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CARBON SEQUESTRATION POTENTIAL OF OAK TREE

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Oak trees (*Quercus* spp.) are an important species in temperate forests with varied altitudinal gradients playing a vital role in significant carbon sequestration. According to estimates, the carbon sequestration potential (CSP) of the oak forest is 1.9 Mg C ha^{-1} $year^{-1}$. Lower elevation oak forests are sparse forest stands with poor capacity for regeneration, excessive grazing, and extensive lopping. If this disturbance is avoided, oak forests' carbon stocks can rise to 361.7 Mg C ha^{-1}, the level found at higher altitudes. The dry biomass of the oak, including roots, is estimated to be 871 pounds using carbon online estimator (COLE), of which 435.5 pounds are carbon. To equal the carbon in the large oak, 35.22 young trees of this size would be required. Even though trees primarily store carbon, they do occasionally release some of it, for example when their leaves decompose or when their roots burn sugar to absorb nutrients and water. Let's look at a real-world example: a white oak can live for 200 years while removing and storing carbon from the atmosphere.

Introduction

The carbon that trees store was initially taken in from the atmosphere as CO_2. With the aim of slowing down global climate change, forest carbon sequestration involves increasing the carbon content of the forest through mechanisms that remove carbon dioxide from the atmosphere (such as photosynthesis). After being trapped, the carbon is stored in the forest's living biomass, soil, and litter, adding to the stock of carbon there. According to Climate Change and Temperate Forests report, temperate forests store 37% of the world's annual carbon emissions, or between 0.2 and 0.4 Pg C per year. According to research, the Pacific Northwest's temperate forest stores 334 Mg C per hectare on average. Forest carbon stocks in New Zealand were estimated to be between 364 Mg C ha^{-1} and 672 Mg C ha^{-1}. In Chile, the temperate forests contain carbon stocks that range from 326 Mg C ha^{-1} to 571 Mg C ha^{-1} (Poudel *et al.,* 2020). Due to the ideal climatic and soil conditions for tree growth, temperate forests can have high carbon stocks per unit area. The presence of mature stands, dense canopy cover, fast growth, slow decomposition, high plant species diversity, and minimal human disturbance may also contribute to the high carbon stocks and carbon sequestration per unit area in the temperate forests. According to Singh and Dhar (2019), the carbon sequestration rates of *Quercus leucotrichophora* forests under conditions of low, moderate, and high human influence were 5 Mg C ha^{-1} $year^{-1}$, 2.6 Mg C ha^{-1} $year^{-1}$, and 1 Mg C ha^{-1} $year^{-1}$, respectively. According to Jina *et al.* (2008), In India's central Himalayan Region, the carbon stock in an oak forest site that had not yet degraded ranged from 16.7 Mg C ha^{-1} to 18.5 Mg C ha^{-1}, while that of an oak forest site that had ranged from 81.3 Mg C ha^{-1} to 115.4 Mg C ha^{-1}. Another study by Boulmane *et al.* (2017) discovered that the unmanaged oak forests in the Moroccan Atlas region had average aboveground carbon stocks of 54 Mg C ha^{-1}. The value of oak forests in reducing the effects of climate change and point to the necessity of proper conservation in order to prevent overgrazing and eventual degradation of the forests and associated carbon stocks (Mayer *et al.,* 2020). An in-depth knowledge of the relationships between tree growth requires is necessary for accurate prediction of forest carbon sequestration potential. However, there have only been a few studies to determine the potential carbon sequestration of tree growth.

The age distribution of the population and the dominant species type have an impact on the current carbon stock, making it frequently unstable (Bachelet *et al.,* 2015). The maximum growth of the forest's carbon stock that is feasible under the current conditions is known as the carbon sequestration potential and is the anticipated outcome of the forest's dynamic growth (Law *et al.,* 2018). The existing studies typically select the current state of carbon stock as the variable and analyze its influencing factors, ignoring the growth status of the forest and focusing solely on the impact of environmental conditions under the current state of carbon stock because the carbon stock of forest ecosystems is the fundamental parameter for studying the carbon exchange between forest ecosystems and the atmosphere (Garcia-Pausas *et al.,* 2017).

Process of carbon sequestration

The process of removing and storing carbon dioxide from the atmosphere is known as carbon sequestration. Carbon in forests is primarily stored in the soil and trees. Trees use carbon dioxide from the atmosphere to produce sugar during the process of photosynthesis, but they also release this gas back into the atmosphere during decomposition (Fares *et al.,* 2017). Within forests, a cycle of gas capture and release is present. After that, sequestered carbon builds up in forest soils, biomass, deadwood, and litter. Respiration and oxidation are examples of natural processes that release carbon from forest ecosystems, as well as intentional or unintentional effects of human activity (*i.e.* harvesting, fires, deforestation). About 11% of the world's greenhouse gas emissions as of 2019 are caused by deforestation. Deforestation in the tropics is increasing carbon emissions. Degradation of peatlands releases greenhouse gases (GHG) as well. Growing forests act as a carbon sink and have the potential to lessen the effects of global warming (Harenda *et al.,* 2018). As much as 48 pounds of carbon dioxide can be absorbed annually by a typical hardwood tree. By the time it is 40 years old, it will have sequestered about 1 ton of carbon dioxide. The average tree can take in about 21 kilograms of carbon dioxide (CO_2) annually, but this capacity is only reached when the tree is fully grown; saplings will take in much less. In fact, there are some forests where the soils contain more carbon than the living trees do. Every year, trees absorb more carbon as they age, and as they grow larger, they store more carbon.

Potential of oak trees to sequester carbon

The live oak is the most effective tree at capturing carbon; over the course of its lifetime, it can sequester 10,994 equivalent pounds of CO_2. Trees not only absorb carbon dioxide, but also assist the soil in absorbing and storing carbon. Trees are crucial to halting climate change even though they don't do as much as oceans, which absorb 90% of all carbon emissions and then experience the effects of ocean acidification. One acre of forest can hold roughly 2.5 tons of CO_2 per year, according to calculations. By absorbing carbon dioxide from the air, storing it in the soil and trees, and releasing oxygen into the atmosphere as they grow, trees reduce the rate of climate change. Trees provide many benefits to us, every day. Every year, 2.6 billion tonnes of carbon dioxide are absorbed by the world's forests. A member of the Fagaceae family, *Quercus leucotrichophora* is a tree that can be found in pine forests and the Himalayan region of India. Indian hill states use oak wood to craft agricultural tools. India has 16 different species of oaks, ten of which are found in the eastern

Himalayas and six in the western Himalayas (Gupta and Gupta 2020). Cork oak, Desert oak, Red oak, White oak, and other varieties of oak trees can be found in India. It is a tree that can live for more than a thousand years. The boiled bark of the oak tree, which has multiple uses, has medicinal qualities. Animals are fed by its fruit (acorns) during times of scarcity, and it has also been used for human consumption.

Table 1. Carbon sequestration potential of Oak Tree

Forest/Rotation	Sequestration Rate Per Acre Per Year (lbs)	Carbon Sequestered @ 1 year (tons)
S.R (years = 209)	918	9,769
P.G (years = 153)	1,207	4,422
G.R (years = 120)	1,625	14,235

Depending on the average age of the trees in the stand and the number of trees in the stand, forests capture and store carbon at varying rates. Young forests are densely treed and very good at absorbing carbon. Young trees absorb carbon quickly and grow quickly. Due to competition for resources, light, and growing space, not every small sapling grows into a large tree, but when they die and decompose, little carbon is released (Rice *et al.,* 2004). As the forest ages, the remaining trees continue to grow and trap more carbon. "Middle-aged trees," which range in size from medium to large, are healthy, and have a substantial root system, make up established or mature forests. Large trees do occasionally die, but the younger trees that quickly replace them make use of the new space. The overall net productivity (how many trees grow versus how many die) is positive because more trees are thriving than are dying, which improves carbon sequestration (Dass *et al.,* 2018). A more static or less dynamic carbon cycle exists in live and dead trees as well as the soil in old-growth forests. In old growth forests, large trees predominate by shading out small saplings, resulting in zero net productivity and recruitment of young trees (Clark *et al.,* 1999). However, the large trees, rotting logs, dense leaf litter, and soil are excellent carbon sinks. Despite the fact that there are typically fewer trees in an old growth stand, large individual trees may absorb as much carbon as a single middle-aged tree. However, the total additional carbon capture is frequently lower.

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