therefore, climate change will not only disturb the functioning of trees, it will also deeply change their environmental conditions.

This is the idea conveyed by this map, which shows the changes in the areas where the climate will be accessible to beech trees, between the current conditions at the top of the slide and the projected conditions in 2050!

Moreover, drought episodes are increasingly provoking diebacks, for example of fir and spruce in the mountains in eastern France, or pine and fir in the the Mediterranean inland, or, more recently, beech in eastern France, as shown in this photo from the Department of Forest Health.

This is why, amongst adaptation measures, foresters prioritize searching for species adapted to warmer and drier climates.



SV5

Introducing species, in the past and today

Douglas fir in private forests in Pionsat (France)
© D. François, ONF

The natural range of the Douglas fir
USGS 1999

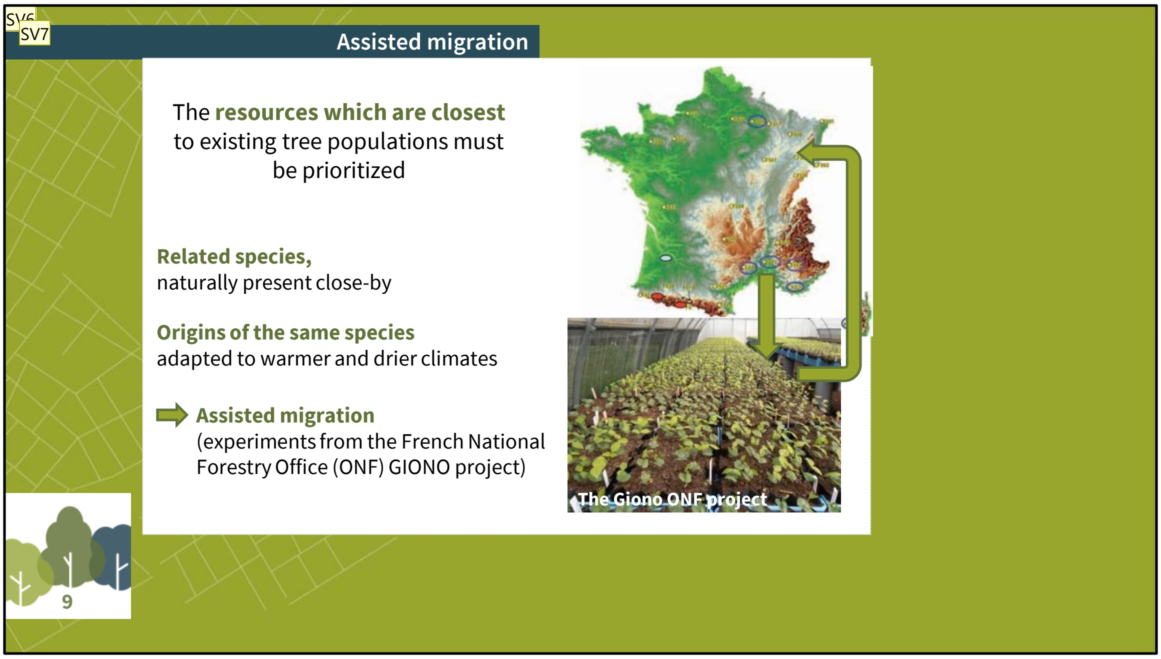
8

Europeans have been moving tree species for a long time: chestnut trees were introduced in France in Gallo-Roman times, maritime pine was planted in Fontainebleau as early as 1530, Scots pine was massively used for reforesting in the 19th century in regions where it did not occur spontaneously, cedars were introduced from North Africa, locust trees were introduced in France in 1601, from the Americas.

More recently, in the 20th century, the use of Douglas fir, introduced from the Americas, also increased with great success. Here, we can see an illustration of this, with spectacular individuals growing in a forest of the Massif Central, in Central France.

These trees sound familiar. This is because their introduction in France was successful, and they are now part of our landscapes. However, we must also remember that there have been numerous failures. This is because it isn't easy to assess the environmental conditions which are necessary for a species, and even harder, perhaps impossible, to anticipate how it will react to the ecosystem in which it is introduced. In this ecosystem, it can either be eliminated, adapt or become invasive.

Here, our new quest is the search for new forest species adapted to warmer and drier climates.



SV6 SV7

Assisted migration

The **resources which are closest** to existing tree populations must be prioritized

Related species,
naturally present close-by

Origins of the same species
adapted to warmer and drier climates

➡ **Assisted migration**
(experiments from the French National Forestry Office (ONF) GIONO project)

The Giono ONF project

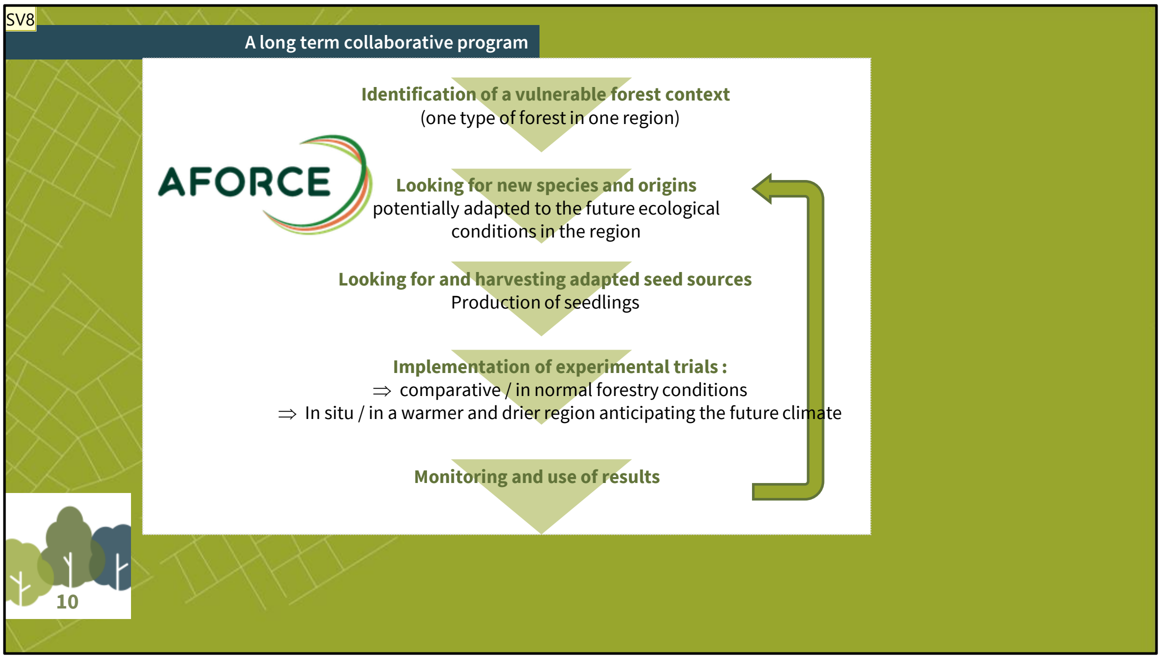
For convenience, I have mainly talked about new species today. We must however be aware that these new species aren't all exotic, far from it.

We can also look for neighbor species. For example, in the large family of oaks, many species are close to ours but grow in drier climates.

We can also look for different species, but which grow in neighboring regions.

More simply, we can even go South to look for the seeds of the same species in our vulnerable zone. These seeds are used to growing in drier and warmer climates, and thus have different genes. In technical terms, this is called "different origins".

This slide shows the Giono project of the French National Forestry Office (ONF) which consists in testing beech trees from the Southern borders' of the species' range by implementing them in the heart of the species' range, in Verdun.



SV8

A long term collaborative program

AFORCE

Identification of a vulnerable forest context
(one type of forest in one region)

Looking for new species and origins
potentially adapted to the future ecological conditions in the region

Looking for and harvesting adapted seed sources
Production of seedlings

Implementation of experimental trials :
⇒ comparative / in normal forestry conditions
⇒ In situ / in a warmer and drier region anticipating the future climate

Monitoring and use of results

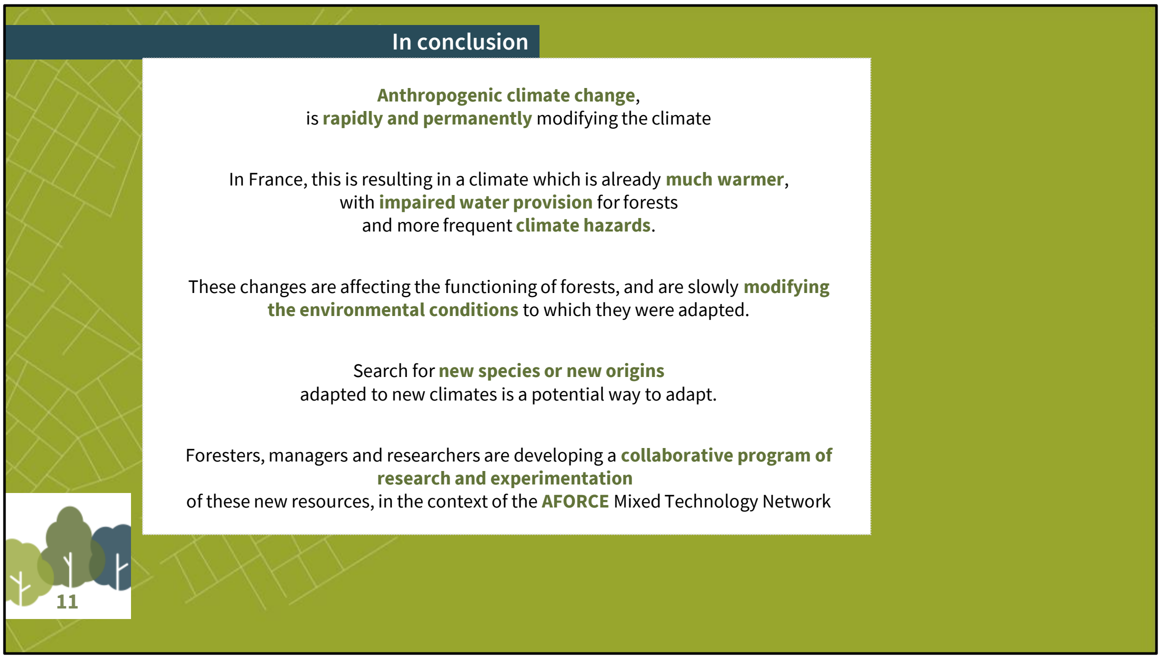
This is why foresters have methodologically undertaken an approach to **look for and test new species**. Efforts do not aim to replace today's species with new species, but rather to look for and test new species as of now, so that these can diversify the species present and take over if these species are threatened by global warming.

First, researchers are looking for species which grow in climates which are warmer and drier than those of the forest area which must be adapted. They are then planting these species in experiments and observing their behavior over time, both in the forest area which must be adapted and in zones which have warmer and drier climates similar to future expected conditions.

Different types of experiments are considered. Some follow a strict scientific protocol, allowing precise measurements and reliable statistical comparisons between tested species. Others are more simple, in normal forest conditions, and work with field foresters collaboratively to accelerate the process of data acquisition. At the French National Forestry Office (ONF), these collaborative tests of new species are called "isles of the future"

In all cases, these experiments will have to be carefully documented and tracked.

These experiments are debated, but this is also one of their objectives : to make all stakeholders – forest managers, foresters, elected officials, wood processors, or hikers – consider the impacts of climate change on forests and start looking at the different solutions which must be developed so that forests can adapt to climate change.



In conclusion

Anthropogenic climate change,
is **rapidly and permanently** modifying the climate

In France, this is resulting in a climate which is already **much warmer**,
with **impaired water provision** for forests
and more frequent **climate hazards**.

These changes are affecting the functioning of forests, and are slowly **modifying the environmental conditions** to which they were adapted.

Search for **new species or new origins**
adapted to new climates is a potential way to adapt.

Foresters, managers and researchers are developing a **collaborative program of research and experimentation**
of these new resources, in the context of the **AFORCE** Mixed Technology Network

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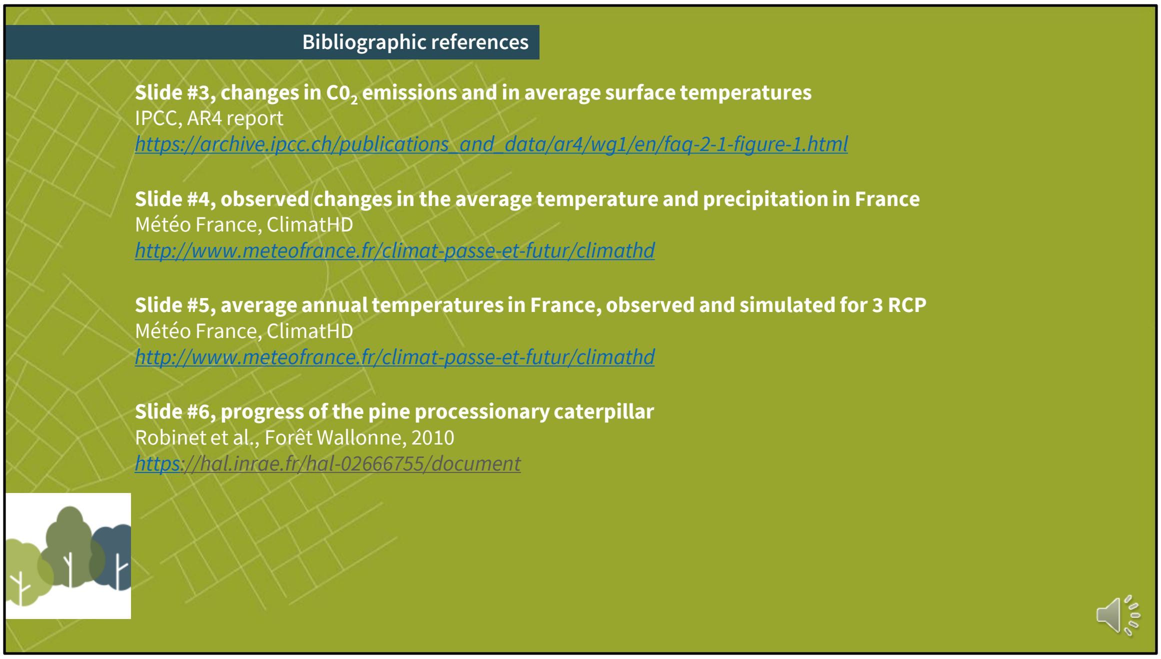

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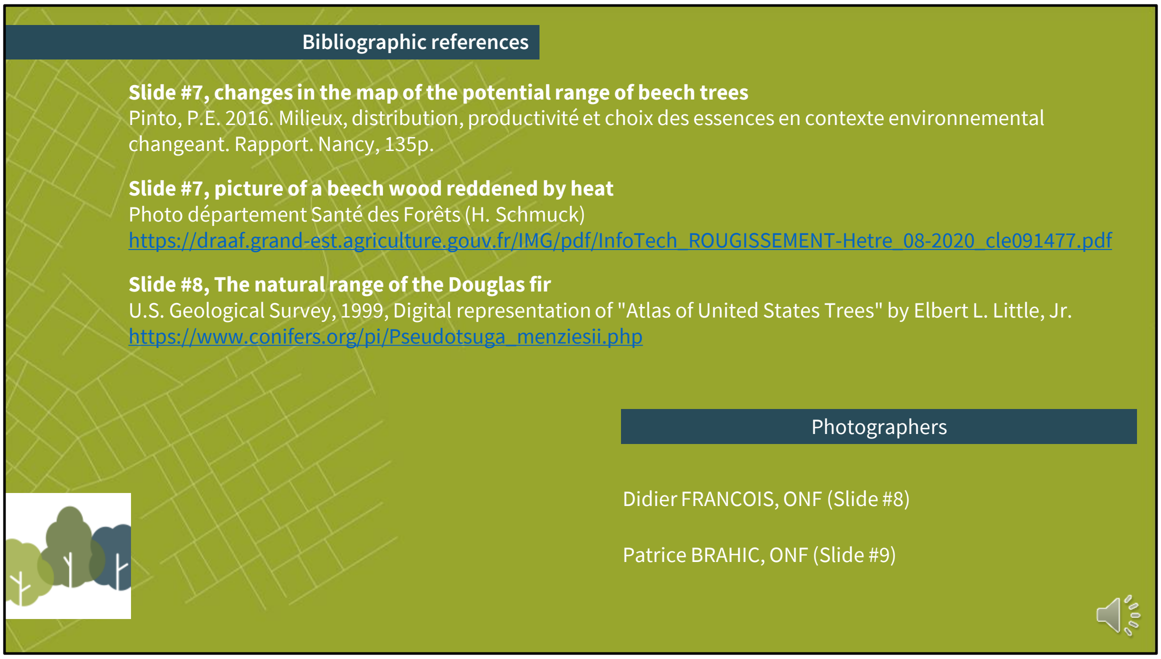
IPCC, AR4 report
https://archive.ipcc.ch/publications_and_data/ar4/wg1/en/faq-2-1-figure-1.html

Slide #4, observed changes in the average temperature and precipitation in France
Météo France, ClimatHD
http://www.meteofrance.fr/climat-passe-et-futur/climathd

Slide #5, average annual temperatures in France, observed and simulated for 3 RCP
Météo France, ClimatHD
http://www.meteofrance.fr/climat-passe-et-futur/climathd

Slide #6, progress of the pine processionary caterpillar
Robinet et al., Forêt Wallonne, 2010
https://hal.inrae.fr/hal-02666755/document



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Pinto, P.E. 2016. Milieux, distribution, productivité et choix des essences en contexte environnemental changeant. Rapport. Nancy, 135p.

Slide #7, picture of a beech wood reddened by heat
Photo département Santé des Forêts (H. Schmuck)
https://draaf.grand-est.agriculture.gouv.fr/IMG/pdf/InfoTech_ROUGISSEMENT-Hetre_08-2020_cle091477.pdf

Slide #8, The natural range of the Douglas fir
U.S. Geological Survey, 1999, Digital representation of "Atlas of United States Trees" by Elbert L. Little, Jr.
https://www.conifers.org/pi/Pseudotsuga_menziesii.php

Photographers

Didier FRANCOIS, ONF (Slide #8)

Patrice BRAHIC, ONF (Slide #9)

Transcription of the video

From the seed to the tree, kickstarting growth in French forests (*Original title : De la graine à l'arbre, coup de pousse pour les forêts françaises)*

Made by the National Forestry Office, « demain prend racine aujourd'hui », www.onf.fr www.youtube.com/watch?v=BiZyMM48juM

All over France, forests are being hit hard by climate change: droughts, storms, destructive insects and parasites' invasions, such attacks are increasingly frequent and causing the death of thousands of trees. Three hundred thousand hectares of public forests have been affected, which is about 30 times the area of Paris.

Some species such as beech, ash, fir or spruce could even disappear from our forests. On the long term, it is estimated that more than 60% of the trees will no longer be adapted to their original environment, a catastrophe of unprecedented magnitude. Foresters are anticipating these changes and are doing everything they can to improve the resilience of our forests.

"This one still has green needles and already has less bark, so it is doomed. Looking up at the horizon, between dry trees and dying trees, it is no longer possible to guarantee a "forested" atmosphere is this stand, which is itself doomed.

The National Forest Office (ONF) has always preferred natural regeneration. We implement a multifunctional and sustainable management for future generations. But in some cases, climatic and sanitary hazards force us to review our principles. Today, with massive bark beetle attacks, very often, the only solution is to plant, because these attacks are on stands which are not resilient.

The forest is sick and fragile, it is threatened by climatic events and we know that will not be able to adapt on its own. To adapt on its own, the forest has two solutions: either its pollen will move, or the seeds will be moved by birds, for example. We know the speed of such movement is ten times slower than that of climate change itself. We must try to rely on nature, of this we are certain: it is important. We do not have a choice, there is no question of replanting the entire French forest. But because climate change is going much faster than the capacity of trees to adapt, we will also have to resort to planting.

Today, we are betting on the diversity of species because we can see that these monospecific planted forests over large areas do not yield anything good. One of the keys for our future forest is probably to have mixed, more open and younger forests. We are looking to reproduce what nature does. The challenge for the National Forestry Office is twofold: it is both to replant in quantity to compensate for dieback, while diversifying species and silviculture methods. We call this strategy that of the "mosaic forest". In December 2020, to help forests face the climate crisis, the French government launched a recovery plan of 150 million euros, dedicated to the reforestation of French forests. This is unprecedented. The objective is to be able to adapt, regenerate or reconstitute 45 thousand hectares of forests, this corresponds to more or less 50 million trees.

The supply of quality seeds is crucial. The Joux drying plant, located in the Jura and managed by the National Forestry Office, is one of the two main suppliers of forest seeds in France. Every year, it processes several tons of seeds from a hundred different species.

"In our workshop, we receive seeds in their raw state, we sort them, and separate the good seeds from the bad seeds. We conduct analyses to ensure their quality. We then store them in a cold room and send them back to tree nurseries all over the country. We provide a seed bank and logistics support. In my opinion, this is clearly a central element for reforestation in the future. Increasingly, we are going to have to resort to assisted migration to bring southern species towards more northern forest areas. Inevitably, this will entail a lot more reforestation than what we used to do; and clearly, to conduct such reforestation, you need seedlings, and to produce seedlings, you need seeds.

The seeds treated by the Joux drying plant come from seven seed orchards and from 400 classified stands covering thirty-six thousand hectares in state forests, distributed throughout the country. We harvest hardwood seeds and softwood cones. These seeds are chosen for their genetic qualities and can thus contribute to the adaptation of forests to climate change. Before this, these seeds must be given to tree nurseries, who will have the delicate role of making the seeds germinate and then of raising the young seedlings that will populate our future forests.

Here at Lemonnier Nurseries, we cultivate about fifty "classic" forest varieties. This represents a production of a little less than 2 million seedlings. 2 million seedlings result in 2000 hectares of reforestation. Our idea is to produce seedlings of the best quality, with the best resources within themselves, so that when they are planted in forests, they grow very quickly right from the first year. Climate change raises a lot of questions: "what should we do?", "how should we act?".

We see that we must act now and perhaps that we should have anticipated it a little bit earlier. As a consequence, this is immediately urgent. Those of us who work in nurseries have an important role to play in this transition and in helping the French forests overcome this anticipated climate change. Such is the very vocation of foresters, and to do so, we must constantly measure the effects of climate change, test new tree species, and innovate in silviculture methods to help our forests become more resilient, from the seed to the tree.

A whole sector is being set up, mobilising a large number of stakeholders, foresters of course, but also tree nurseries, scientists, elected officials, civil society organisations and citizens. Together, we can prepare future forests.

Video Transcript

Mountain Scarifier

In montane forests, natural regeneration is preferred to planting because costs are lower and existing trees are generally better adapted to local conditions. However, the establishment of natural regeneration can be difficult, especially in the upper montane and subalpine levels. Here, foresters are confronted with very slow seedling acquisition or even complete suppression due to competition from spontaneous vegetation. Moreover, the thick humus typical of forest stands at this altitude accentuates the phenomenon of physical barriers, which prevent seeds from reaching the mineral soil to ensure seed germination, growth, and survival of young plants. Bare soil and temporary removal of vegetation are therefore essential.

These operations can be carried out mechanically using shovel-mounted equipment. In the northern alpine context, work by 50 m² plots is preferred. In addition to stripping, micro-reliefs perpendicular to the slope are created. These micro-reliefs reduce runoff, preserve seeds in the tilled areas, and provide micro-climatic conditions that are more favorable to seed germination.

The mountain scarifier developed by the Grenier Franco company in conjunction with ONF and INRAE is a tool designed to establish these types of plots. It is 1.20 meters wide and features 4 main prongs, 3 secondary prongs, and a curved blade with gripping lugs. Thanks to its robustness, it can be used on the arm of a spider excavator as a support point, which is essential for moving on steep slopes. On gentler slopes, the use of a crawler excavator as an equipment carrier is preferable. The maximum weight of the carrier is 9 tons.

Site preparation is essential to optimize the movements of a spider excavator thus reducing costs. The forester sets up the location of the future plots worked on with large stakes that are clearly visible to the driver. The stakes are placed every fourteen to fifteen meters, aligning them on the slope to limit lateral displacements, avoiding areas too cluttered by rocks or stumps in the area to be worked. The operator of the spider excavator climbs to the highest point and places himself under a milestone that marks the first square. They then perform several tasks: first, they clear the area by pushing back slash and stabilizing the unstable material. Then they use the blade to clear out the competing vegetation and the humus-bearing horizon on the upper ten to fifteen centimeters of the soil. They create micro-relief 30 to 40 cm high then move down a few meters and repeat the process two or three times to obtain a 5 to 6-meter wide and 8- to 10-meter-long plot. Once the plot is completed, the operator proceeds to the next one. Once the work is finished, all the plots obtained account for 20 to 30% of the area covered. This localized work helps minimize the environmental impact.

For several years, ONF has carried out numerous projects on spruce and larch stands in the Northern Alps. Thanks to this technique, 30 times more seedlings are yielded than in unprepared areas. The optimal period for the work is between August and November. In the high mountain environment, the working speed is about 0.6 to 0.7 hectares per day, for an average price of 1800 to 2200 euros per hectare. This price, excluding the cost of transferring the equipment carrier, obviously varies depending on the complexity of the site.

In summary, the success of these work sites requires delineating and mapping the areas to be covered, setting up the plots beforehand, choosing the right equipment carrier, and grouping the work sites geographically and temporally. Trained operators used to the technique are a guarantee of performance and safety in these complex environments.

For more information, contact the Office National des Forêts Pôle de Chambéry or visit the INRAE RENFOR website. www6.inrae.fr/renfor/

To be continued, datasheet.

MOUNTAIN SCARIFIER

Stripping, tilling

Bring about regeneration:

In **spruce, larch, and mountain pine forests**, this equipment makes it possible to:

- **control the competing vegetation** (blocking germination)
- **work the soil** for proper root development of seedlings

This equipment is optimized for steep slopes, but can also be used on flat land!

The **"Mountain" Scarifier** is used in the process **of preparing land for either natural regeneration or plantation** in open areas (opening, regeneration cutting). By stripping the upper 10-15 cm of the soil, this tool mainly eliminates the competing vegetation and the humus-bearing horizons. Subsequently, it helps to carry out land work at 30-40 cm of depth by raking while producing ridges.

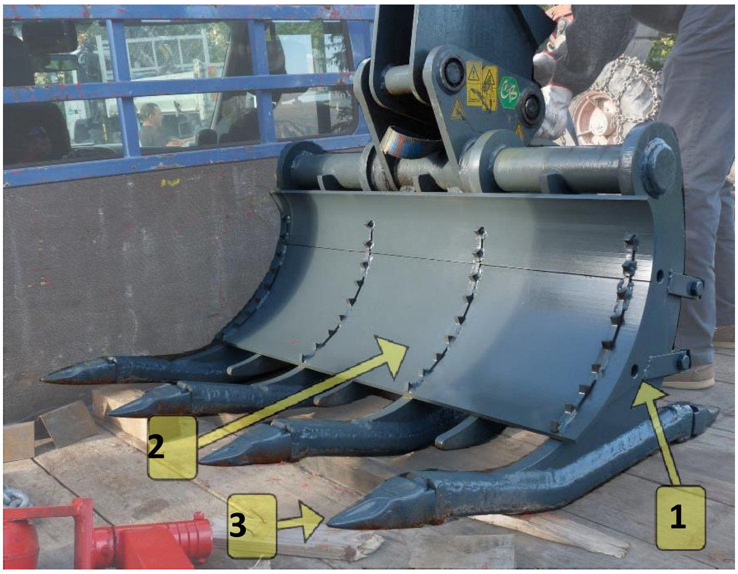
Technical specifications of the equipment

Measuring 120 cm in width and weighing approximately 400 kg, the "Mountain" Scarifier is equipped with:

1 Four main prongs 50 cm in height along with three secondary prongs

2 A curved blade (removable plate) equipped with spikes limiting the sliding of the ridges

3 Shells fixed on the 2 ends of each subsoiling prong (110 cm long)



A device that can be adapted to a spider excavator!

Spider excavators move regularly on steep slopes thanks to their long extension arms. The design and robustness of the "Mountain" scarifier make it suitable for **excavators weighing up to 9 tons.**

MOUNTAIN SCARIFIER

Stripping, tilling

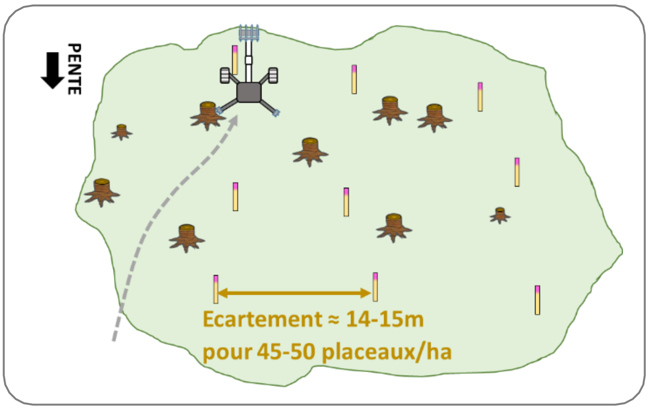
Phases

Phase 1 SITE PREPARATION

Delineate and map the areas to be covered. Work effectively on **25-30% of these areas by unit plots of at least 50 m²**. Plan for **45 to 50 plots/ha**. Stake and map the center of the plots to be covered with a **marker visible from a distance by the operator** of the spider excavator. Avoid areas with a high density of stumps and large boulders. Favor vertical alignment of stakes to limit lateral displacements

Phase 2 MOVEMENT TO THE WORK SITE

Access the summit of the area to be covered without tilling the ground to optimize the speed of movement of the spider excavator. Position the **machine downhill of the stake.**



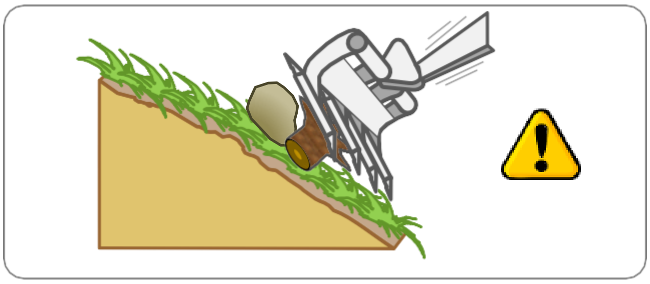
Phase 1 et 2 : SITE PREPARATION & MOVEMENT

Phase 3 TRAVAIL d'un placeau

A plot is made in 2 to 3 passes. For each pass, 3 steps are required:

Phase 3a CLEARING OBSTACLES

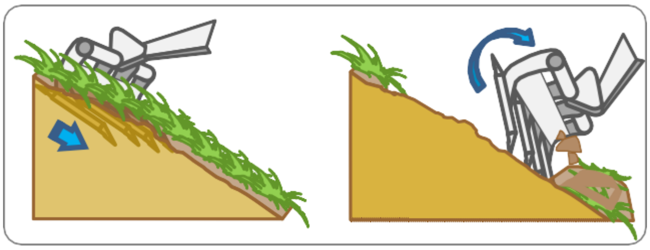
Clearing and **securing obstructions** (slash, stones, small stumps) by lateral movements or against the blade/arms of the spider excavator. Provide **appropriate signage** (+ stop sign) to avoid the **risk of downhill movement**



Phase 3a : CLEARING OBSTACLES

Phase 3b STRIPPING VEGETATION

Stripping competing vegetation and the topsoil horizon to **within the upper 10 to 15 cm of the soil**. Store stripped material down against the blade/arms of the excavator.

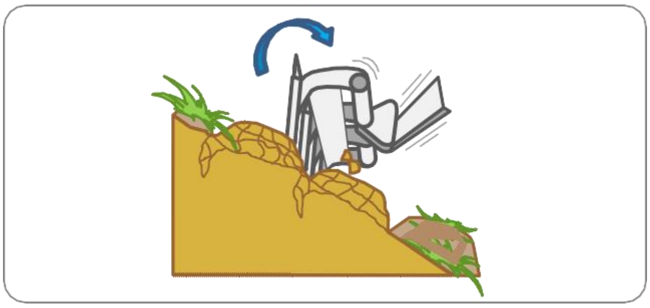


Phase 3b : STRIPPING VEGETATION

Phase 3c RAKING & RIDGE PLOUGHING

Creating micro-reliefs conducive to water and seed retention. Push the subsoiling shells in vertically, **then pull them down to form a ridge about 30 to 40 cm high**.

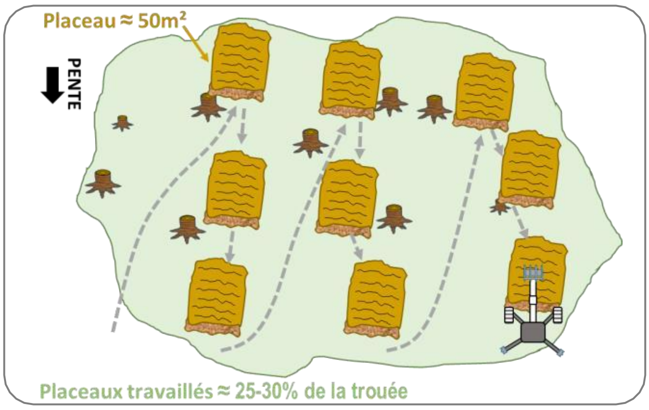
When a section is completed, the spider excavator moves a few meters downhill and repeats the 3 steps to enlarge the plot to 50 m². The spider excavator always remains positioned downhill of the worked plot.



Phase 3c : RAKING & RIDGE PLOUGHING

Phase 4 MOVEMENT BETWEEN PLOTS

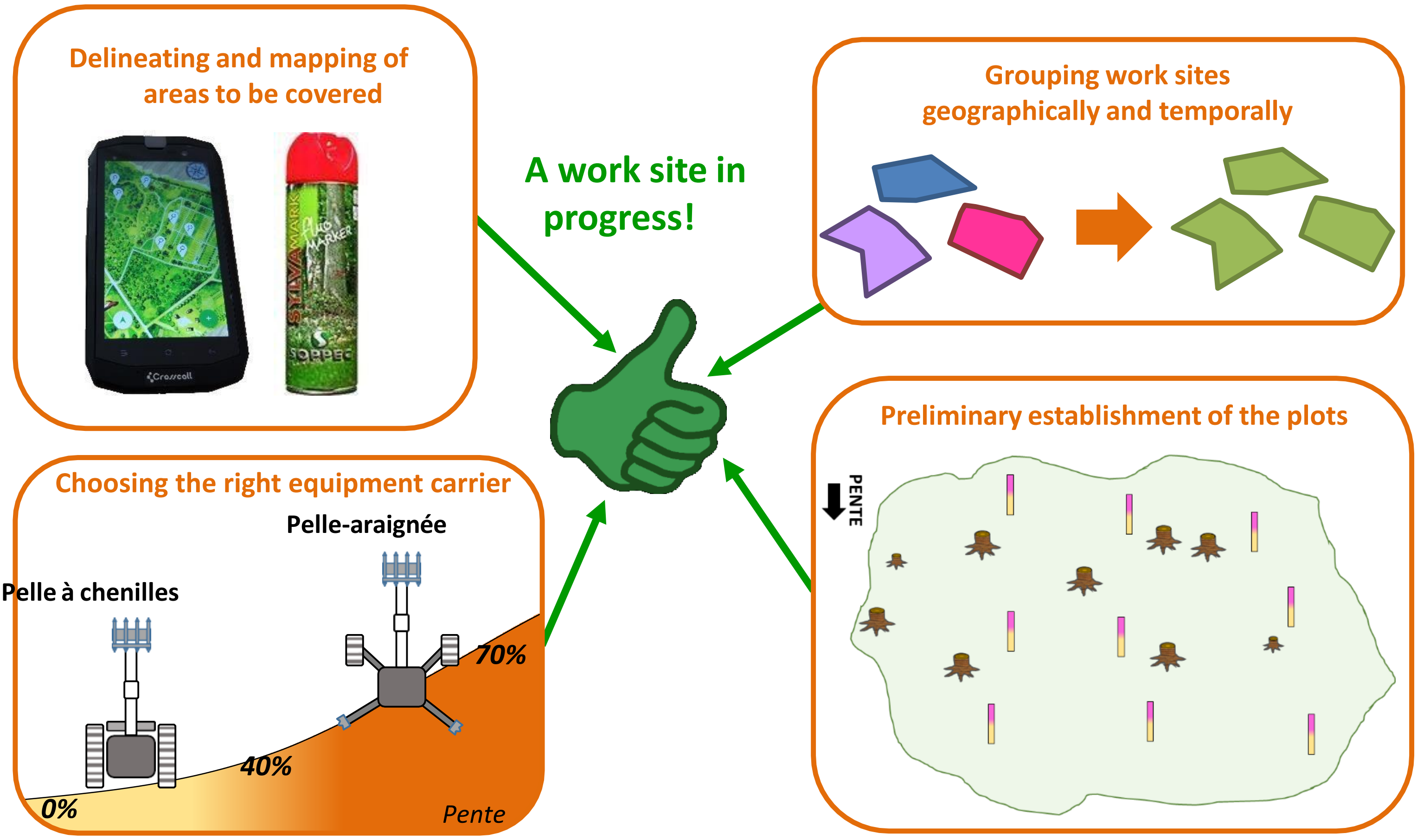
Move down to the next stake. Repeat the process. At the bottom of the row of plots, the spider excavator goes up diagonally towards the next row to be covered.



Phase 4 : MOVEMENT BETWEEN PLOTS

Technical capabilities and economic benefits

The choice of equipment is not the sole determinant of success...



A work site in progress!

Delineating and mapping of areas to be covered

Grouping work sites geographically and temporally

Choosing the right equipment carrier

Preliminary establishment of the plots

Operating speed

- **Output of a spider excavator in an environment with a slope of 40% to 70% and minimal slash:**
  - 12 hours for 1 ha of cleared swath corresponding to 45-50 plots
  - 30% time saving on the establishment of plots compared to a conventional shovel
  - Movements between plots represent 50% of the effective working time

Implementation precautions

- **Site preparation**
  - Install the plots before the beginning of the work
  - Avoid crushing and chopping woody plants of up to 15 cm in diameter ("excavator stripping")
  - Working in autumn in order to obtain a germination bed ready for the following spring

- **During operation:**
  - Secure the surroundings and access to the site
  - Position the excavator downhill of the plot to correctly shape the ridges
  - Limit the displacement of obstacles

- **In the event of plantation:**

This type of land preparation facilitates planting and promotes the establishment of the root system.

Micro-reliefs are essential!

Hollows and bumps slow down seed runoff and increase their potential to germinate on a **micro-site with the right combination of moisture and heat!**

MOUNTAIN SCARIFIER

Highlights

ADVANTAGES

- Efficient technique for mechanical weeding
- More powerful tillage tool than a bucket due to its maneuverability and efficiency
- Conditions with steep slopes ➔ can be used with a spider excavator
- In case of slash ➔ tool well adapted to clearing and unnecessary crushing
- Loosening of the soil up to a depth of 40 cm by raking ➔ root development facilitated (notably in the event of plantation)
- Stripping and ridging ➔ creation of a germination bed suitable for seed establishment (receptive soil for 5 years on average)
- Reduction or elimination of clearances
- Modularity ➔ can be transformed into a reversible scarifier by removing the plate used for stripping

LIMITATIONS & CONTRAINTS

- Stripping phase adapted only to spruce stands, larch stands and mountain pine forests (effectiveness not tested in fir stands)
- Care must be taken to ensure that the best years of grain production are matched with the tillage operation
- Inadequacy on very compact soils and/or soils with a high load of coarse material
- Requires operation on dried or partially dried soil drained
- Visual aspect that can be shocking to the untrained eye during the first year following the operation
- Temporary and restricted surface disturbance of the soil
- Transient diversification of the flora on the worked plots compared to the undisturbed areas

Contact information

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➧ **Pôle renouvellement des peuplements forestiers (RENFOR)**
INRAE Grand-Est Nancy, Silva UMR 1343, rue d'Amance –
54280 CHAMPENOUX - FRANCE
☎ 03.83.39.40.45 –
www6.inrae.fr/renfor

Where to find equipment

➧ **GRENIER FRANCO** - RN7 Creux de la Thine -
26140 ANDANCETTE- FRANCE - ☎ 04.75.03.12.43
✉ francodg@orange.fr

Seedlings of target species in abundance!

The monitoring of sites carried out in the Northern Alps shows that the density of seedlings in the worked plots is on **average 30 times higher in the 5 years following the end of the work** than in the rest of the forest gap.

Fiche technique « Scarificateur Montagne » - Mars 2020

Fiche téléchargeable sur le site : www6.inrae.fr/renfor/Ressources
Crédits photos : ©INRAE et ©ONF – Dessins : L.MALABEUX (ONF)

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Ministère de l'Agriculture et de l'Alimentation

Week 5, video 5, Joint innovations with wood engineers: visit of the ENSTIB (*Ecole Nationale Supérieure des Technologies et Industries du Bois*) – The National Superior School for Wood Technology and Industry.

Meriem Fournier: Hello, we are now in the fifth video of this week dedicated to innovation. Today, we will look into the links between forests and innovation with respect to the uses of wood. We are at the ENSTIB, the school that trains wood engineers in France. Laurent Bléron, the school's director, is welcoming us for the duration of our visit.

Laurent Bléron : Hi! So what do you foresters want to know?

Meriem Fournier: We have come to see you because we have a problem. In France, we have an asset: hardwood trees. We know that you produce systems and are engineers for wood construction, but we have been told that construction requires softwood. How could we solve this mismatch? Are you finding of solutions so that construction can be adapted to the wood that grows in our forests?

Laurent Bléron : We are indeed trying to work with hardwoods. Don't forget that 200 years ago, we used to build with hardwoods, whereas now we mainly use softwoods. Hardwood trees have very resistant wood: when you apply pressure to them, they resist significantly.

Meriem Fournier : Yes. I have heard that hardwood trees are heavy.

Laurent Bléron: That's more of a disadvantage, it adds weight to the structure. But hardwood is very, very resistant. So what we are trying to do is to give value to hardwood species. But something is missing: we don't really know how conduct computations for engineering with these species, because for the past 50 to 100 years, research has focused on softwood. So we need to produce knowledge in order to understand how much **load** oak wood or beech wood can take.

Meriem Fournier: Yes, because carpenters used to build using their experiential knowledge and eyes...

Laurent Bléron: Yes, with eyes only or by "digital balancing".

Meriem Fournier : Whereas today, there are engineering research offices: buildings are calculated, and wood should not be penalised by our lack of knowledge, compared to steel or concrete for example.

Laurent Bléron : Exactly. Today, we have calculation codes and standards. And when we build a building, it must meet safety requirements to resist the weight of snow and to resist wind. These requirements involve calculations, and these calculations must take into consideration the limits of wood as a material, as is done with concrete.

Meriem Fournier: So hardwood could be used for construction if we had sufficient and correct information?
Laurent Bléron: Exactly, what we are missing in terms of knowledge is information on the limits of the materials. We need to characterise these limits for the species that we have in our territory, mainly oak and beech.

Meriem Fournier: I also understood that we could not build with hardwood in exactly the same way as we build with softwood. This is because the reason why we build with softwood: is because it’s light for its mechanical performance.

Laurent Bléron : Yes indeed. When wood bends, its own weight is a disadvantage. For hardwood, we will be using a different construction system, called lattice structures, relatively short bars that are assembled one to the other, in order to transfer tensile and compressive loads through these bars. In these structures, hardwood is very interesting because it is much more resistant than softwood.

Meriem Fournier: Oh, so you need short lengths of wood. You don't need very long trunks. You can use different quality woods...

Laurent Bléron: Precisely, we use wood of log qualities C or D. Poorly shaped wood. We use logs of a length of 2m. We recently built a demo building in Xertigny[1], where we used oak and beech to show that such structures are possible.

Meriem Fournier: So that means that, us foresters, we don't need oak management geered for stave and cooperage production to produce wood for lattice structures. Rather, what you need resembles wood which would be used for firewood.

Laurent Bléron : Exactly, our idea is that before making firewood, we can try to make use of this wood in structures. We will always have enough accompanying wood for firewood. If you’re interested though, we could now go to the chemistry department to see how we can use wood in ways other than construction.

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[1] https://www.vosgesmatin.fr/edition-d-epinal/2018/07/04/une-nouvelle-maison-a-xertigny-qui-se-veut-demonstratrice

Meriem Fournier: Sure, let's go... During week 4, I told you about wood that no longer looks like wood, about particle boards or "medium density fiber" MDF panels. We are now in the chemistry department with the biochemist Arnaud Besserer. So, Arnaud, the people doing our MOOC may not have a very positive image of chemistry. Show us that chemistry is also "good for the environment".

Arnaud Besserer: Exactly! What do we do here? We transform waste from the wood industry into products and materials with high added value. We use fungus biodiversity and wood biodiversity to do so. Here, we have wood which is soaked in a chemical solution of copper and nitrogen, which is used to protect wood in an outdoors setting.

Meriem Fournier: Yes, we see such wood in gardens...

Arnaud Besserer: Exactly, and it represents a large volume. Annually, this type of wood product is used as much as all of buildings' woodwork and wooden structures. The problem is that there is copper in it, which is a dangerous waste according to European regulations. At the end of its life cycle, copper cannot be recycled in a boiler room, nor can it be used in a particle board, and there is nothing else that can be done with it except to bury it in a landfill or to put it in cement kilns. And it's a shame for the wood industry to feed the cement industry. What we have imagined, therefore, is the detoxification of this material by biological means. No GMOs here, just a fungus that grows in nature, that lives in the compost and that we use here in interactions with bacteria to remove copper. This is what you see right there. In this bioreactor, we cultivate the fungus on a laboratory scale. This process is going to be completely scalable at the industrial scale, and can be done for 30 000 or 40 000 litres. Its cost is very low: very little heat (28°C), a very poor environment and wood as a raw material, for other fermentations as well. We can produce ethanol, furfuryl alcohol, or others which have a whole range of uses. For example, lactic acid can be used in textiles, we can replace the polyethylene in water bottles, we can do many things with it. And all this from wood.

A second example of application concerns these MDF panels that you showed us. 1 million m^3 per year of waste from the furniture industry ... everyone knows IKEA, for example, which produces many of these panels. It also constitutes waste, its disposal comes at a cost, and we don't really know what to do with it. This bothers the panel makers and the secondary processing industry. We have set up a detoxification process. We remove the glue which is the major pollutant because it contains formaldehyde - we have all heard about the formaldehyde of wood panels. We remove it using a process called steam explosion, but the problem is that formaldehyde then falls back into the liquids. These liquids must be detoxified: and can't be released into nature, otherwise we would have water loaded with formaldehyde, and that's not great. So we also use mushrooms. Here, we have a Petri dish with the fungus. No GMO, only a fungus which can be found everywhere, but it can adapt to dangerous environments. In a reactor, two days suffice to remove all the formaldehyde from these juices. The fibres can then be reincorporated into panels. We also know how to make panels without glue, just by hot-pressing them, which holds together just as well as a panel with glue and lots of additives. The other one is a particleboard in which we put 10 times more fibres from waste than usual, with decontaminated fibres. We have a zero emissions panel, 100% compostable, 100% recycled and 100% recyclable. All this is patented, in industries that we don't necessarily hear about, and it is done in full partnership with the forestry sector, since the idea is to promote the use of wood in the right place to produce good products. We are right in the middle of the cascade of uses. But you should go see Yann now, he is in charge of energy.

Meriem Fournier: In week 4, we asked ourselves if burning wood was sustainable. Here, we are with Yann Rogaume, who also works in the ENSTIB school and wants to improve the use of wood as an energy. Yann, could you tell us what you do here?

Yann Rogaume: We do a lot of things - combustion, pyrolysis and gasification. Here, you are in front of a gasifier which transforms wood into gas. Technically, it is a bed of hot sand into which we inject wood which then transforms into gas. We also transform coal into gas. We use residual wood from the forest which cannot be transformed into anything else. We also use waste wood, once it is at the end of its life and can no longer be valued with chemistry or in any other way. This kind of machine uses medium amounts of power - a few Megawatts. It could be used all over France. It transforms wood into gas. The gas can then be used for heating, although for heating direct wood combustion also works. The advantage is that these gases can be used as energy carriers. Methane, hydrogen. Or they can be used to make electricity. This is their main advantage, compared to more conventional solutions.

Meriem Fournier: So compared to the traditional method, where I cut wood in the forest and put the logs in my wood stove, here, with wood, I can produce a whole range of modern energy solutions, and I can also use waste wood, without necessarily using wood fresh from the forest.

Yann Rogaume: Yes. It is interesting to note that in France, for the past 3 years, more pellet stoves have been sold than log stoves. So even individual consumers are gradually giving up on logs and shifting towards higher quality fuels. Here (in the gasifier), the idea is to use wood that cannot be used elsewhere, and to do so locally. To supply this kind of energy plant, a 50km radius is sufficient. These plants could be scattered all over the country. Rather than using only wood chips or only wood at the end of its life cycle, the idea is also to use mixtures, including even a little bit of straw if necessary. Mainly, the added value is much higher, with heat (electricity of heat) and gaz. Hydrogen is the fuel of the future. Methane can be used to replace the one currently purchased elsewhere. The idea is to transform all of our local green resources into products with high added value.

Meriem Fournier: If I'm not mistaken, furniture today is not properly recycled. So your idea is to use a resource which today goes to landfills, is that right?

Yann Rogaume: Today, a significant part of recycled furniture returns to furniture via particle panels. This is because the government favours recycling matter over recycling energy. But energy will always be an outlet, because the more we recycle, the more wood is loaded with products and the more it is difficult to recycle. If we use the same fibres two or three times, we will have used as much of the product as is possible before using it as energy, which remains a final productive use.

Meriem Fournier: Thank you for this visit. We have learned that like foresters, wood engineers aim to use resources well, without wasting them and by taking advantage of all of their qualities. Nature gives us wood with its remarkable properties, and it is great to be able to use it in a way that takes advantage of all of them. We have the same environmental concerns and must help society adapt by consuming less and consuming better. I have one last question that is bothering us foresters. For us, the link between climate change and the forest is not just that the forest sequesters carbon. It's also that warming is killing trees and is going to cause disruptions in forest ecosystems, to an extent which I am not sure people are fully aware of. In some places, such as the Vosges mountains, we are well aware of this already, for example with spruce trees that are dying from bark beetle attacks. The future wood resource that you will be transforming is going to change constantly. Today there are lots of cheap spruce trees, but in the future, there won't be any more spruce trees, and then there won't be an more beech trees… In 50 years, the species may be completely different. Is the industry getting ready to adapt?

Laurent Bléron : It will for sure be necessary to consume better, to use the right material in the right place, be it wood, concrete, steel, or whatever else... As far as resources are concerned, in 100 years, there will no longer be any beech trees, so we will have to use other species. But the wood industry does not have the same rhythm as that of the foresters: its time scale is of 3 to 5 years. A forester sees much further, it is a different scale. The wood industry is used to this agility, to these changes, because the market changes. For example, today, we are investing in robotics to develop single unit products in series because customer A does not want the same thing as customer B. Production line systems are much more flexible and more agile. In my opinion, manufacturers are ready or they will be ready. Looking forwards, there is also the topic of reuse: to use recycled wood, a whole issue to characterize it: is it still as resistant? is it less so? In the future, reuse will gain in importance in the overall use of wood.

Meriem Fournier: So let's continue innovating together. Thank you and goodbye.

Week 5

Forest management and innovation

Video 6

New forms of governance

The forest manager, “guardian” of the forest

© Aussie Oc

For a long time, forests were distant landscapes, a separate, inwardly focused environment, which operated independently from the rest of society.

Forest managers were expert guardians of the forest, serving both forest owners and humanity as a whole.

Wood funded everything

© Yves Ehrhart

Wood sales were sufficient to finance forest protection and renewal by private and public foresters.

The sustainability of harvests was guaranteed by the law and by foresters’ expert knowledge.

Society worked with this.

With conflicts

Marche des arbres pour le climat, Durban Cop 17, 2011© John Robinson/ Greenpeace

25 JANVIER 2020

25 JANVIER 2020

Mobilisations et conflits forestiers hier et aujourd'hui

191 rue
Saint-Jacques
75005 PARIS

9h – 17h

https://ghff.hypotheses.org/

However, conflicts were frequent
They could take various shapes and resulted from different reasons

In 2020, the French Forest History Group organized a symposium on these conflicts.

The harshest and most visible conflict concerns the clash between public and private interests. The opinions of foresters and people have changed.

Historically, foresters have defended the higher interests of the country against rural communities who carried out agropastoral activities that were less useful or even harmful to the forests.

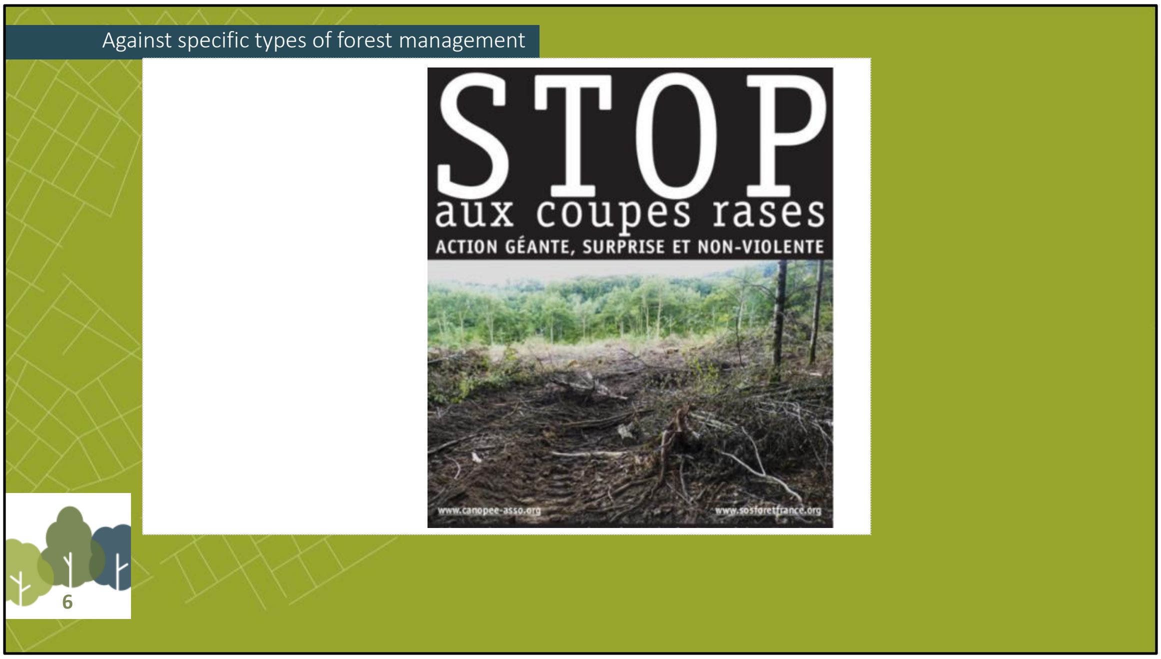
Title reads "forest conflicts and mobilizations, in the past and today"

New conflicts

Today's conflicts are different.

Foresters continue to produce wood, and this activity is perceived by some as serving private or corporate interests which could be incompatible with the common good.

Title reads "Our forest are being appropriated"



Against specific types of forest management

These citizens wish to protect the common good, focusing on issues like the fight against climate change, the conservation of biodiversity, the protection of landscapes, the well-being of populations… they consider that some frequent forest management practices cannot satisfy this common good.

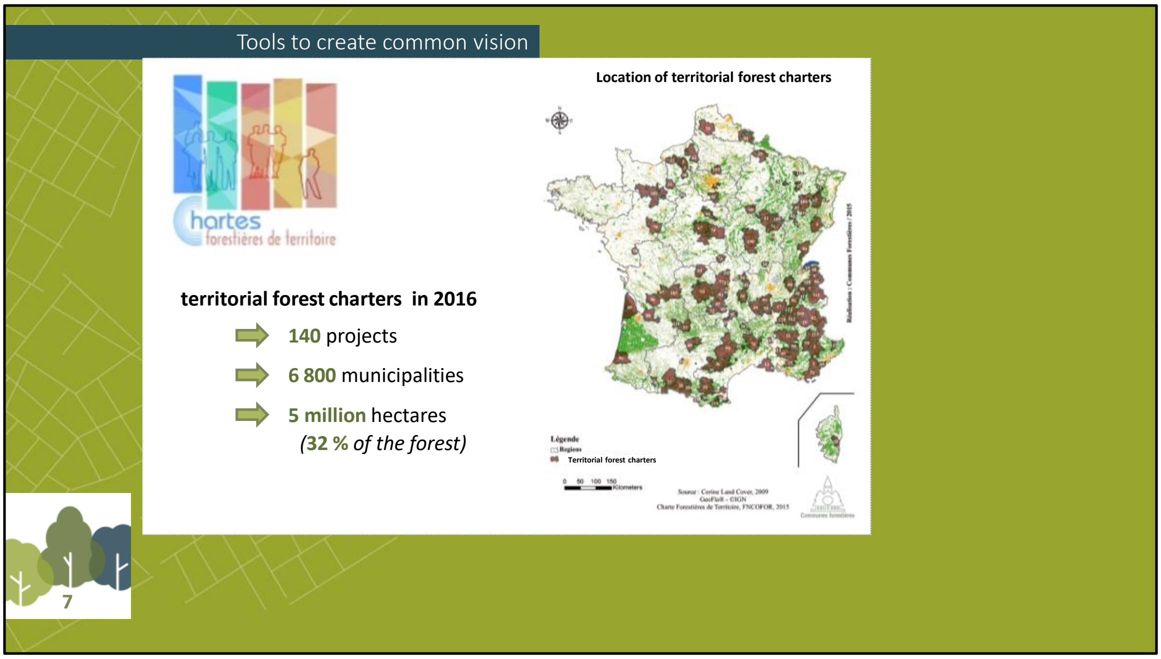
They focus on denunciating certain management practices, for example clearcutting.

Foresters believe these criticisms are stereotypical, and justify their practices by focusing on the same objectives: climate change, biodiversity, landscapes… Today, the situation is one of tension, or even of conflict.

These conflicts show a general divide.

Beyond the need to control or forbid clear cuts, forest management cannot be consensual if the expectations we have for forests and the objectives of forest management diverge. We need to innovate in our ways of conceiving and carrying out management, we need to build a common vision of forest management and we need to involve society into the elaboration of a collective project for forests. Today, foresters cannot hide behind expert knowledge to justify their practices and impose their vision without communication and consultation.

Title reads “Stop clear cuts. Giant, non-violent, surprise action”



Tools to create common vision

territorial forest charters in 2016

- **140** projects
- **6 800** municipalities
- **5 million** hectares
  *(**32 %** of the forest)*

Location of territorial forest charters

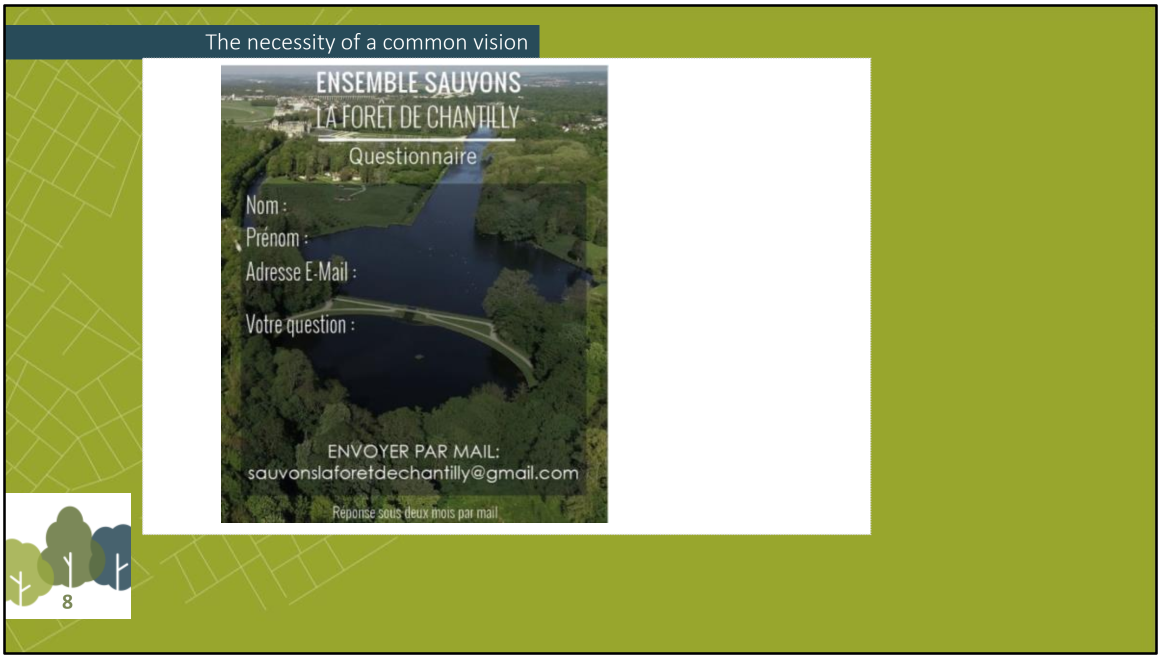
Some tools, for example the territorial forest charters (**charte forestière de territoire, CFT)** have been developed in France.

These were implemented following the forest orientation law of July 2001. They are contractual tools, implemented through the initiative of local actors, starting with local elected officials.

- territorial forest charters aim to make the forest a levy for local development
- Territorial forest charters rely on a framework of consultation between relevant stakeholders
- territorial forest charters materialize through the implementation of an action plan.

In 2016, there were 140 projects of territorial forest charters

Is there a territorial forest charters where you live ?
Do you know what its action plan consists of?



The necessity of a common vision

ENSEMBLE SAUVONS
LA FORÊT DE CHANTILLY
Questionnaire

Nom :
Prénom :
Adresse E-Mail :

Votre question :

ENVOYER PAR MAIL:
sauvonslaforetdechantilly@gmail.com

Réponse sous deux mois par mail

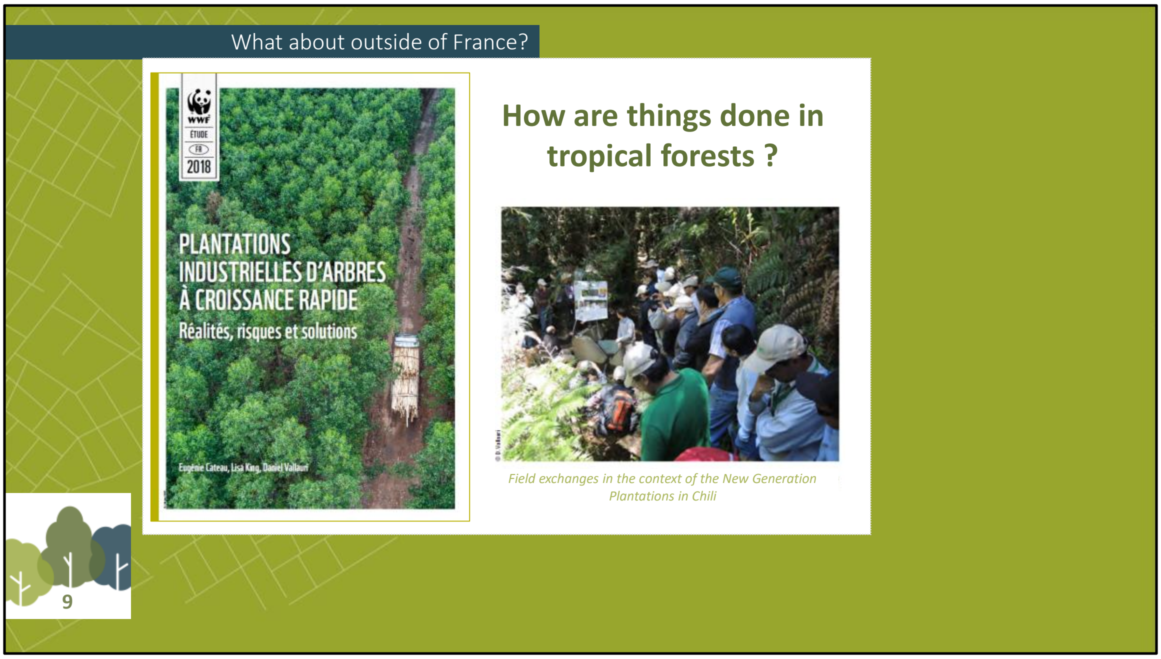
Some initiatives are ambitious. They dare to involve citizens in a very active way and without intermediaries, ranging from simple consultations to citizens working in the forest with foresters.

These initiatives are implemented when **there are new climate change related problems** and **innovation** in forest management is urgently needed to regenerate the forest or even to maintain a forest cover.

Here, for example, we have the "*Together, let's save the Chantilly forest*" movement. The future of this oak forest, owned by the Institute of France and which is a heritage of exceptional natural and cultural value, is threatened by chafers.

Field work involving foresters, researchers, elected officials, and volunteer citizens has started. Here, we can see a consultation which is aimed at rallying citizens.

Title reads: "Together, let's save the forest of Chantilly"



What about outside of France?

WWF
ÉTUDE
FR
2018

PLANTATIONS INDUSTRIELLES D'ARBRES À CROISSANCE RAPIDE

Réalités, risques et solutions

Eugénie Cateau, Lisa King, Daniel Vallauri

How are things done in tropical forests ?

© D.Vallauri

Field exchanges in the context of the New Generation Plantations in Chili

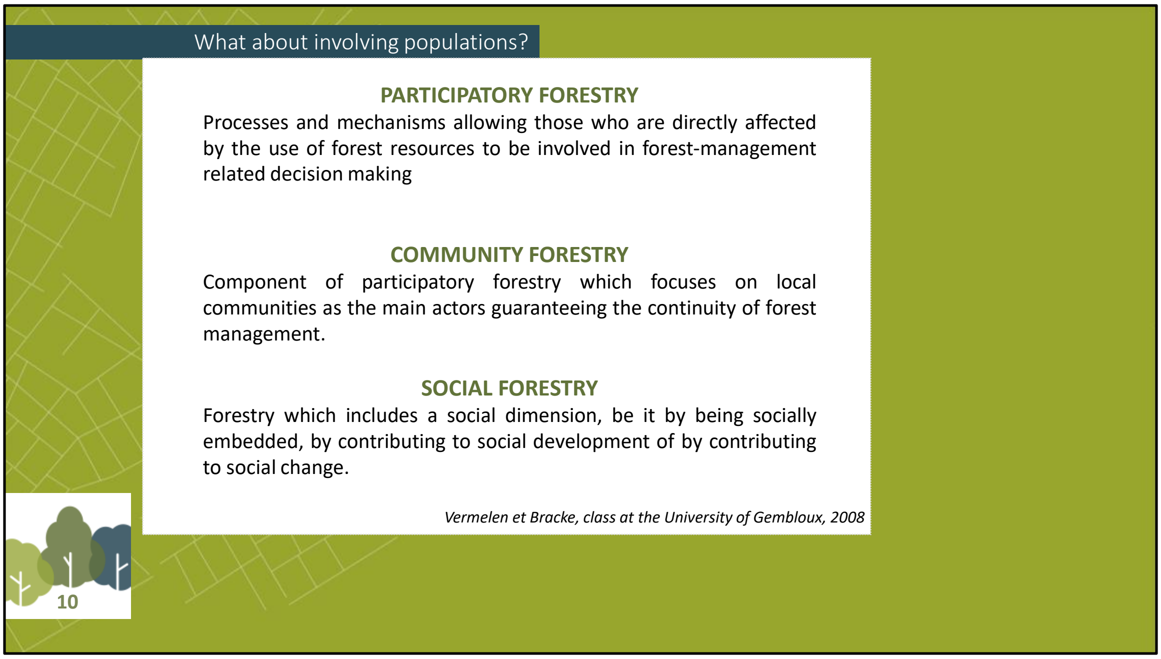
Conflicts which must be solved do not only occur in France and in Europe. Tropical forestry has had to deal with such challenges for decades. In these countries, foresters, often state employees, face failures in applying the State's vision if they do not negotiate and converge with all of the stakeholders.

These stakeholders include private companies, often powerful multinational companies who control the international industry wood markets the world over.

In 2018, WWF showed that the plantation of fast growing trees by these companies can be unsustainable, but can also be part of a common vision for the well being of society and can combine visions which are compatible ecologically and socially.

WWF is thus involved in exchange platforms, for example **New Generation Plantations (NGP).** Using field trips, workshops and conferences, NGP facilitates sharing and learning best practices for industrial plantations.

Title reads: "industrial plantations of fast growing trees. Realities, risks and solutions"



What about involving populations?

PARTICIPATORY FORESTRY

Processes and mechanisms allowing those who are directly affected by the use of forest resources to be involved in forest-management related decision making

COMMUNITY FORESTRY

Component of participatory forestry which focuses on local communities as the main actors guaranteeing the continuity of forest management.

SOCIAL FORESTRY

Forestry which includes a social dimension, be it by being socially embedded, by contributing to social development of by contributing to social change.

Vermelen et Bracke, class at the University of Gembloux, 2008

Moreover, in many tropical countries, forests belong to the state but rights for communities living in them are not guaranteed by property rights. Poor populations have no rights over these forests, despite the fact that they rely on them for fundamental needs, especially firewood.

As a result, in the 90s, concepts such as participatory forestry, community forestry or social forestry appeared.

These concepts were developed in the context of tropical forests, but we can adapt them to urbanized populations in developed countries working in the tertiary sector but also assert their attachment to forests and demand to be involved in forest management.

How do we finance forest management?

PRO SILVA FRANCE

Close-to-nature, continuous, non-uniform forestry

➡ Sustainably producing quality lumber wood, whilst guaranteeing biodiversity, stability and resilience

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Now let’s imagine that we have succeeded in creating a collective project, in which citizens are locally involved in forest management, which has solved conflicts – what an innovation. A final problem arises: how do we finance this new management, and how do we pay the highly skilled labor of foresters?

There are several possibilities.

Those who promote uneven-aged stands suggest we use ecologically complex management. This suits citizens and is financially viable thanks to the sustained production of high quality lumber wood, which can sell at high prices. This financial model would allow us to continue to pay for management through the production and sale of wood.

With private investors

reforestACTION

PLANTONS pour l'avenir

FA3R

NEOSYLVA
valoriser nos forêts

ecotree

SYLV'ACCTES
DES FORÊTS POUR DEMAIN

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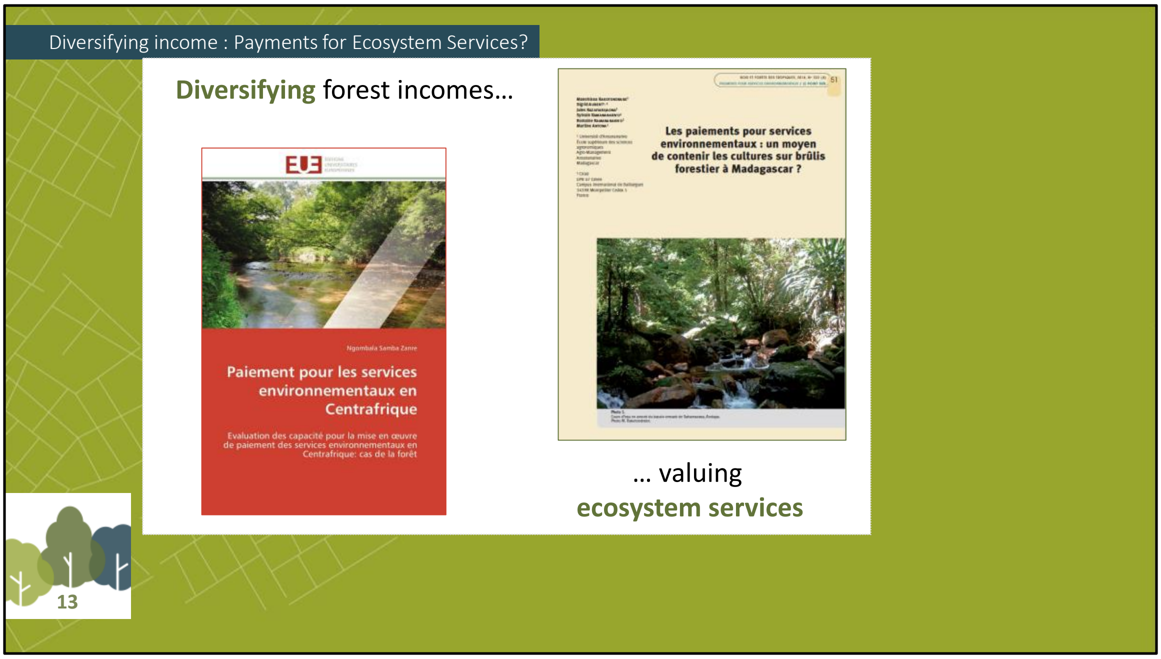
However, other economic models exist. These involve private investors, or public-private partnerships, especially to guarantee forest renewal which requires important investments.

There are different, varied sources of funding, be they economic players in green or regular finance, industries from the wood chain, or citizens through participatory finance.



Diversifying income : Payments for Ecosystem Services?

Diversifying forest incomes…

Ngombala Samba Zanre

Paiement pour les services environnementaux en Centrafrique

Evaluation des capacité pour la mise en œuvre de paiement des services environnementaux en Centrafrique: cas de la forêt

Les paiements pour services environnementaux : un moyen de contenir les cultures sur brûlis forestier à Madagascar ?

… valuing **ecosystem services**

Also, with fluctuating or decreasing prices and income from wood, most forest owners and foresters are looking to **diversify their sources of income.**

Here, the idea would be for forest management to charge for services outside the usual wood production and renting forests for hunting, both of which are being criticised in the name of the common good. If these are criticised, then we must find other sources of income for forest management. For example, we can fund forest management because: it results in the avoidance or the compensation of greenhouse gas emissions (the “carbon service”), it protects biodiversity, it provides clean water without the need for costly water treatment facilities, it reduces health spending for those who exercise in forests, it reduces cardiovascular diseases and cures burn outs (all diseases which are the plight of our century).

These environmental services could be financed by private actors or by public authorities. In either case, we need to know how to quantify the services which result from management (we cannot pay for things we do not know how to evaluate) in terms of added value for the common good or of avoided costs. The organisation of ecosystem services markets is complex. In many tropical countries, these questions have been at the centre stage for a while, because in order to protect forests from deforestation, one needs to give them a value outside of services like wood provision or hunting.

Titles read

- *“payment for ecosystem services in the Central African Republic”*
- *“payments for environmental services: a way to control slash and burn farming in Madagascar?*

In conclusion

Forest management cannot, or can no longer, occur without **shared governance between all of the actors who are concerned**.

Different tools exist, for example **Territorial Forest Charters** and **creative initiatives** in some forests.

Conflicts **between private interests and the common good** are not new, and we can learn from tropical forestry to solve them.

We must also build **new management economic models** by diversifying incomes from and for forests and by **paying for more forest services.**

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