NATURE RESTORATION LAW AND WETLANDS CONSERVATION

REWET TRAINING

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HYBRID EVENT
SEVILLE, SPAIN & ONLINE

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GHG FLUXES MEASUREMENTS IN PEATLANDS COULD HELP TO CHECK FOR THEIR FUNCTIONING IN NATURAL, DEGRADED, AND (HOPEFULLY) RESTORED CONDITIONS

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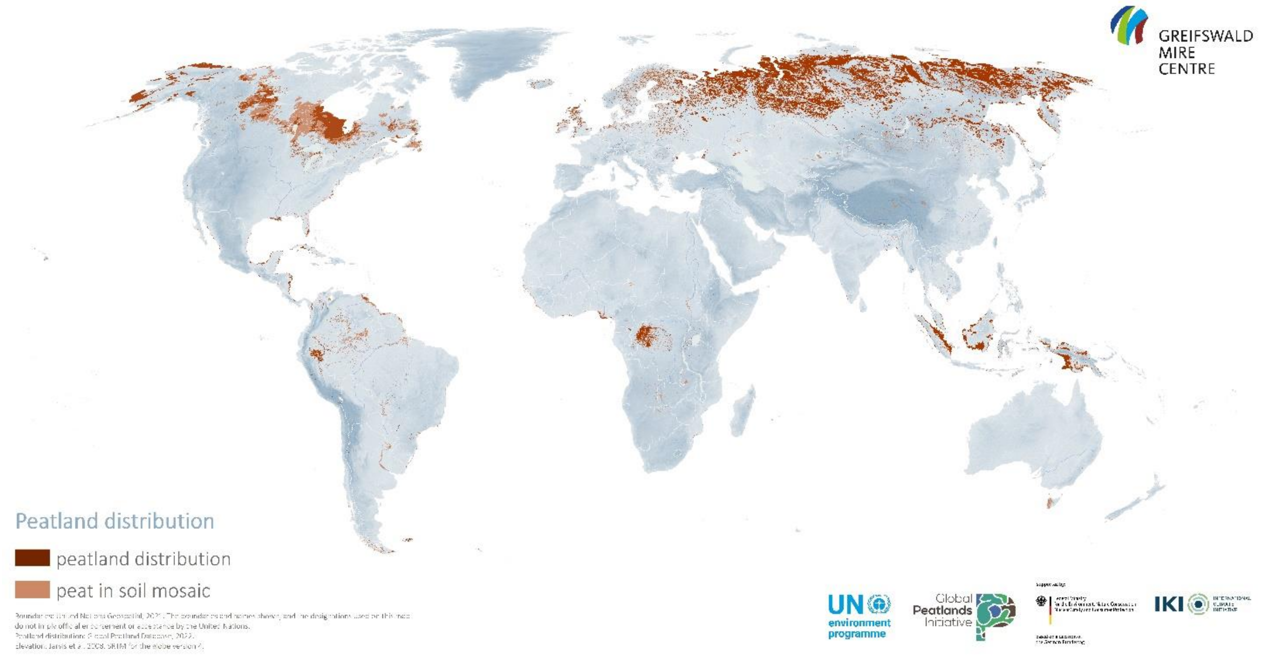
PEATLANDS

Peatlands are terrestrial wetland ecosystems with a unique type of peat soil formed from plant material that has only partially decomposed due to **water saturated soil conditions**

While they are relatively rare, covering around 3-4% of the planet's land surface, **they contain up to one third of the world's soil carbon**. This is twice the amount of carbon as found in the entirety of Earth's forest biomass!



Keeping this carbon locked away is absolutely critical to achieving global climate goals!

Peatlands are habitats with very specific characteristics that organisms have to cope with in order to survive. This requires them to adapt their physiology, anatomy, morphology, life cycle and behaviour

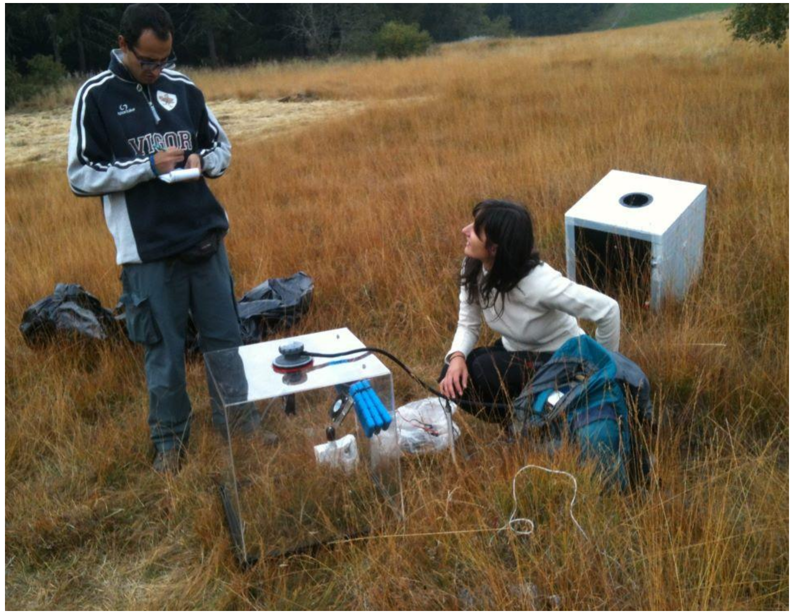
Due to this reasons, **peatlands are home to rare, relatively rich and unique biodiversity**, including endemic and endangered species

Several environmental factors such as climate, geomorphology and the origin of the water exert a strong control on peatland ecosystem diversity. It follows that, at the global level, peatlands **represent also incredible and unique ecosystem diversity**, ranging from northern bogs and fens to tropical forests and swamps

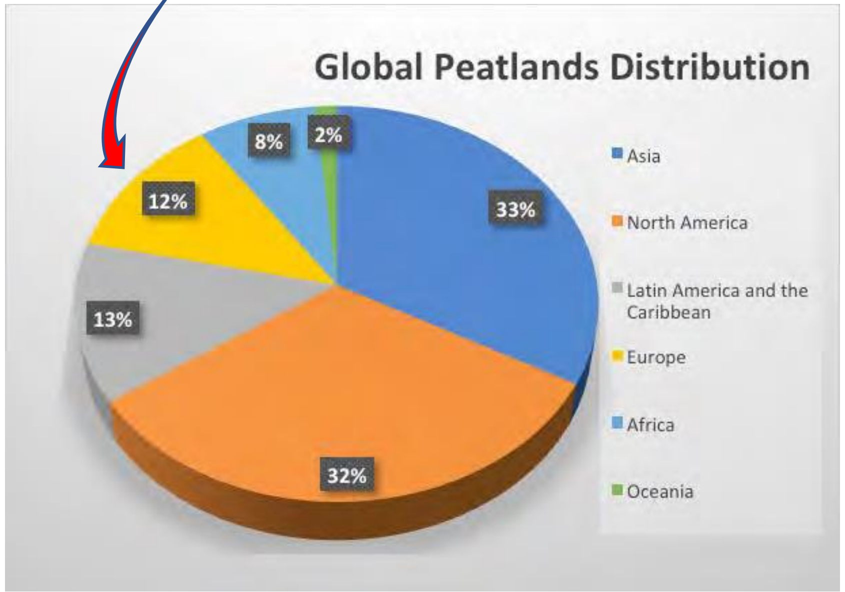
Conserving the biodiversity of peatlands is a priority!

PEATLANDS ARE WONDERFUL ECOSYSTEMS






EUROPE

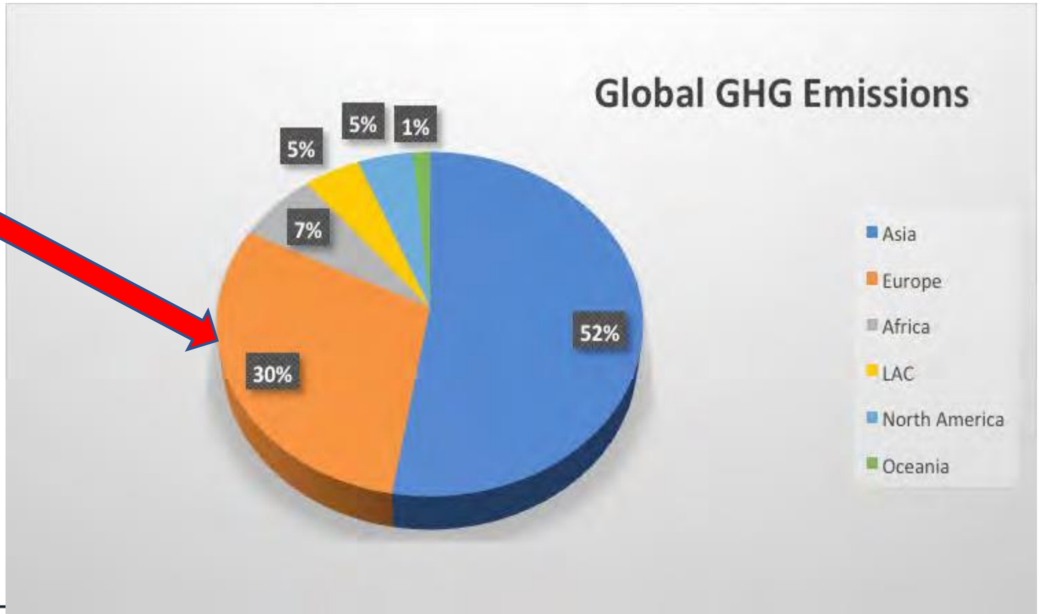


Drainage, deforestation and other land use changes have had a detrimental effect on many peatlands by destroying peatland-specific biota and biodiversity and by reducing carbon sequestration and storage and causing net GHG-emissions

Drained peatlands only cover ~0.3% of the global land area yet are contributing disproportionately between ~3–5% of the total global anthropogenic emissions

Drained peatlands in Europe emit about the 5% of total EU emissions

This situation is being made worse by climate change as higher temperatures and unpredictable rainfall patterns render peatlands drier and more vulnerable to fires that release more GHG, warm the climate further and create a dangerous feedback loop



Countries are increasingly becoming aware that conserving, restoring and sustainably managing peatlands is important for climate action, biodiversity conservation and resilience building. This has been reflected in a growing number of international peatland resolutions and a number of projects to restore these ecosystems

The most effective method to halt CO_2 emissions from oxidation in drained peatlands is to raise the water level re-establishing water saturated conditions, a restoration action commonly referred to as **rewetting**

Wetlands are varied terrestrial ecosystems that, although occupying only 7% of the earth's surface, **store 33% of the world's terrestrial carbon**. Marshes, floodplains, and peatlands are the natural habitats of 1 million species threatened with extinction, and **they provide livelihoods, food and fresh water to around 1 billion people worldwide**. Freshwater wetlands, in particular peatlands, contain **great amounts of carbon locked in the submerged soil or as waterlogged undecomposed organic material**.

When these ecosystems are drained to be converted into agricultural or forestry exploitations, and/or for extracting peat or other minerals, they release greenhouse gases (GHG), especially **carbon dioxide, methane and nitrous oxide**, increasing global warming, and therefore, consequent climate change. This, in turn, may cause floods, droughts and fires, feeding a vicious cycle and accelerating climate disruption with many negative impacts.

"Sustainable restoration and conservation of terrestrial wetlands"

REWET: maximising wetlands carbon absorption respecting their biodiversity

The objective of the REWET project is to facilitate sustainable restoration and conservation of terrestrial wetlands.

The objective of the REWET project is to facilitate **sustainable restoration and conservation of terrestrial wetlands, including freshwater wetlands, peatlands, and floodplains**, by applying fit-for-purpose technologies to monitor greenhouse gas emissions, biodiversity, meteorological events, and social aspects of sustainability.

REWET project focuses on **determining how the restoration and management of wetlands can be optimised to maximise their carbon uptake while in balance with type-specific natural processes and biodiversity**.

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PEATLANDS IN NATURE RESTORATION LAW

…**binding nature restoration targets**…

…covering forests, grasslands, wetlands, **peatlands**, pollinators, free-flowing rivers, coastal areas and marine ecosystems…

…**recognises that cost-effective adaptation to climate change can be achieved by protecting and restoring wetlands and peatlands**…

…having **a greater number of biodiverse ecosystems leads to higher resilience to climate change** and provides more effective forms of disaster reduction and prevention…

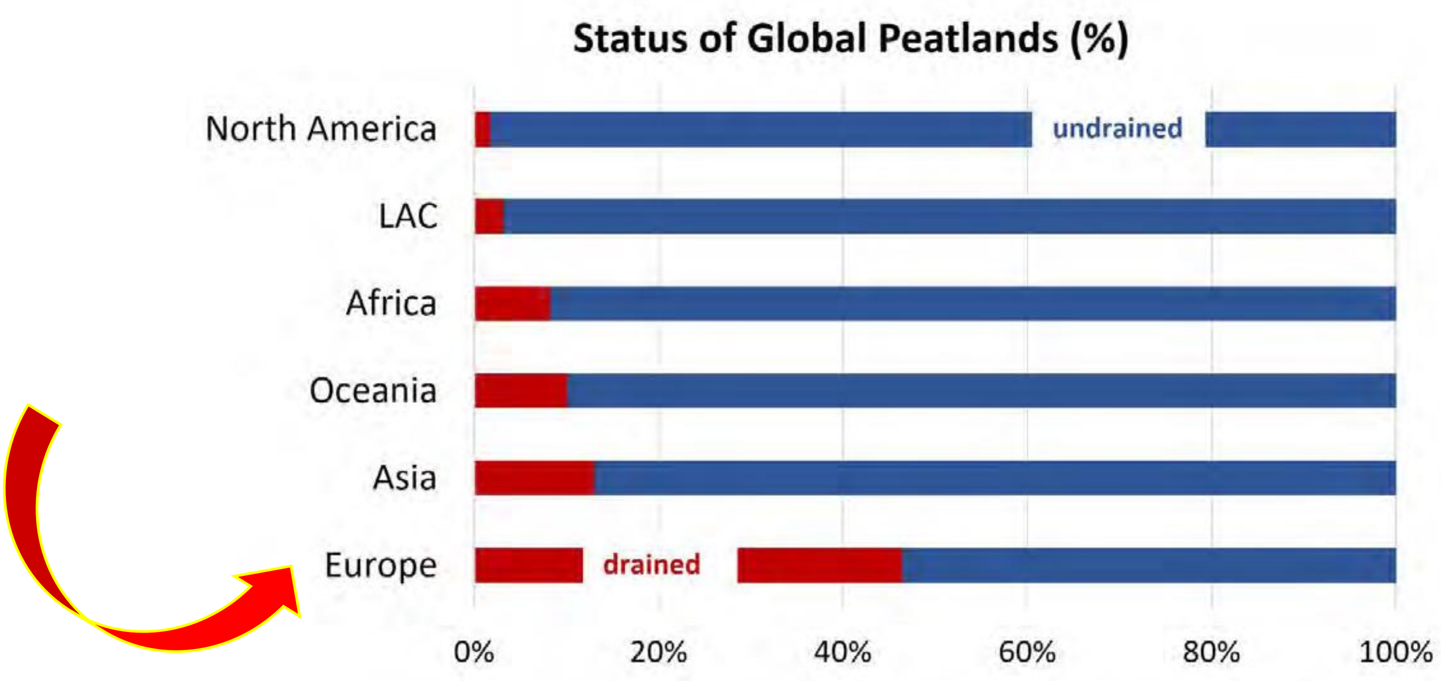
…**emphasises the need for rewetting peatlands**…

…'**restoration**' means the process of actively or passively assisting the recovery of an ecosystem **in order to improve its structure and functions…**

…'**good condition**' means…a state where **the key characteristics of the habitat type, in particular its structure, functions and typical species or typical species composition**, reflect the high level of ecological integrity, stability and resilience necessary to ensure its long-term maintenance …

Rewetting and restoration of degraded peatlands is urgently needed to meet biodiversity and climate goals!

Hundreds of projects devoted to peatland restoration have been funded by the EU in recent years (through LIFE projects, for example), and the wonderful REWET is one of them, but we need more 'REWET-like' projects aimed at restoring peatlands (and hopefully other wetlands) to **GOOD CONDITIONS**



First of all, **we have to find a good place to work**. This is easy because there are so many disturbed, drained, mined or degraded peatlands in EUROPE!

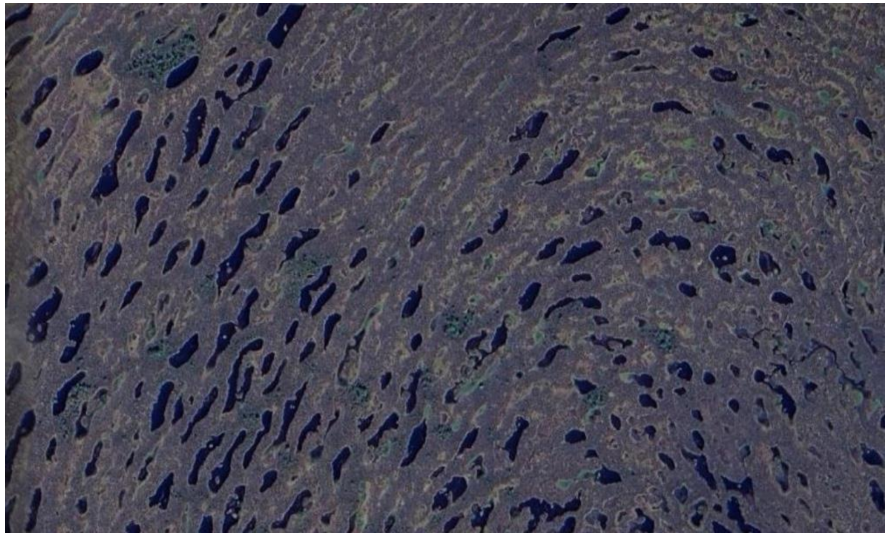
Secondly, **we need to find a way to rewet these peatlands**. This is not always easy, but it is often possible

Finally, **we must implement a monitoring protocol** to check that our activities have returned the peatlands back to **GOOD CONDITION** in terms of structure and composition of the vegetation and in terms of functioning

How can we check that rewetting has brought peatlands back to **GOOD CONDITION**?

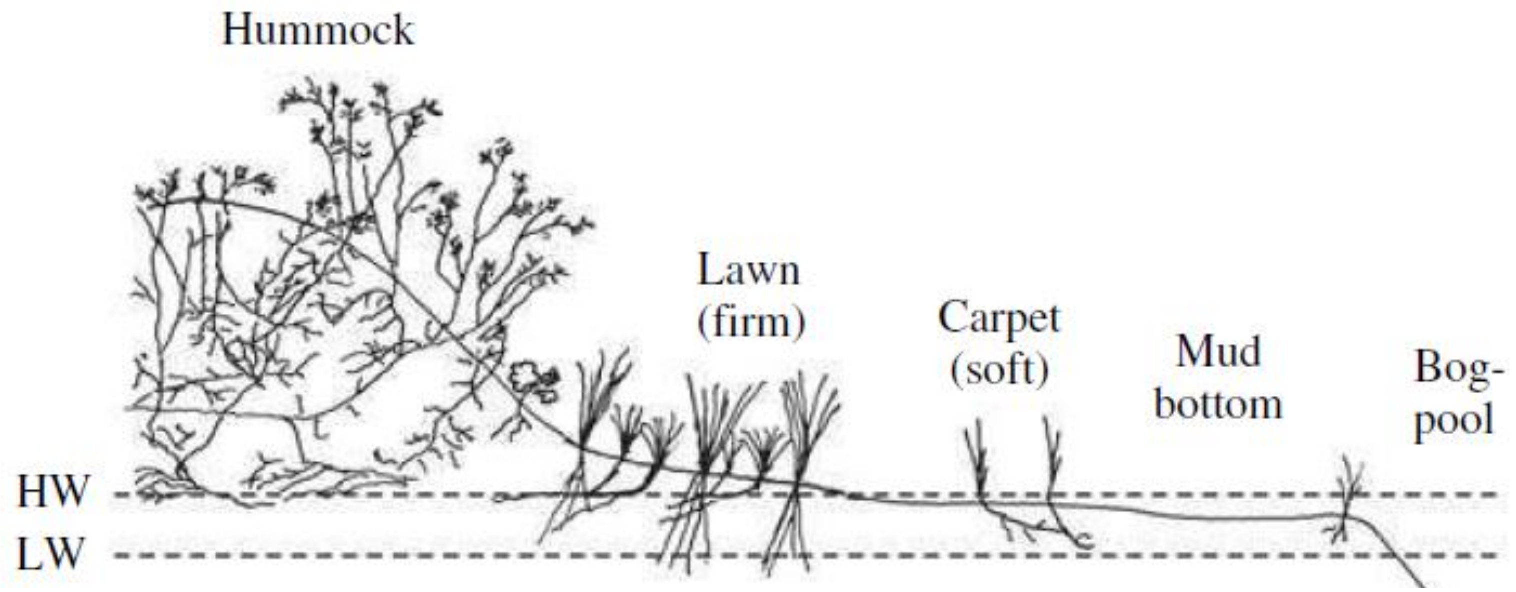
I would like to discuss with you some points that could help us to choose the best way (in my opinion) to check for **GOOD CONDITIONS** in the short time usually allowed in national and European projects, which usually last 2-5 years

To do that we have to come back to spatial distribution of species and plant communities in peatlands



Peatlands develop surface patterns with **regularly ordered vegetation types** that are not mere classification constructs, but real, discrete entities, separated by distinct borders

The occurring of these "discrete entities" are closely linked to specific ranges of some ecological drivers such as water level, pH values and nutrient availability



(Sjörs, 1948)

Schematic presentation of the microtopographic gradient in a bog

As the distribution of plant species and communities is closely linked to the depth of the water table, it is highly likely that the spatial distribution of species and plant communities in a drained peatland will be rearranged according to their optimum water table depth

In addition, some areas begin to dry out and become home to species coming from the more mesic habitats that develop around the peatland

For a plant ecologist it is not difficult to see **how far** is a peatland from **GOOD CONDITION**

OK folks, just as plants can tell us how far we are from **GOOD CONDITIONS**, plants can tell us if our rewetting project has worked!

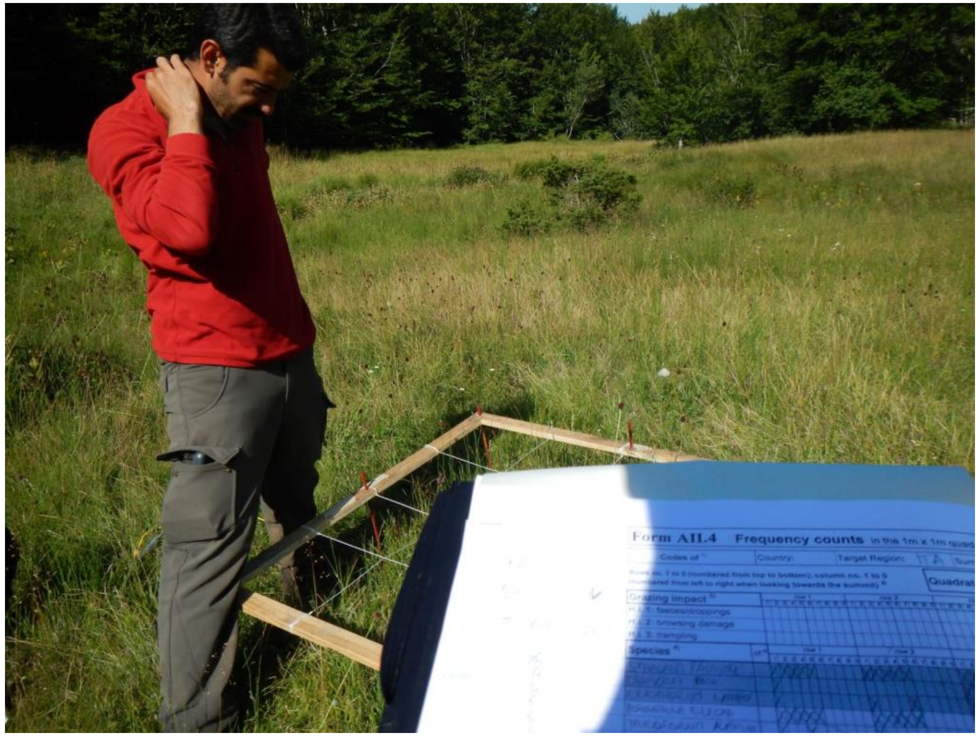
But not, because

- **it takes several years for plants to come back** and, even if they are locally available, the recovery of a typical vegetation structure or the typical species composition may be relatively slow

- if the rewetting action is aimed at **raising the water table in a particularly disturbed and massively altered agricultural area**, it is very likely that the recovery of the typical vegetation structure can be very slowed down by the relatively scarce availability of “propagules” of typical species

- the rewetting intervention could only aim to reduce carbon loss from the soil, not to restore a peatland with its typical biodiversity. This type of intervention could be linked to some form of use of the environment for agricultural purposes

Therefore, **the study of the vegetation** and the analysis of its theoretical distance from the potential vegetation of a peatland **can indicate its state of conservation** and confirm the **“need to rewetting”**, but it may not have the power to confirm the success of a rewetting



- if we only have 1-3 years after the rewetting to monitor the effects

- or we have no intention of restoring the biodiversity of these habitats at all

I'm not saying that the monitoring of plant species and vegetation can never give an indication of the success of the intervention, but that in some cases it could not be decisive!!!

We need to find another method or, if possible, try to combine the vegetation survey with other measurements

Returning to the definition of **GOOD CONDITIONS**, it is clearly stated that, in addition to the typical species and the structure of the vegetation, the rewetting intervention must bring the ecosystems back to **good functioning conditions**

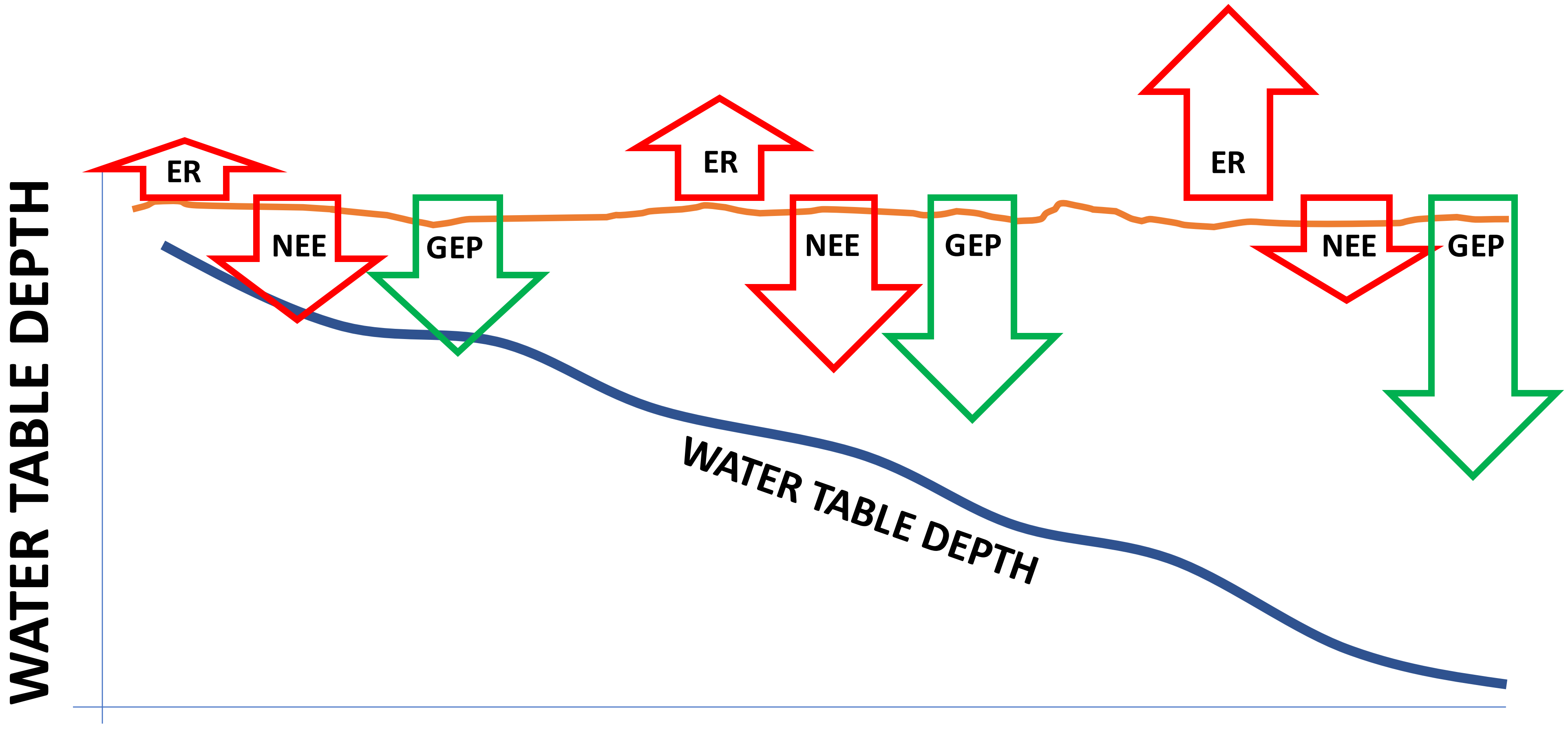
When functioning well, peatlands play a fundamental role in the accumulation and long-term storage of carbon in the peat

Maintaining or restoring this very important ecosystem service is one of the main reasons for carrying out rewetting interventions

Are there any indicators of good functioning that can be always measured everywhere?

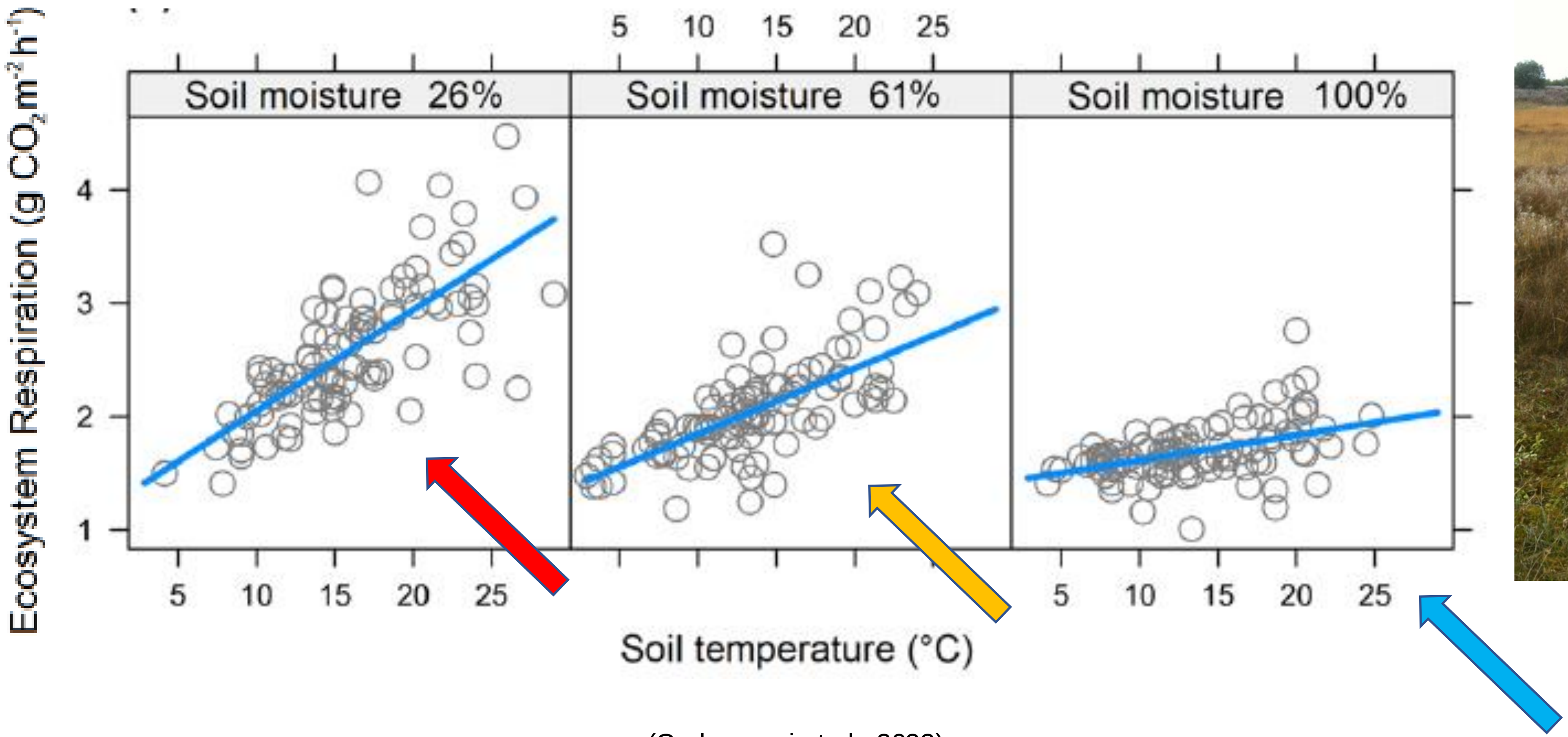
Although many of us are familiar with these concepts, it is useful to remember some of the key points of the mechanisms to facilitate the choice of a good monitoring method that adapts to very different situations

Carbon fluxes in peatlands in GOOD CONDITIONS, where the water table is close to the ground and the impact of anthropogenic activities is low or absent, **are mainly controlled by the depth of the water table**



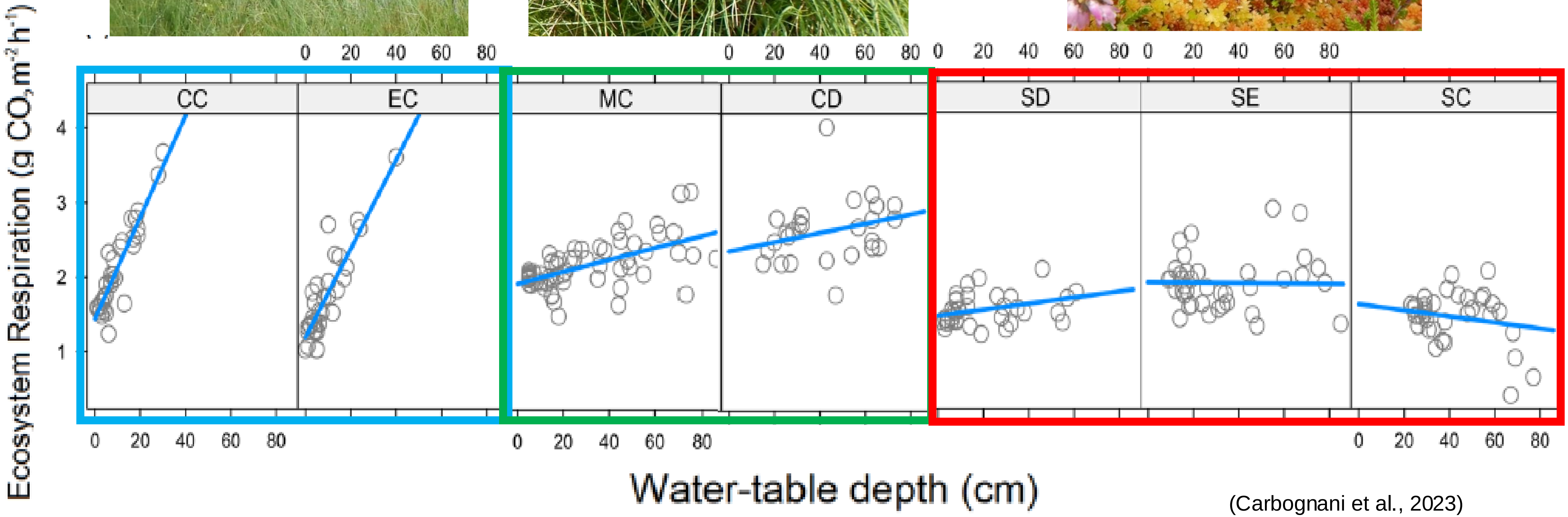
However, **temperature and soil moisture (and the interactions between them) are also important!**

- A peatland in the Alps
- Static chambers
- 27 plots
- 12 sampling dates (mid May-mid October)



(Carbognani et al., 2023)

In addition, **the interaction between Ecosystem Respiration** (and, hence, GEP and NEE) and **the type of vegetation**, which can be more or less productive and absorb or release more or less CO_2 depending on the period of the growing season, are often reported in the literature



(Carbognani et al., 2023)

Many studies have linked the transformation of peatlands from carbon sinks to carbon sources to drainage and human disturbance of these environments, and to the effects of climate change

These ecosystems need to be helped to stop losing carbon so that they can resume their role as long-term carbon sinks

As ER is closely linked to water table depth, if our rewetting action has restored water table depth close to ground level, we are very likely to measure lower ER than before rewetting

Measuring ER at different points in the peatland before and after rewetting is one of the most effective ($?) ways of monitoring the success of rewetting on carbon emissions in the short term

If someone thinks that we need to measure GEP and NEE: you are right! If you can, you should, and you will understand so many interesting things about the recovery of ecosystem functions in your study area






As ecosystem respiration is significantly reduced when the water table is very close to the surface, all rewetting projects should consider bringing the water table back **«in close contact»** with the surface as a top priority

It seems very simple, but we need to be clear about what is meant by **“in close contact”** or **“close to the ground level”** or **“close to the surface”**

Water level management plays a critical role for mitigation purposes, with **the recommended optimum range of 0 to 0.2 m** (i.e., close to the surface and slightly above the surface)

What could happen if we do not take care of this recommended optimum?

I can show some results of **soil respiration monitoring** carried out in four drained peatlands in the Northern Apennines (Italy) during the 2022 growing season

The water table depth at the 86 points we measured five times from mid-May to mid-October **was, on average, about 40 cm** (60 to 20 cm)

Do you have any hypothesis?

Analysis of Deviance Table (Type II Wald F tests with Kenward-Roger df)

Response: er

	F	Df	Df.res	Pr(>F)
t.soil	50.7717	1	19.72	7.208e-07 ***
wt	2.0643	1	309.82	0.1517944
tdr12	11.1305	1	263.36	0.0009715 ***
t.soil:tdr12	11.4130	1	290.74	0.0008288 ***
wt:tdr12	6.1165	1	330.12	0.0138955 *

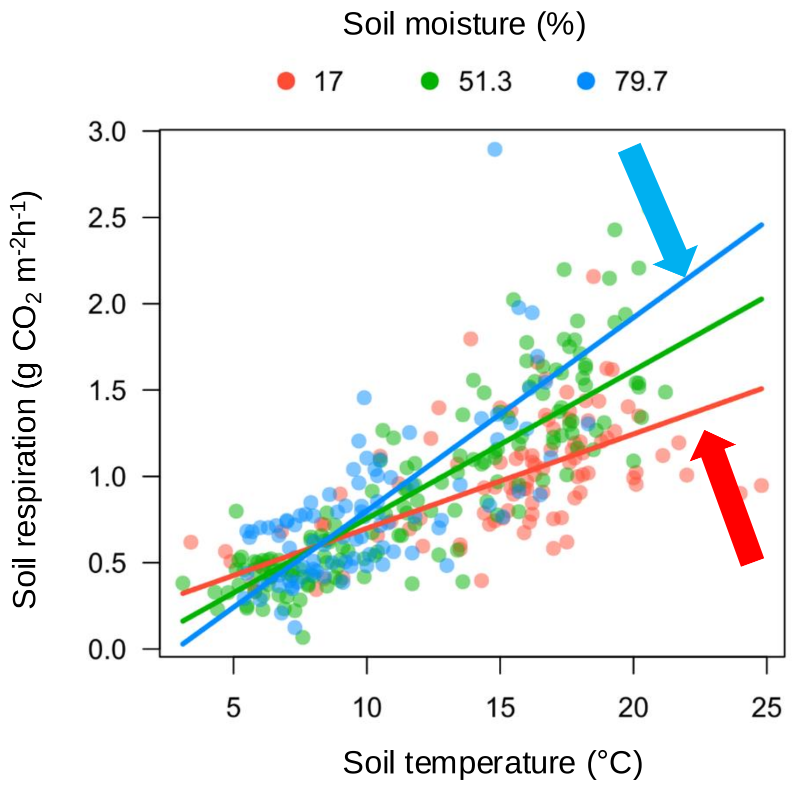
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The main driver of soil respiration is not the depth of the water table!!

This means that these peatlands are not in good conditions in terms of their functioning as carbon sinks

The hypothesis of my MS was correct! If the depth of the water table is close, but not very close, the peatland will continue to lose carbon from the peat

In these drained peatlands, soil respiration is primarily controlled by soil temperature and moisture, **with an interesting and instructing role of their interactions**



Soil respiration increases with temperature. This is not surprising because the depth of the water table is far from the surface and this means «no saturation»

Where the soil is drier, respiration increases less with temperature than where the soil is wetter

In conclusion, if the water depth is not **very close to the surface**, the rewetting could not achieve our ultimate goal of making these ecosystems effective carbon sinks again in the long term

I fully agree with the general recommendation that the water table should be restored to a depth of 0-0.2 m from the surface

Indeed, if the soil is wet, but not saturated, the temperature "will do its work" stimulating carbon loss from these important ecosystems

We can use these initial information to discuss the protocol for monitoring the success of our rewetting

To begin with, it can be very useful to study the vegetation in the area where you want to raise the water table. The vegetation (even if it is not well preserved) will help us to identify the points where we need to carry out monitoring (water table depth, carbon fluxes and vegetation)

If the peatland is severely disturbed and altered, then we have to give up the help of vegetation and use other methods to locate monitoring points

Now is the time to increase the depth of the water table "very close to the surface" (0-0.2 m). Make sure that you cover as much of the area as possible with these average groundwater depths

- Set up a series of ER measurements (yes, of course you should also measure NEE and GEP) which should be lower than before the rewetting, even in the first year after the intervention. If the ER values are lower, your rewetting has been successful

- Do not forget to monitor vegetation changes, as we know that typical species and vegetation composition and structure should be restored to GOOD CONDITIONS

- Be patient, as rewetting has been shown to take several years to be fully successful

Personally, I would add that however you want to do the rewetting and monitoring, **do it as soon as possible**. If we leave these wonderful ecosystems in BAD CONDITIONS, they will lose their carbon stocks and their wonderful biodiversity forever

THANK YOU

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