Changes in CO_2 Flux Conditions in the Spruce Forest of Various Ages in the Central Forest Reserve of Russia

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Abstract

Today, researchers and policymakers are very concerned about increasing greenhouse gases and CO_2 because they detect infrared radiation emitted from the earth's surface. The amount of gaseous carbon dioxide released by plants, either from the air or from plants to the air. The Central Forest fir trees are a natural resource that is essential for life in Russia. One of the benefits is that it can control and absorb carbon dioxide in the air. The factors that influence the release of CO_2 are air temperature, soil temperature, and humidity. The purpose of this study was to determine the amount of CO_2 flux emitted in various conditions of the spruce forest including the spruce forest. This research was conducted in the summer of 2018 using a camera in the field which includes weather and environmental parameters in the soil and air (soil humidity, soil temperature, and water temperature). These results suggest that in general, there is no correlation between soil temperature and moisture and the release of CO2 fluxes in various Russian forests.

Keywords: *CO_2 flux; Russian forest reserves; greenhouse gases*.

A. INTRODUCTION

The sour shield spruce is one of the most common types of evergreen trees. Usually grows in the central, southern taiga and sub-zone of broadleaf coniferous forests. This research was conducted at the Central Forest Reserve located in the Western European part of Russia. The Central Forest Reserve was founded on December 31, 1931, initiated by a group of Russian scientists led by the first Grigory Leonidovich professor of the Smolensk Pedagogical Institute. At that time, he was appointed as Director of reserves (http://www.clgz.ru/). Sour shield pine trees are very beneficial for human life, namely economic and ecological benefits. The economic benefit of pine forests is the availability of goods and services that can be utilized. Meanwhile, its ecological function has a major impact on the environment, including carbon storage, water regulator (hydrology), and storing various kinds of biodiversity (germplasm).

The ecological function of pine forests is very important in controlling carbon dioxide (CO_2). CO_2 is one of the greenhouse gases that are useful in supporting life on earth. However, increasing industry, land clearing, fires, and illegal logging can produce CO_2 which raises concerns about an increase in temperature on the earth's surface (global warming). The increase in temperature goes hand in hand with the increase in CO_2 gas and it is stated that CO_2 gas is the main supplier of increasing earth's temperature.

The release of CO_2 into the air is influenced by several factors, one of which is environmental factors (microclimate). In conditions of shallow young vetroval 1 (10-20 years old), a mound of deep old vetroval 1 (80-100 years old), and a mound of deep old vetroval 2 (80-100 years old) the microclimate had a major effect on the release of CO_2 flux which consists of air temperature, soil temperature, and humidity. Judging from the physical condition of the forest itself, the microclimate is related to the release of CO_2 flux and affects several forest conditions, including a hillock of shallow young vetroval 1 (10-20 years old), a hillock of shallow young vetroval 2 (20-30 years old), shallow young vetroval 2 (20-30 years old), deep old vetroval 1 (80-100 years old), deep old vetroval 2 (80-100 years old), and background.

In hillock conditions of shallow young vetroval 2 (20-30 years old) and shallow young vetroval 2 (20-30 years old), the ability to absorb CO_2 is greater than the release. This is because the humidity is higher and the forest canopy is still dense so that the incoming sunlight does not immediately make up for the bottom of the soil. Likewise, in the conditions of a hillock of shallow young vetroval 1 (10-20 years old), deep old vetroval 1 (80-100 years old), deep old vetroval 2 (80-100 years old), and background, the ability to absorb CO_2 is smaller than with the release, because in these conditions the incoming sun directly redeems the ground and the open forest canopy.

B. METHODS

The research was carried out in the Central Forest Reserve located at the intersection of Nelidovsky and Antrapolsky of the Tver area. The central estate (Zapovedny settlement) is located 42 km north of the administrative center-Nelidovo. The total reserves are 24415 ha and protected 2 areas covering an area of 705 km (http://www.clgz.ru/) in the summer of July and August 2018. The method used is in the form of qualitative and quantitative methods with field observation approaches and conducting intensive tests on soil samples from research locations in the laboratory to obtain conformity data between the facts and the theories used.

The agro-ecological laboratory for monitoring, modeling, and confiscation of ecosystems has developed a protocol for measuring greenhouse gases in subsoils (Research Reports, 2011; 2012).

Table 1: Brief description of the research site and objects

Object	**Localization (coordinate system)**	**Dominant background vegetation**	**Background soil profile**
Spruce forest of various ages: 1. Background 2. hillock of shallow young vetroval 1 (10-20 years old) 3. hillock of shallow young vetroval 2 (20-30 years old) 4. shallow young vetroval 1 (10-20 years old)	Quarter 81 (N 56° 28’ 54,1” E 032° 58’ 36,1” 246m)	Ель европейская (*Pícea ábies*) Дуб обыкновенный (*Quercus robur*), Береза повислая (*Betula pendula*) Папоротник (*Dryópteris fílix-mas*)	O+4 – A02 – A14 – A2A19 – A2f′17 – A2f″28 – A2f‴(c)33 – (A2ко)42 – IIA2B(g)42 – IIB1t(g)65 – IIB2(t)90 –

5. shallow young vetroval 2 (20-30 years old) 6. mound of deep old vetroval 1 (80-100 years old) 7. mound of deep old vetroval 2 (80-100 years old) 8. deep old vetroval 1 (80-100 years old) 9. deep old vetroval 2 (80-100 years old)		Кислица обыкновенная (*Oxalis acetosella L.*) Щитовник мужской (*Dryopteris filix-mas L.*)	IIBC120↓

The material used in this study is air samples taken as many as nine points in the field using equipment such as a chamber with a diameter of 20 cm and a height of 15 cm with a depth of 5-7 cm from the ground to prevent diffuse gas from the external environment. Air from the chamber is pumped into the gas analyzer using a built-in pump because the device registers an increase in indoor CO_2 concentration with a frequency of 1 Hz, an injection syringe measuring 20 ml/cc, a 10 ml/cc tube bottle, a syringe, a clamp, a temperature gauge. soil, air temperature gauges, and soil moisture testers. Besides, a tube containing 10 ml/cc of air was examined in the laboratory using gas chromatography to see the amount of CO_2 concentration.

Sampling in the field was done by using the purposive random sampling method. A sampling of air, temperature and humidity was carried out at 9 different points, namely hillock of shallow young vetroval 1 (10-20 years old), a hillock of shallow young vetroval 2 (20-30 years old), shallow young vetroval 1 (10-20 years). years old), shallow young vetroval 2 (20-30 years old), mound of deep old vetroval 1 (80-100 years old), a mound of deep old vetroval 2 (80-100 years old), deep old vetroval 1 (80 -100 years old), deep old vetroval 2 (80-100 years old), and Background.

Taking the air sample directly in the field using a chamber, base chamber, injection syringe measuring 20 ml/cc, tube bottle measuring 10 ml/cc, syringe, and clamp. Before taking air samples, first, a device is installed to measure the temperature and humidity of the soil outside the chamber. The next step is to install the chamber head and then clamp it. Sampling is carried out after the chamber head has been installed for 0.5 or until a steady increase in the CO_2 concentration in the chamber is more than 100 ppm compared to the atmosphere using an injection syringe measuring 20 ml/cc. The air sample is sucked and put into a 10 ml/cc tube bottle. The air sample has been inserted into the tube bottle and then taken to the laboratory to measure CO_2 levels using gas chromatography. Based on the data obtained on increasing the concentration, the calculated CO_2 flux (in g CO_2 m2 day-1) is then converted into units of gr CO_2/m2/hour, taking into account the temperature and air pressure in the room according to the ideal gas equation. In parallel with the CO_2 emission analysis, temperature (with temperature check hi98501 thermometer) and humidity (with humidity meter HH2 sensor) were determined at each point, averaging three repetitions for the 10 cm layer at a distance of 3-5 cm from the base.

C. RESULTS AND DISCUSSION

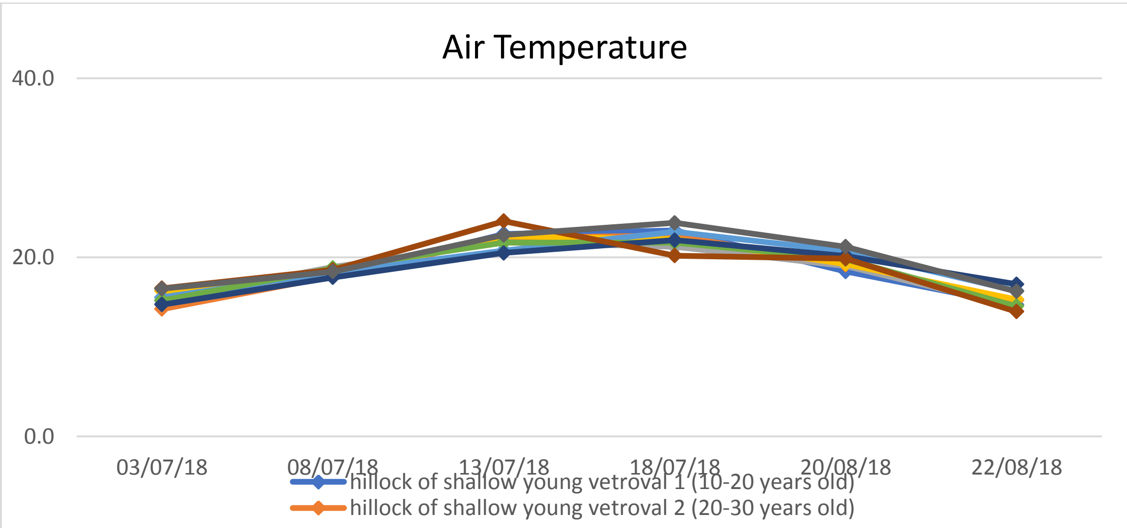
1. Microclimate at the Sampling Point

This research was conducted in July and August 2018 which are summer. From the research results, the highest average air temperature at the research location on 03.07.2018 was found in deep old vetroval 2 (80-100 years old), namely 16.6 °C. While the lowest average temperature on that date is at the location of deep old vetroval 1 (80-100 years old), namely 14.7 °C.

The highest average air temperature at the study location on 08.07.2018 was in shallow young vetroval 1 (10-20 years old), namely 18.9 °C. Meanwhile, the lowest average temperature on that date is at the mound of deep old vetroval 2 (80-100 years old), which is 17.8 °C. The highest average air temperature at the study location on 13.07.2018 was found in deep old vetroval 2 (80-100 years old), namely 24.1 °C. Meanwhile, the lowest average temperature on that date is in the location of deep old vetroval 1 (80-100 years old), which is 20.5 °C. The highest average air temperature at the research location on 18.07.2018 is in the background, namely 23.9 °C. While the lowest average temperature on that date is at the location of deep old vetroval 2 (80-100 years old), which is 20.2 °C. The highest average air temperature at the research location on 28.08.2018 is in the background, namely 21.2 °C. Meanwhile, the lowest average temperature on that date is at the hillock of shallow young vetroval 1 (10-20 years old), which is 18.4 °C.

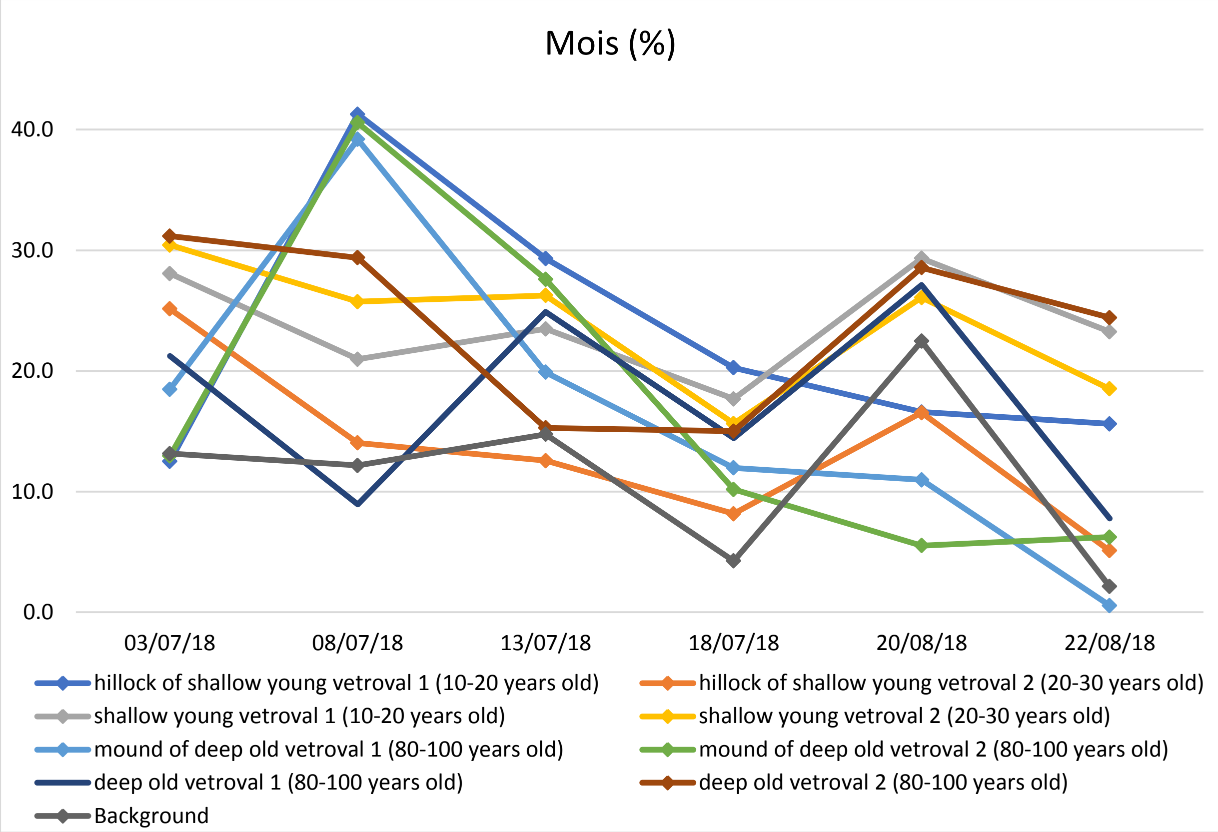
On 22.08.2018, the highest average air temperature at the study location was found in deep old vetroval 1 (80-100 years old), namely 17.0 °C. While the lowest average temperature on that date is at the location of deep old vetroval 2 (80-100 years old), which is 14.0 °C.

It can be seen that the air temperature has undergone very significant changes due to the dense forest canopy and the sampling time is not at the same time every time. Can be seen in graph 1.1.



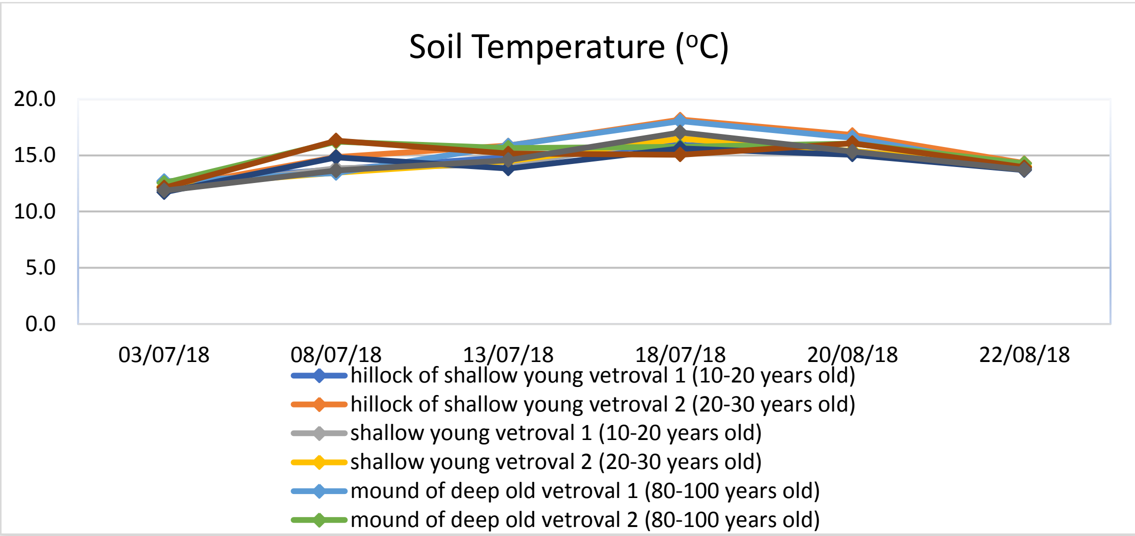
Graph Number 1.1: Air temperature in the spruce forest in July - August 2018.

The humidity in the study area showed the lowest, namely 0.6% on 22.08.2018 with the highest humidity of 41.3% on 08.07.2018 because the sampling was carried out at different times, namely morning and evening. As can be seen in graph 1.2



Graph 1.2: Soil moisture in July - August 2018 in the spruce forest

The highest average soil temperature is found at the location of a hillock of shallow young vetroval 2 (20-30 years old), namely 18.2 °C on 18.07.2018 and the lowest average soil temperature is at the location of deep old vetroval 1 (80-100 years old)) ie 11.7°C on 03.07.2018 (see graph 1.3).



Graph 1.4: Soil temperature in the spruce forest in July - August 2018 with a depth of 0 - 10 cm above ground level.

The amount of CO2 flux produced is influenced by differences in soil temperature and humidity at each sample point. This relates to the activity of soil microorganisms and plant roots that process respiration to release CO_2 fluxes.

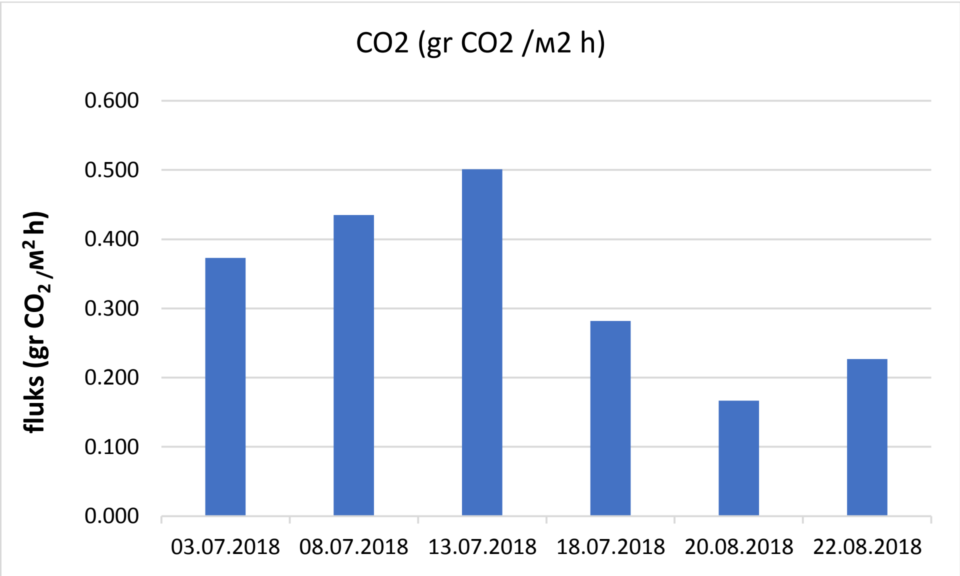
The release of CO_2 into the air is caused by the influence of the microclimate and the activity of soil biota. Loss of forest cover as carbon storage can result in the release of large CO_2 fluxes. The loss of forest cover is inseparable from the occurrence of forest conservation such as forest clearing, forest fires, tree cutting, and infrastructure development which harm reducing carbon storage in forests.

2. CO_2 flux at the Study Site Spruce forest of various ages in a central Russian forest reserve

Soils play an important role in regulating the flow of greenhouse gases because they are responsible for 60-80% of CO_2 emissions from soil ecosystems [Blagodatsky S. A. et al., 2007; Kurganova I. N., 2010]. Soil also has a very important role in managing the water system ecosystem.

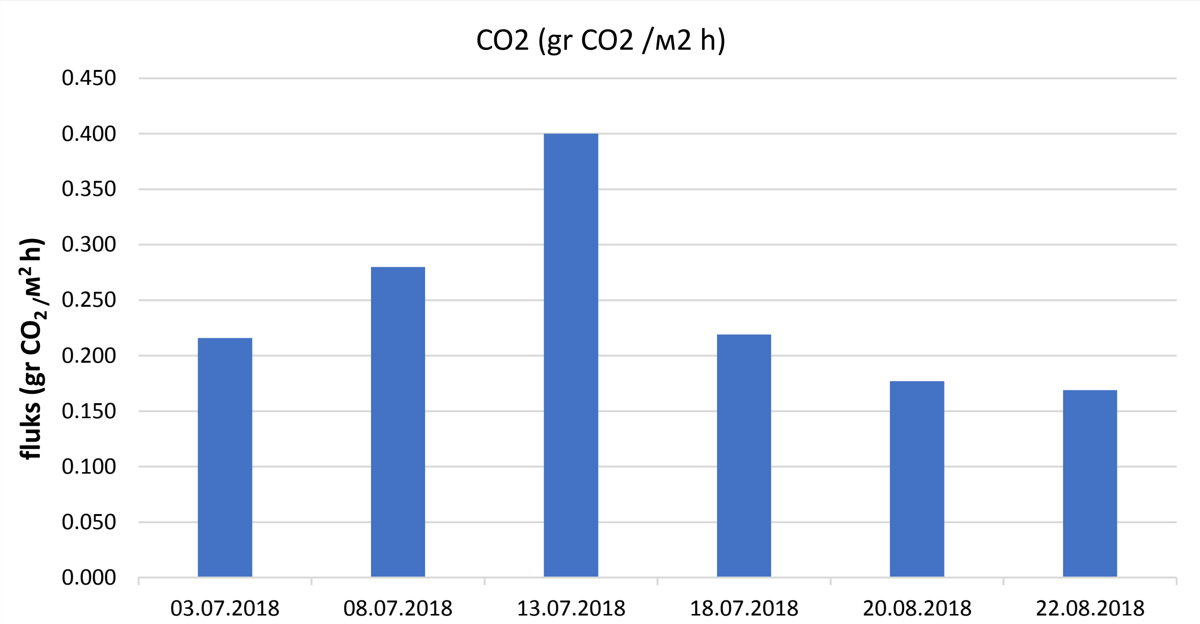
At the research location, measurements of CO_2 flux levels were carried out at different times, namely July and August. Where July is the peak of summer so there is more sunshine. Meanwhile, August is the transition from summer to autumn, so the conditions for the measurement point are getting humid and wet, which can affect the resulting CO_2 flux. As can be seen in the following graph:

Figure 1.6: Hillock of shallow young vetroval CO_2 flux 1 (10-20 years old)



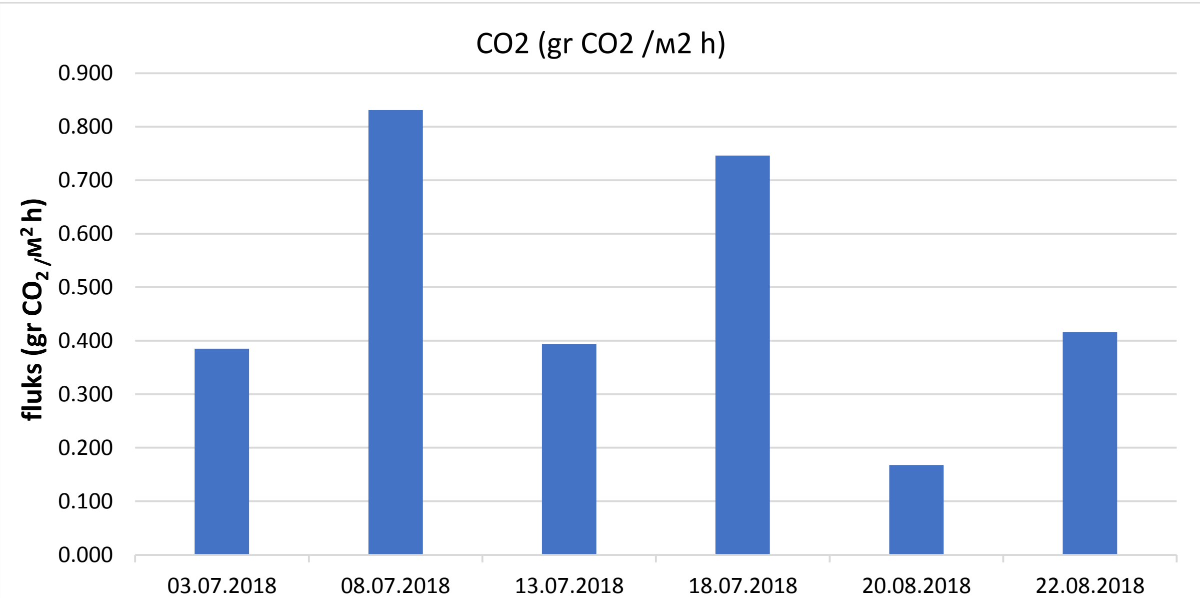
The data above shows that there is a difference in CO_2 flux. In July and August 2018 at the hillock of shallow young vetroval 1 location (10-20 years old), namely 0.373 CO_2 (gr CO_2 / м2 hour), 0.435 CO_2 (gr CO_2 / м2 hour), 0.501 CO_2 (gr CO_2 / м2 hour)), 0.282 CO_2 (gr CO_2 / м2 hour) 0.167 CO_2 (gr CO_2 / м2 hour) and 0.227 CO_2 (gr CO_2 / м2 hour) with an average of 0.216 CO_2 (gr CO_2 / м2 hour).

Figure 1.7: Hillock of shallow young vetroval 2 (20-30 years old) CO2 flux



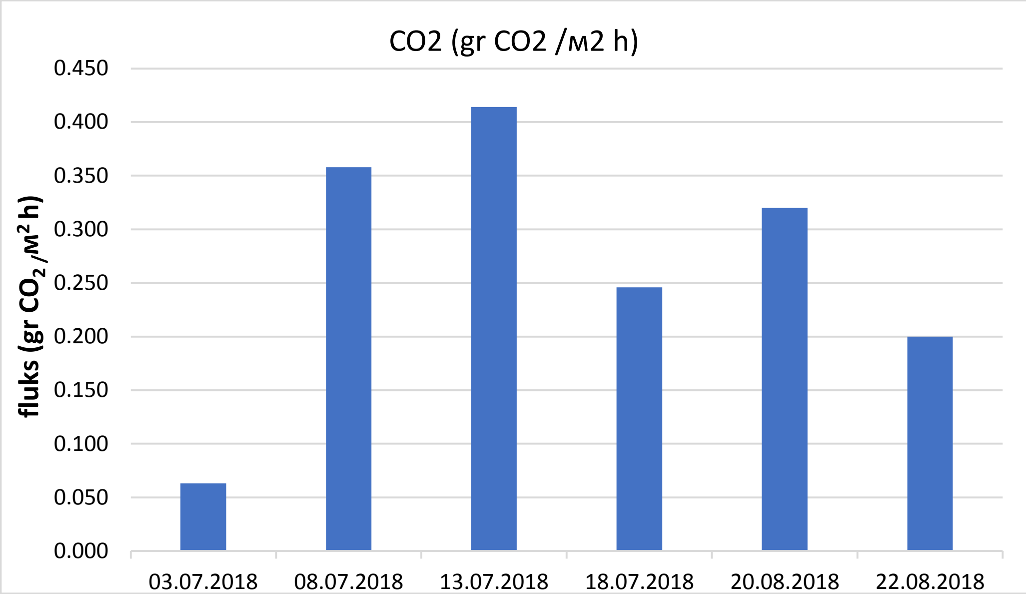
The data show that there is a difference in CO_2 flux. In July and August 2018 at the hillock of shallow young vetroval 2 (20-30 years old), namely 0.216 CO_2 (gr CO_2 / м2 hour), 0.280 CO_2 (gr CO_2 / м2 hour), 0.400 CO_2 (gr CO_2 / м2 hour), 0.219 CO_2 (gr CO_2 / м2 hour) 0.177 CO_2 (gr CO_2 / м2 hour) and 0.169 CO_2 (gr CO_2 / м2 hour) with an average of 0.244 CO_2 (gr CO_2 / м2 hour).

Graph 1.7: CO_2 flux shallow young vetroval 1 (10-20 years old)



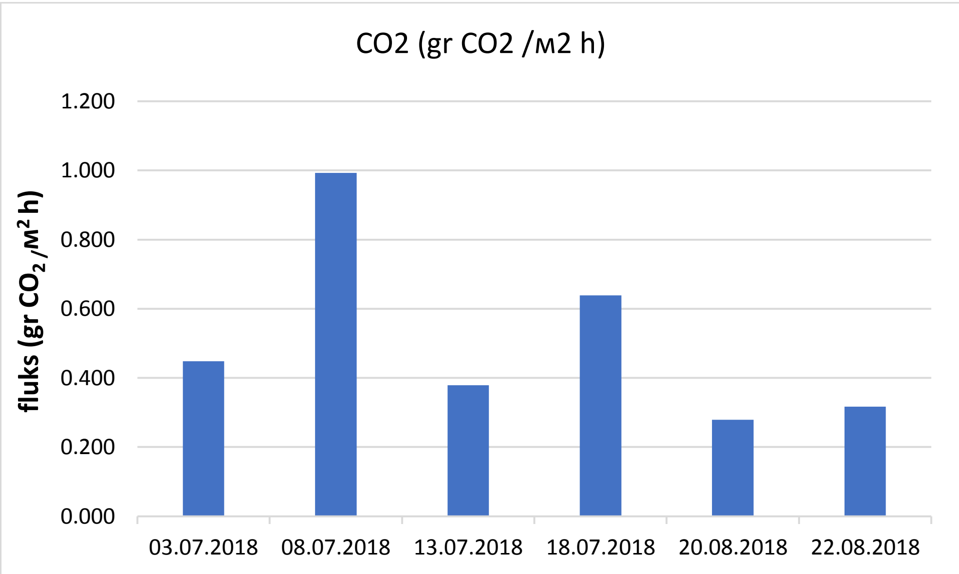
The data show that there is a difference in CO_2 flux. In July and August 2018 at shallow young vetroval 1 locations (10-20 years old), namely 0.385 CO2 (gr CO_2/ м2 hour), 0.831 CO_2 (gr CO_2 / м2 hour), 0.394 CO_2 (gr CO_2 / м2 hour), 0.746 CO_2 (gr CO_2 / м2 hour) 0.168 CO_2 (gr CO_2 / м2 hour) and 0.416 CO_2 (gr CO_2 / м2 hour) with an average of 0.490 CO_2 (gr CO_2 / м2 hour).

Graph 1.8: CO2 flux shallow young vetroval 2 (20-30 years old)



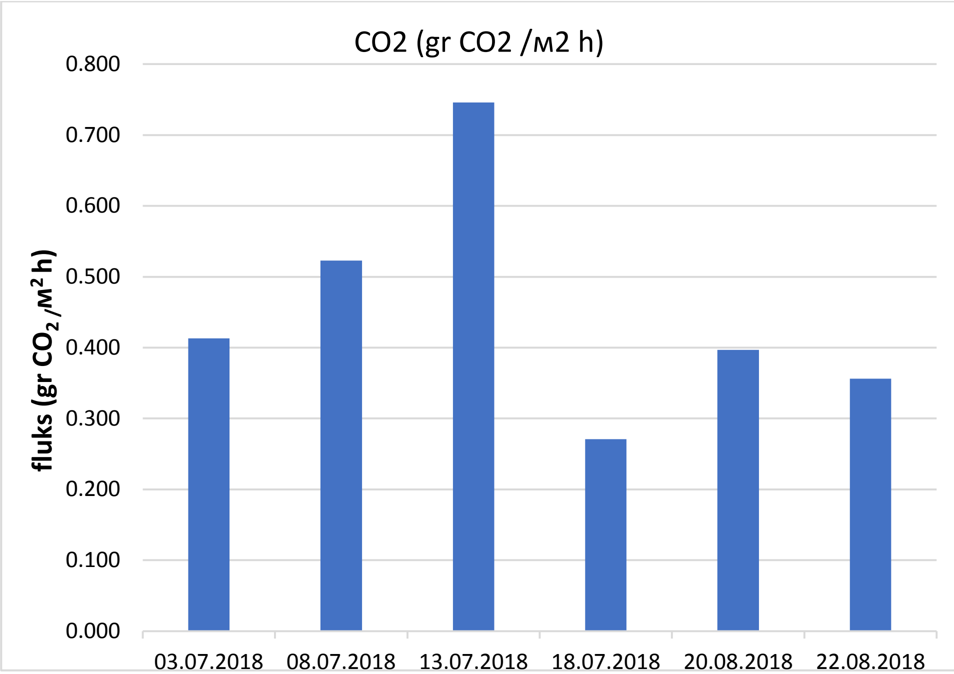
The data show that there is a difference in CO_2 flux. In July and August 2018 at shallow young vetroval 2 locations (20-30 years old), namely 0.063 CO2 (gr CO_2 / м2 hour), 0.358 CO_2 (gr CO_2 / м2 hour), 0.414 CO2 (gr CO_2 / м2 hour), 0.246 CO2 (gr CO2 / м2 hour) 0.320 CO_2 (gr CO_2 / м2 hour) and 0.200 CO_2 (gr CO_2 / м2 hour) with an average of 0.267 CO_2 (gr CO_2 / м2 hour).

Graph 1.9: CO_2 flux mound of deep old vetroval 1 (80-100 years old)



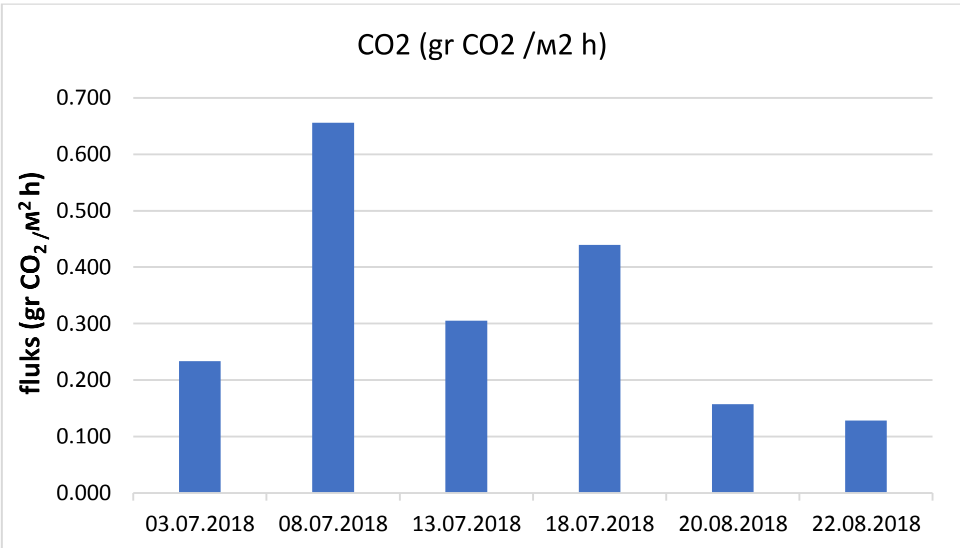
The data show that there is a difference in CO_2 flux. In July and August 2018 at the mound of deep old vetroval 1 (80-100 years old) location, namely 0.448 CO_2 (gr CO_2 / м2 hour), 0.993 CO_2 (gr CO_2 / м2 hour), 0.379 CO2 (gr CO_2 / м2 hour)), 0.639 CO_2 (gr CO_2 / м2 hour) 0.279 CO_2 (gr CO_2 / м2 hour) and 0.317 CO_2 (gr CO_2 / м2 hour) with an average of 0.509 CO_2 (gr CO_2 / м2 hour).

Figure 1.10: CO2 flux mound of deep old vetroval 2 (80-100 years old)



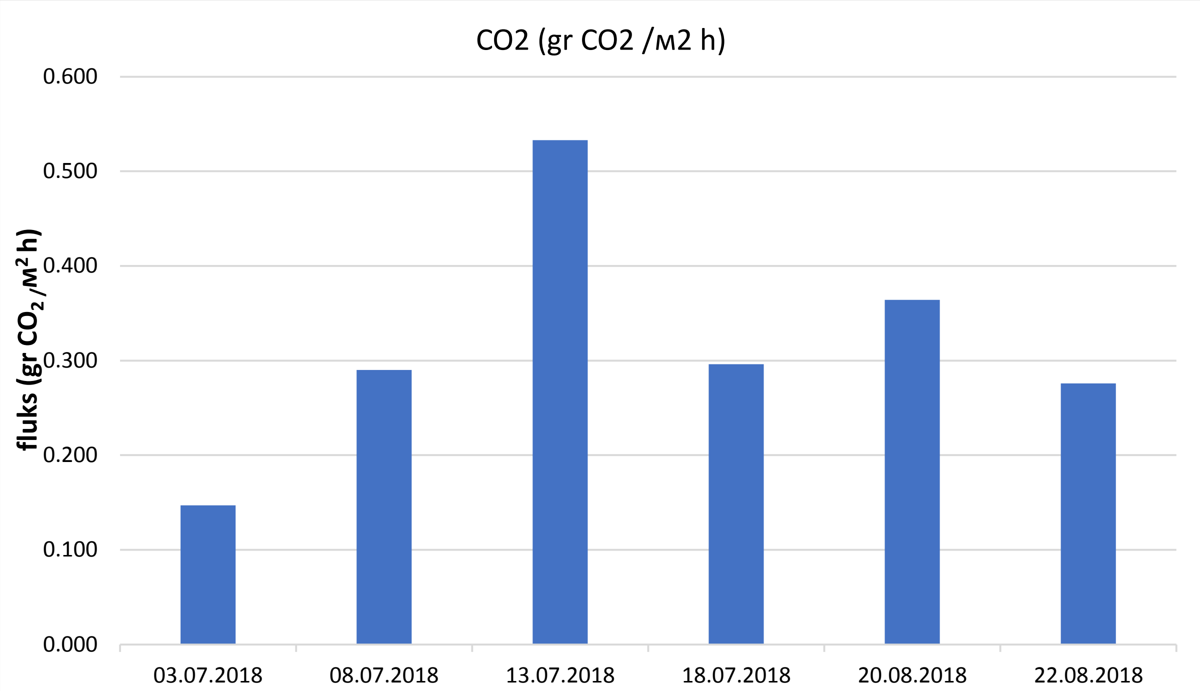
The data show that there is a difference in CO_2 flux. In July and August 2018 at the mound of deep old vetroval 2 (80-100 years old) location, namely 0.413 CO_2 (gr CO_2 / м2 hour), 0.523 CO_2 (gr CO_2 / м2 hour), 0.746 CO_2 (gr CO_2 / м2 hour)), 0.271 CO_2 (gr CO_2 / м2 hour) 0.397 CO_2 (gr CO_2 / м2 hour) and 0.356 CO_2 (gr CO_2 / м2 hour) with an average of 0.451 CO_2 (gr CO_2 / м2 hour).

Figure 1.11: Deep old vetroval 1 (80-100 years old) CO_2 flux



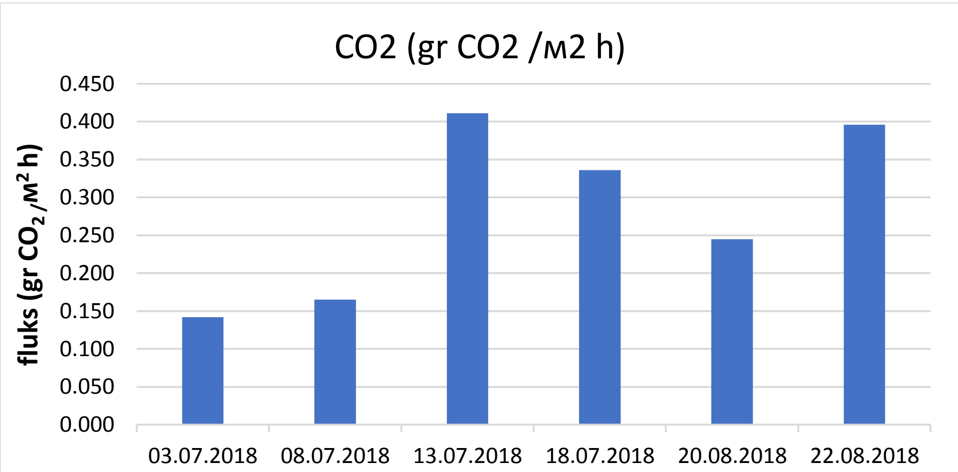
The data show that there is a difference in CO_2 flux. In July and August 2018 at the location of deep old vetroval 1 (80-100 years old), namely 0.233 CO_2 (gr CO_2 / м2 hour), 0.656 CO_2 (gr CO_2 / м2 hour), 0.305 CO_2 (gr CO_2 / м2 hour), 0.440 CO_2 (gr CO_2 / м2 hour) 0.157 CO_2 (gr CO2 / м2 hour) and 0.128 CO_2 (gr CO_2 / м2 hour) with an average of 0.320 CO_2 (gr CO_2 / м2 hour).

Figure 1.12: Deep old vetroval 2 (80-100 years old) CO2 flux



The data show that there is a difference in CO_2 flux. In July and August 2018 at the location of deep old vetroval 2 (80-100 years old), namely 0.147 CO_2 (gr CO_2 / м2 hour), 0.290 CO_2 (gr CO_2 / м2 hour), 0.533 CO_2 (gr CO2 / м2 hour), 0.296 CO_2 (gr CO_2 / м2 hour) 0.364 CO_2 (gr CO_2 / м2 hour) and 0.276 CO_2 (gr CO_2 / м2 hour) with an average of 0.318 CO_2 (gr CO_2 / м2 hour).

Figure 1.12: Background CO_2 flux



The data show that there is a difference in CO_2 flux. In July and August 2018 the background locations were 0.142 CO_2 (gr CO_2 / м2 hour), 0.165 CO_2 (gr CO_2 / м2 hour), 0.411 CO_2 (gr CO_2 / м2 hour), 0.336 CO_2 (gr CO_2 / м2 hour) 0.245 CO_2 (gr CO_2 / м2 hour) and 0.396 CO_2 (gr CO_2 / м2 hour) with an average of 0.283 CO_2 (gr CO_2 / м2 hour).

Measurements at the Spruce forest of various ages research location showed differences in the results of CO_2 flux at the mound of deep old vetroval 1 (80-100 years old), shallow young vetroval 1 (10-20 years old), and a mound of deep old vetroval 2 (80-100 years old) on 03.07.2018 to 22.08.2018 influenced by high temperature and low humidity, which caused the release of CO_2 flux to be greater than absorption. The high temperature in that location is influenced by the cover of land that is already open so that the forest gets full sunshine throughout the day resulting in the release of CO_2 fluxes greater than absorption. The source of CO_2 flux comes from the respiration of plant roots and biological oxidation of soil biota.

Different in the locations of a hillock of shallow young vetroval 1 (10-20 years old), a hillock of shallow young vetroval 2 (20-30 years old), shallow young vetroval 2 (20-30 years old), deep old vetroval 1 (80- 100 years old), deep old vetroval 2 (80-100 years old), and background with the same average value due to conditions of low temperature and humidity, the release of CO_2 flux is smaller than the release. The difference from the measurement results at nine locations shows that forest conditions affect the resulting CO_2 flux.

D. CONCLUSION

From the above discussion, there are changes and differences in CO_2 flux in different weather conditions and forest environments. Apart from differences in humidity and forest conditions, it also affects the CO_2 flux of an area. For example, in hillock conditions of shallow young vetroval 2 (20-30 years old) and shallow young vetroval 2 (20-30 years old), the ability to absorb CO_2 is greater than the release. This is because the humidity is higher and the forest canopy is still dense so that the incoming sunlight does not immediately make up for the bottom of the soil. Likewise, in the conditions of a hillock of shallow young vetroval 1 (10-20 years old), deep old vetroval 1 (80-100 years old), deep old vetroval 2 (80-100 years old), and background, the ability to absorb CO_2 is smaller than with the release, because in these conditions the incoming sun directly redeems the ground and the open forest canopy.

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