HOW TO SUPPORT CARBON SEQUESTRATION AND RECREATIONAL POTENTIAL AT THE SAME TIME

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Abstract
In recent years, planting trees to protect the climate has become very popular both in the world and here in the Czech Republic. The Paris Agreement in December 2015 and the resulting Nationally Determined Contributions significantly supported the need for the creation and improvement of carbon accounting methods for investments into the forest sector. Appropriately chosen and well-executed tree planting offers a natural, ecological, relatively cheap, and above all simple way to reduce the amount of carbon dioxide (CO2) in the atmosphere as well a number of other environmental benefits. One of these benefits is the positive effects on human well-being and landscape aesthetics both of which is commonly utilized to support recreational potential. However, understanding the financial value of environmental benefits (ecosystem functions) of natural ecosystems and woody vegetation has been an ongoing challenge that still limits the full utilization of close-to-nature landscape management up to this day. Here we show how carbon sequestration potential of individual trees can be evaluated which can in return serve as a motivation tool for conscious tree planting in the rural landscape during all steps of decision making process.

Key words: tree planting, rural landscape, biomass, CO^2 concentration

Introduction
In recent years, planting trees for climate protection has become very popular both in the world and in the Czech Republic. Based on the Paris Agreement of December 2015 and the resulting Nationally Determined Contributions have significantly supported the need for the development and improvement of carbon accounting methods for investments not only in forestry (Van der Gaast et al., 2018). Appropriately chosen and well executed tree planting offers a natural, ecological, relatively cheap, and above all simple way to reduce the amount of carbon dioxide (CO2) in the atmosphere. At the same time, trees are very popular with a large part of the urban population in particular. This combination has given rise to many initiatives that have started to plant trees with the financial support of donors who want to offset their carbon footprint or simply contribute to environmentally beneficial projects.
As part of the carbon cycle, trees are an important reservoir of CO2, absorbing and storing it in the wood pulp, where it can remain for tens to hundreds of years. During its lifetime, a tree absorbs CO2 associated with its growth. You could say that the tree feeds on CO2. The tree takes CO2 from the air and begins to process it through photosynthesis. This gas contains two elements - oxygen and carbon. The tree doesn't need the oxygen, so it releases it back into the atmosphere and keeps only the carbon. This is converted into sugars, which the tree uses for its growth. Some of the carbon is shipped to the leaves, and the carbon that ends up in the wood can be held there for decades. When the tree dies, its tissues begin to decompose and become part of the soil. During the process of decomposition, CO2 is released back into the air by the respiration of the microbes that cause the decomposition, but some of the carbon remains in the soil for decades or centuries. Terrestrial plants, along with soil, hold approximately 2,500 gigatons of carbon, which is 3 times more than is found in the atmosphere (Waring, 2021).
It should also be said that trees are indispensable on a planetary scale for many other reasons, and carbon sequestration is just one ecosystem service on an incalculably long list (Miura et al., 2015). They are also widely sought after by people for recreation, relaxation and even promote better mental health. It is clear that trees are an important tool not only for protecting the climate, maintaining biodiversity and ecological stability, but also for maintaining a good quality of life for people.
In the Czech Republic, forest covers 33% of its territory. This is a relatively high figure, but it does not in itself guarantee sufficient climate function or sufficient CO2 storage. This is mainly due to the deterioration of the current state of forests in the Czech Republic and rapidly changing climatic conditions, especially warming causing an increase in evapotranspiration (Kupec et al., 2021). The current composition of our forests is 70% coniferous forests and 30% deciduous forests, although the natural composition corresponding to natural conditions is exactly the opposite, i.e. 35% coniferous

and 65% deciduous (CENIA, 2022). This has a major impact on spruce in particular, which was planted in areas outside its natural habitat where it was too warm and dry for it, making the trees more vulnerable. Monocultures, production forests full of trees of the same age with trees planted too densely are also less resilient. This brings to the forefront the importance of green infrastructure, e.g. trees growing outside of the forest land, which is extremely important for the health of landscapes and communities. This is where the intersection between climate protection and recreational potential can be seen.

Planting trees that match the natural species composition in suitable locations outside the forest can help to improve the environment ecologically and has the potential to improve the quality of place for people to live in and travel to. In addition, it will promote CO_2 storage. A good example of planting 'scattered greenery' is, among other things, the restoration of old dirt roads that have been ploughed for agricultural purposes in the past. Similarly, planting, for example, avenues along cycle paths, restoring orchards and planting in villages can also help them to adapt better to climate change. Such multifunctional approach has been called for a long time now (Otte et al., 2007)

The ideal species for planting in our conditions are native forest and noble fruit species. Non-native tree species do not belong in our nature, usually do not provide food for native insects and can be invasive and there use is limited by the Nature law (114/1992 Coll. Nature and Landscape Protection Act). Therefore, planting should always be planned and implemented under the supervision of experts. Unprofessional planting can cause more harm than good, either by choosing unsuitable species or inappropriate locations. Inappropriate species may not thrive on the site, may have invasive potential or may cause allergies, for example. On a poorly chosen site, trees may not survive or have the opposite effect to that expected. Similarly, it is important to remember that the Czech landscape is a cultural landscape, where different types of use and management have historically been mixed. Planting should not be a source of excessive restriction of its other functions.

Material and methods

To assess the efficiency of trees for carbon sequestration, it is necessary to know how much CO_2 such a tree can absorb in its lifetime. That is, the amount that is captured in its body at maturity. This amount is determined by the volume of its total biomass. The non-invasive determination of a tree's biomass is relatively complicated, mainly because of the very diverse shapes of the crown and branches. Thus, in practice, we usually rely mainly on trunk thickness and tree height. For forestry purposes and economic tree species, we have a large amount of data available and, as a result, there are mathematical equations for individual species that can estimate tree biomass with accuracy reaching or exceeding 90% based on stem diameter and tree height alone (Zianis et al., 2005). The situation is more complicated for non-forest and fruit trees. For these species not primarily grown for timber, there is insufficient growth data available and their growth may also differ significantly from their forest counterparts.

Anyway, determining the biomass of an individual tree is the first step. Based on this and the average wood density for the species, the dry weight of the tree can then be calculated. About half of this mass is then made up of carbon. According to the molar mass of the elements in the CO_2 molecule, the number is multiplied to find out how much CO_2 has been used for the growth of the tree and retained in the biomass. In order to estimate as accurately as possible the potential amount of CO_2 that can be retained in the bodies of newly planted trees over their lifetime, it is therefore necessary to know the expected size of the tree at mature age.

In order to get a general idea of the amount of biomass of commonly growing fruit trees, the actual field measurements were carried out in cooperation between CI2, o. p. s. (www.offsetujemeco2.cz), the landscape company Memory of the Landscape, s.r.o. (www.pamet-krajiny.cz) and Mendel University in Brno. Locations with mature fruit trees were selected. They were surveyed for basic dendrometric characteristics, physiological age and growth conditions according to a modified methodology presented by the Czech Nature Conservation Agency (AOPK CR standards, 01 001 Tree Condition Assessment, https://nature.cz/platne-standardy).

Results

A total of 584 fruit tree specimens were evaluated. These were commonly occurring fruit tree species without distinguishing varieties. 128 pears (*Pyrus communis*), 138 apple trees (*Malus domestica*), 122 cherries (*Prunus avium*) and 170 plums (*Prunus domestica*) were evaluated. The majority of individuals were in the physiological stage 4 - mature tree on site 2 - with good growing conditions.

Tab. 1: Median values for evaluated tree species

Fruit tree	height (m)	coefficient of variation	DBH (cm)	coefficient of variation	CO2 sequestration (ton)
Pear	10,9	0,18	50,50	0,18	2,21
Apple	6,8	0,17	36,00	0,17	1,38
Cherry	8,3	0,17	41,50	0,17	1,54
Plum	6,1	0,12	38,50	0,1	0,97

The coefficient of variation on more than 120 individuals of each fruit tree species did not exceed 0,2 (Table 1). Thus, the results can be interpreted in a way that more than 80% of the individuals were very similar to each other in dendrometric parameters. This indicates that under similar growth conditions and at similar physiological ages, the variability in growth of fruit trees is not so dramatic as to preclude generalization of the results. The results show that extensively grown long-lived fruit trees (cherry, apple and pear) are able to sequestrate around 1,5 tons of CO2 during their lifetime.

Discussion

Planting trees alone will not stop climate change, but it will contribute to reducing greenhouse gases already present in the atmosphere. While this is a long-term issue, lasting several decades, the CO2 that already exists can be actively absorbed. In contrast, renewable energy sources, for example, work immediately when they are installed, but do not 'merely' emit new CO2 during their operation and do close to nothing to reduce its current concentrations. It is therefore necessary to look for other strategies to remove the carbon that has already accumulated in the atmosphere. A combination of several measures at the same time is therefore ideal. In this sense, the benefits of tree planting come not only from the reduction of greenhouse gases, but from the overall positive benefits to the landscape and its inhabitants described in the introduction. In addition, trees also help us to better adapt to changes in the climate, for example during hot summers, and improve the quality of the environment in which we live.

At the same time, the current campaigns to plant new trees are commendable, but they must be done judiciously. It is not only the number of trees that matters, but also their characteristics, species composition and site-specific conditions. Young plantings will only be effective in terms of greenhouse gas retention if they reach mature age. They should therefore be given proper care. A major risk of these planting initiatives is when they focus primarily on the number of trees planted or their growth rate. Both are inappropriate indicators of a tree's ultimate carbon storage capacity and even worse indicators of biodiversity. The solution is therefore not to reforest every available area. Trees planted in places where no trees should grow will not provide the desired benefit. Neither will trees that are unnecessarily felled. On the other hand, every suitably planted tree that lives to a mature age counts.

Conclusions

Appropriately chosen and well-executed tree planting offers a natural, ecological, relatively cheap, and above all simple way to reduce the amount of carbon dioxide (CO^2) in the atmosphere as well a number of other environmental benefits. One of these benefits is the positive effects on human well-being and landscape aesthetics both of which is commonly utilized to support recreational potential. However, understanding the financial value of environmental benefits (ecosystem functions) of natural ecosystems and woody vegetation has been an ongoing challenge that still limits the full utilization of close-to-nature landscape management up to this day. According to our result, the total CO2 sequestered in mature most common fruit trees in the CR was estimated to ca 1,5 tons (0,97 – 2,21 according to tree species). This can help to motivate and promote future greening projects especially in the rural landscape where extensive management of fruit trees has been a part of the traditional and cultural way of life.

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Souhrn
V posledních letech se výsadba stromů na ochranu klimatu stala ve světě i u nás v České republice velmi populární. Pařížská dohoda z prosince 2015 a z ní vyplývající národně stanovené příspěvky významně podpořily potřebu vytvoření a zdokonalení metod uhlíkového účetnictví pro investice do lesního sektoru. Vhodně zvolená a dobře provedená výsadba stromů nabízí přirozený, ekologický, relativně levný a především jednoduchý způsob, jak snížit množství oxidu uhličitého (CO2) v atmosféře i řadu dalších environmentálních přínosů. Jedním z těchto přínosů je pozitivní vliv na pohodu člověka a estetiku krajiny, přičemž obojí je běžně využíváno k podpoře rekreačního potenciálu. Podle našeho výsledku bylo celkové množství CO2 sekvestrovaného ve vzrostlých nejběžnějších ovocných stromech v ČR odhadnuto na cca 1,5 tuny (0,97 - 2,21 podle druhu stromu). To může přispět k motivaci a podpoře budoucích ekologizačních projektů zejména ve venkovské krajině, kde je extenzivní hospodaření s ovocnými stromy součástí tradičního a kulturního způsobu života.

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