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IMPACT OF ARTIFICIAL AFFORESTATION ON GLOBAL CARBON CYCLE

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Afforestation is essential for carbon sequestration in the terrestrial ecosystem, as well as for the soil and water conservation in diverse landscapes. The forest ecosystem, which is an integral part of terrestrial ecosystems, can play an important role in sequestering carbon dioxide from the atmosphere and contributing to the mitigation of global climate change, which subsequently contributes to meeting national commitments and requirements to reduce carbon emissions and increase carbon sequestration. Afforestation and reforestation provide relatively inexpensive and effective solutions to increase carbon sequestration in forest ecosystems. Meanwhile, the ability of a forest ecosystem to sequester carbon is strongly influenced by various natural and anthropogenic factors that can transform a forest ecosystem from a carbon sink into a global carbon source. Therefore, understanding the impact of afforestation on the capacity of a forest ecosystem to sequester carbon is essential for an accurate assessment of the global and regional carbon balance of forest ecosystems.

Current research studies are focused on the impact of carbon sequestration measures and the complex impact of disturbances on the capacity of forest ecosystems to sequester carbon. In addition, the control of afforestation, along with the reduction or prevention of carbon leakage due to afforestation, would greatly contribute to forest carbon sequestration.

After the industrial revolution, the rapid increase in the concentration of greenhouse gases in the atmosphere led to global climate change [1]. Since the 1860s, the concentrations of methane and nitrous oxide in the atmosphere have increased by 155% and 19%, respectively [2]. The impact of plantations on the content of methane and nitrous oxide in soil was mainly explained by the changes in soil characteristics such as temperature and moisture content since they largely corresponded to the content of methane and nitrous oxide in the soil in different experimental plots [3]. A study by scientists at the University of Cambridge highlights that afforestation is an effective land-use management practice to reduce non-carbon greenhouse gas emissions.

With growing concern for climate change, carbon sequestration is also beginning to be considered as a main goal for forest conservation and artificial forestry. An example of this trend is the recent development of carbon sequestration guidelines for mangrove restoration projects certified under the Clean Development Mechanism Program of the United Nations Framework Convention on Climate Change [4]. Studies on the accumulation of carbon in the soil of forest areas have shown that, on average, for all projects, the carbon content in the soil initially decreases after afforestation and the decrease can continue for additional 30 years [5]. However, results vary considerably depending on forest types, previous land use, soil clay content, and climate. Under experimental conditions, the carbon content in the soil increases relatively faster after afforestation, where trees were grown in treeless areas [6]. Given the high proportion of carbon stored in the soil of terrestrial ecosystems, determining the exact amount of carbon that has entered the soil due to reforestation is especially important for estimating the total carbon in ecosystem during forest development.

The approach to reforestation has an impact on the structure and function of the forest. The number of trees and the types of tree species planted (exotic or native, mixed or single species) and the inclusion of shrubs are key decisions that the scientists will have to consider during their research. Many studies conclude that plantations of fast-growing tree species can sequester carbon faster than native mixed plantations. For example, planting different tree and shrub species provides higher structural complexity than planting tree species in nurseries, resulting in greater ecosystem biodiversity and helping to accelerate tree growth [7]. Most trees in the habitat develop very slowly. Plant organic matter is an important structural component of forests; therefore, reforestation should mimic the heterogeneity of tree structures found in natural forests by creating a mosaic of different combinations of tree species and tree densities in the forested area.

For this purpose, scientific experiments were carried out to determine the principles for the formation of artificial plantations in forest ecosystems. The survival rate data presented in Table 1 of pine and birch tree species was 64.5% and 60.5%respectively. When studying the absorption of carbon dioxide (CO_2) and the release of oxygen (O_2) in crops created by diagonal and row tree plantings, it was found that pine absorbs 124.7 tons of carbon dioxide, and releases 95.1 tons of oxygen. The amount of carbon in the biomass of pine is 51.5%, oxygen - 40.1%. Consequently, pine tree species in landscape groups contains 210.3 tons of carbon, 171.1 tons of oxygen, i.e. to obtain this amount of carbon, plants had to absorb 771.9 tons of carbon dioxide and release 588.1 tons of oxygen. The amount of carbon in the wood mass of row plantings is 33.9 tons, oxygen - 27.7 tons.

Table 1 - Biometric indicators of 8-year-old pine and birch crops

Tree Species	Survival rate, %	Height, m		Diameter, cm		Growth, cm	
		X±m	V, %	X±m	V, %	X±m	V, %
Pine	64.5	1.5±3.6	12.3	1.6±0.2	46.6	15.8±1.4	44.8
Birch	60.5	3.7±0.1	30.2	3.1±0.1	42.9	4.8±2.3	38.2

Table 2 - Determination of the amount and cost of accumulated carbon in pine crops, depending on the method of afforestation

Planting type	The age of trees	Phyto mass m^3	Quantity (tons)		Quantity in plant wood biomass (tons)	
			Absorbed carbon dioxide	Released oxygen	Carbon dioxide	Oxygen
Diagonal tree planting	10	412.9	771.9	588.1	210.3	171.1
Row tree planting	4	66.0	124.7	95.1	33.9	95.1

According to this forest management study, it was revealed that the largest areas are occupied by mature and overmature plantations, in which it is necessary to carry out measures to promote natural regeneration through soil mineralization and sowing of seeds in case of unsatisfactory afforestation.When comparing the two planting methods, it can be seen that the higher survival rate of pine was with row planting (44.6%). Additional observations are needed to obtain reliable conclusions about the advantages of various planting methods.Deforestation has a significantly negative impact on the climate, hydrology, soil and biodiversity of forest ecosystems. Afforestation is an important tool for biodiversity conservation at all levels (ecosystem, genetic and species) and climate change mitigation. Forests ecosystems provide many services to the world's population, such as provisioning services (food, raw materials, medicines), regulating services (carbon sequestration, dealing with extreme natural events), supporting services (animal and plant habitats), and cultural services (recreation and health improvement). The role of forest resources, therefore, in human life can hardly be overestimated. Research into the restoration of forests lost by human activity is now of global importance. Widespread reforestation will help improve the significant environmental impacts of past deforestation but must be designed with an integrated analytical approach to avoid detrimental environmental and social impacts.

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