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BACHELOR THESIS

(EXPLANATORY NOTE)

SPECIALTY 101 “ECOLOGY”,
EDUCATIONAL AND PROFESSIONAL PROGRAM:
“ECOLOGY AND ENVIRONMENT PROTECTION”

Theme: «Remote assessment of the Holosiivskiy forest ecosystem»

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МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
ФАКУЛЬТЕТ ЕКОЛОГІЧНОЇ БЕЗПЕКИ,
ІНЖЕНЕРІЇ ТА ТЕХНОЛОГІЙ
КАФЕДРА ЕКОЛОГІЇ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач випускової кафедри
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« _____ » _____ 2022 р.

ДИПЛОМНА РОБОТА
(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ БАКАЛАВРА

ЗА СПЕЦІАЛЬНІСТЮ 101 «ЕКОЛОГІЯ»
ОПП «ЕКОЛОГІЯ ТА ОХОРОНА НАВКОЛИШНЬОГО СЕРЕДОВИЩА»

Тема: «Дистанційна оцінка екосистеми Голосіївського лісу»

Виконавець: студент групи ЕК-411, Тимчишин Максим Анатолійович
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« _____ » _____ 2022

BACHELOR THESIS ASSIGNMENT

Maksym A. Tymchyshyn

1. Theme: «Remote assessment of the Holosiivskyi forest ecosystem» approved by the Rector on April 18, 2022, № 388/ст.
2. Duration of work: from 23.05.2022 to 19.06.2022.
3. Output work (project): published data on the Holosiivskyi forest environmental state, space images of the Gogle Earth Engine
4. Content of explanatory note: (list of issues): analytical review of the literature on the topic of the diploma. Analyses, consideration, and assessment of the Holosiivskyi forest ecosystem using different remote methods.
5. The list of mandatory graphic (illustrated materials): figures, graph, space images.

6. Schedule of thesis fulfillment

№ з/П	Task	Term	Advisor's signature
1	Receive themes task, search the literature and legislation	10.04.2022	
2	Preparing the main part (Chapter I)	23.05- 30.05.2022	
3	Preparing the main part (Chapter II)	25.05- 1.06.2022	
4	Formulating conclusions and recommendations of the thesis	2.06.2022	
5	Making an explanatory note to the previous presentation of the department, consultation with the norms controller	3.06- 7.06.2022	
6	Presentation of the work at the department	08.06.2022	
7	Taking into account the comments and recommendations and training to protect	09.06 - 13.06.2022	
8	Thesis defense at the department	14.06.2022	
9			
10			
11			

7. Date of task issue: «23» May 2022

Diploma (project) advisor:

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Task is taken to perform:

(graduate's signature)

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«_____» _____ 2022 р.

ЗАВДАННЯ

на виконання дипломної роботи

Тимчишина Максима Анатолійовича

1. Тема роботи «Дистанційна оцінка екосистеми Голосіївського лісу»

затверджена наказом ректора від «18» квітня 2022 р. № 388/ст.

2. Термін виконання роботи: з 23.05.2022 р. по 19.06.2022 р.

3. Вихідні дані роботи: опубліковані дані про екологічний стан Голосіївського лісу, космічні знімки Google Earth Engine.

4. Зміст пояснювальної записки: аналітичний огляд літератури за темою диплома. Аналіз, розгляд та оцінка екосистеми Голосіївського лісу різними дистанційними методами.

5. Перелік обов'язкового графічного (ілюстративного) матеріалу: рисунки, графіки, космічні зображення.

6. Календарний план-графік

№ з/п	Завдання	Термін виконання	Підпис керівника
1	Отримання теми завдання, пошук літературних джерел та законодавчої бази	10.04.2022	
2	Підготовка основної частини (Розділ I)	23.05-30.05.2022	
3	Підготовка основної частини (Розділ II)	25.05-1.06.2022	
4	Формулювання висновків та рекомендацій дипломної роботи	2.06.2022	
5	Оформлення пояснювальної записки до попереднього представлення на кафедрі, консультація з нормоконтролером	3.06-7.06.2022	
6	Представлення роботи на кафедрі	08.06.2022	
7	Урахування зауважень, рекомендацій та підготовка до захисту	09.06 - 13.06.2022	
8	Захист дипломної роботи на кафедрі	14.06.2022	

7. Дата видачі завдання: «23» травня 2022 р.

Керівник дипломної роботи (проекту): _____
(підпис керівника)

Дудар Т. В.
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Завдання прийняв до виконання: _____
(підпис випускника)

Тимчишин М.А.
(П.І.Б.)

ABSTRACT

Explanatory note to thesis «Remote assessment of the Holosiivskyi forest ecosystem»: 53 pages, 29 figures, 27 references.

Object of research – remote assessment of the forest ecosystem conditions.

Aim of work – to assess the Holosiivskyi forest present day ecosystem conditions using remote sensing methods.

Methods of research: analytical, statistical, graphical, remote sensing methods - Hansen dataset, Sentinel-2 imagery, Google Earth engine.

Practical importance: remote assessment of the Holosiivskyi forest ecosystem was done by myself namely: calculation Normalized Difference Vegetation Index and analyses the historical deforestation and reforestation changes with help of Hansen dataset.

FOREST ECOSYSTEM, REMOTE ASSESSMENT, NDVI (NORMALIZED DIFFERENCE VEGETATION INDEX), SENTINEL-2, GOOGLE EARTH, GOOGLE EARTH ENGINE.

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INTRODUCTION

Relevance of the work. The modern development of urban areas has led to the formation of a special urban environment, the ecological condition of which requires constant improvement of methods of monitoring, remote assessment and assessing the effects of urbanization. The environmental crisis of the city of Kyiv, as well as various large cities has led to a revision of traditional ideas about ecosystems and the state of their main component - vegetation. The methods of research of ecological monitoring and further development of programs for leveling the problem of vegetation on the example of the Holosiivskyi Forest in the city of Kyiv should be directed to the search for ways to solve the problem of supporting the vital activity of vegetation in the environment. Greenery plays a significant role in reducing the effects of toxic substances on people, thereby improving the quality of life (improving the health of the population. Operational environmental monitoring of vegetation change on the example of the Holosiivskyi Forest in Kyiv is very important for the development of programs and methods to solve the problem of the environment in the area. The Holosiivskyi forest is a forest massif of mostly natural origin. The vegetation of the Holosiivskyi Forest is represented mainly by deciduous forests. The largest area is occupied by hornbeam-oak and hornbeam. Pure oak forests now occur in small areas [1].

Aim of the work – to assess the Holosiivskyi forest present day ecosystem conditions using remote sensing methods.

Tasks of the work:

1. To overview the concept of ecosystem and ecological problems in regard to the Holosiivskyi forest;
2. To calculate the NDVI indices for the Holosiivskyi forest different surface covering;
3. To analyze vegetation patterns historical deforestation using Hansen dataset and Google Earth image.

Object of research is remote assessment of the forest ecosystem conditions.

Subject of research is remote methods for the forest ecosystem assessment.

Methods of research – analytical, statistical, graphical, remote sensing methods - Hansen dataset, Sentinel-2 imagery, Google Earth engine

Personal contribution of the graduate: all the work was done personally by the author

Approbation of results was performed at the following conferences:

1. XVI Всеукраїнська наукова on-line конференція здобувачів вищої освіти і молодих учених з міжнародною участю «Сучасні проблеми екології» (м. Житомир, 10 квітня 2020 року).

2. Екологічна безпека держави: XIV Всеукраїнської науково-практичної конференції молодих учених і студентів, м. Київ, 23 квітня 2020 р., К.

3. 6-й Міжнародний молодіжний конгрес «Сталий розвиток: захист навколишнього середовища. Енергоощадність. Збалансоване природокористування» Львів, 09 –10 лютого 2021 року.

4. Екологічна безпека держави: XV Всеукраїнської науково-практичної конференції молодих учених і студентів, м. Київ, 22 квітня 2021 р

5. Remote detection the CO2 concentration within different land classes cover on the territory of Ukraine. European Association of Geoscientists & Engineers., Conference Proceedings, Geoinformatics, May 2021

6. Application of remote sensing data for detection the landslide areas in Ukraine., European Association of Geoscientists & Engineers., Conference Proceedings, Third EAGE Workshop on Assessment of Landslide Hazards and Impact on Communities, Sep 2021

7. Міжнародна науково-практична конференція за участю молодих науковців «ГАЛУЗЕВІ ПРОБЛЕМИ ЕКОЛОГІЧНОЇ БЕЗПЕКИ – 2021» 27 жовтня 2021, Харків

Publications:

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7. Tymchyshyn M.A., Dudar T., INVESTIGATION OF BIOGEOCHEMICAL CYCLES PECULIARITIES IN DAMAGED ECOSYSTEMS., Міжнародна науково-практична конференція за участю молодих науковців «ГАЛУЗЕВІ ПРОБЛЕМИ ЕКОЛОГІЧНОЇ БЕЗПЕКИ – 2021» 27 жовтня 2021, Харків., ISBN 978-617-619-258-9., ст. 25-27

CHAPTER 1

CHARACTERISTICS OF THE HOLOSIIVSKYI FOREST ECOSYSTEM

1.1. The concept of ecosystem

The concept of ecosystem is very important today. Without this basic knowledge, it is impossible to evaluate nature as a scientific component. An ecosystem is a system consisting of biotic and abiotic components that interact and function together as a whole. Biotic components are living nature, ie all living beings, while abiotic components are inanimate beings. The definition of ecosystem science involves ecological biotic connections and the coexistence of different species in a particular habitat. The natural sciences, such as ecology and geography, mark and represent the ecosystem as a geographical area where organisms, landscape and weather interact to form a "sphere of life" [2].

1.1.1. Biotic components (Biotic factors)

Biotic components (also known as biotic factors) are living components in any ecosystem. The ecosystem includes all living organisms as well as physicochemical components. They are also called biotic components and abiotic components. They are interconnected, interact and function together as one. Abiotic factors are chemical and physical factors and conditions such as solar radiation, water, pressure, temperature, weather, wind, various types of precipitation, and various other inanimate components of the ecosystem. Biotic factors are life, ie living components such as plants, animals, insects, birds, marine organisms, and other living things present in the ecosystem.

Biotic components - are living components or factors that affect ecosystems or other organisms that live in this ecosystem. Bacteria and viruses that cause disease act as a biotic component and can affect human health in the same way as other living organisms. population of living organisms, causing disease, especially on a large scale. Another

example is the biotic relationship between animals and plants such as predation, parasitism, commensalism, and so on. In addition to pathogenic microbes, biotic components may include various types of microorganisms.

The relationships between living organisms in an ecosystem shape its environment. In water bodies such as rivers or seas, examples of biotic components include marine life. Both biotic and abiotic components play an important role in creating unique ecosystems [3]. Also, the interaction between biotic and abiotic components as an example - produces photosynthesis which provides oxygen for all living things on earth.

Types of Biotic Factors

1. Producers (Autotrophs)
2. Consumers (heterotrophs)
3. Decomposers (detritivores)

Producers (Autotrophs)

Through the process of photosynthesis involving light energy, an autotrophic organism can produce complex organic compounds using inorganic molecules. Also for the production of complex organic compounds using inorganic molecules can be achieved through the use of chemical energy also known as chemosynthesis.

Since producers are at the first trophic level of the food chain, they serve as a source of food for consumers or for higher trophic levels. Producers produce organic compounds from atmospheric carbon dioxide. Everything living on earth directly or tangentially depends on the producers, they are the basis of the food chain. An example is algae in aquatic ecosystems, as well as plants in terrestrial ecosystems. Producers are able to produce their own food. Primary producers are those who are able to produce their own food through photosynthesis. Photosynthesis is a process of synthesis between plants that absorb the abiotic component (sunlight) and when they interact, the products of synthesis are oxygen as a by-product. In other cases, producers can also produce their own food through chemosynthesis [4].

Consumers (heterotrophs)

Consumers or heterotrophs are organisms that usually receive food by eating other organisms or organic matter due to the inability to produce their own food from inorganic

sources.

At most levels of the food chain there are heterotrophs, in addition to producers and decomposers. Consumers are called heterotrophs because they are producers of the food chain. Thus heterotrophs are heterotrophic bacteria and fungi, as well as various species of animals. Some plants are heterotrophs and therefore consume organic matter, so they are both producers and consumers.

In the trophic chain, consumer levels are primary consumers, secondary and tertiary consumers. Herbivores are the main consumers, but those that feed on producers. Secondary consumers are consumers fed by primary consumers and / or producers. Tertiary consumers are consumers that feed on secondary and primary consumers, as well as producers [5].

Decomposers (detritivores)

Decomposers are organisms that decompose the organic remains of a dead organism. Decomposition is the process of breaking down complex organic matter into a simpler form.

Types of decomposers:

Fungi

Insects

Earthworms

Bacteria [6].

1.1.2. Abiotic components (Abiotic factors)

Abiotic components, or abiotic factors, are not living components, they can be natural phenomena, conditions, physical phenomena, they affect the functioning of organisms and ecosystems. Abiotic factors can be: pressure, humidity, solar radiation, weather, temperature, availability of nutrients. There are certain microorganisms that are able to live in abiotic living conditions [7].

1.2. Components of the ecosystem of the Holosiivskyi forest

Holosiivsky Forest is a unique ecosystem located in the city, in a metropolis where more than one million people live. Diverse flora and fauna. Unforgettable natural beauty. Historical monuments and rich recreational opportunities. The cost of ecosystem services provided by Holosiivskyi Forest is very high. Because ecosystem services are all the benefits that nature gives to man valued in dollar terms.

1.2.1. Trees and other plants communities

Due to the specifics of physical and geographical conditions of Goloseev forest, the general nature of the park's vegetation is due to its location on the border of forest-steppe and forest zones of Ukraine, both on the Kiev forest plateau and in the Dnieper river valley. The vegetation of the park can be divided into two parts: northern and southern.

The northern part is characterized by a valley-beam and ravine relief, which is located on the Kiev forest plateau. The soil cover is mainly made up of gray forest soils, but also a small area is occupied by meadow-swamp, sod-podzolic and sod soils.

The landscape of this part of the territory includes: slopes of ravines and gullies, plateau-like areas, inter-slope depressions, sometimes with pond complexes created on the site of small dammed watercourses. Oak forests mainly grow in this part of the territory. Currently, a large area is occupied by oak-hornbeam and their derived hornbeam forests with the participation of Central European species in wood and grass cover due to the expansion of hornbeam. There are a lot of clean oak plots left in this part of the territory. Alder, aspen, oak, pine and some other species also grow in the northern part of the Holosiivsky Forest.

A number of groups are oak-hornbeam forests, among which are predominant: hairy, starfish, coniferous and butterbur (with fragrant butterbur) oaks. Common vegetable and ungulate groups, also common on the slopes - rare and alder-legged species. All these species suffer from the effects of recreation. Rooting of weeds and introductory plants into natural cenoses is observed in the northern part of Holosiivsky Forest. In the oak-hornbeam

and hornbeam forests of this part of the park, a sinus of spring ephemeroids with a predominance of anemone anemones, hollow anemone, compacted rust, compacted rust, occasionally tuberous toothed, spring wheat, and glandular is well detected. some rare species in the forests of this part of the park have become widespread, the population density of which is declining due to human influence.

In the southern part of the Holosiivskyi forest there is an massif that stretches along the Dnieper floodplain in the direction of the southeast. Lisnyky tract, on the area of 1110.2 hectares created a botanical reserve of national importance occupies the northern part. Pine forests are terrestrial, lichen in a complex with oak-pine forests, thyme, which are located on elevated areas in the depressions - lily of the valley and eagle pine forests. Deciduous forests with a predominance of ash, oak, aspen and maple, where they are distributed in low leveled areas.

Oak with ash and maple are the most typical in the southern part of Holosiivsky forest. In autumn, the groups with a predominance in the grass layer of yeast (bear's onion), listed in the Red Book of Ukraine, are well identified. These groups are also included in the Green Book of Ukraine.

Raw alder forests (nettle, blackberry) and alder swamps with sharp sedge occupy the lowest areas in the reserve. Aquatic vegetation on the lakes Shaparnya, contains a rare group of salvinia floating and water fern. The southern part of the Lisnyky tract is not part of the park. The location of the Lisnyky tract is outside the lands subordinated to Kyiv [8].

In the National Nature Park, work is underway to inventory the species of flora. The northern part of the Forest-Steppe is the most studied. In the northern part of the Forest-Steppe, according to the materials of the park, there are 752 species of higher vascular plants of natural flora, 155 species of mosses and 150 cultivated species without natural regeneration. 40 species are from the Red Book of Ukraine according to herbarium, literary and modern research, of which the habitat of 29 species has been confirmed at the present stage. More than 70 species of regionally rare species are listed [9].

Also, for example, some species of plants found in the Holosiivskyi National Park will be demonstrated:

Hellebore (Epipactis helleborine).



Fig. 1.1. Hellebore (*Epipactis helleborine*).

Epipactis helleborine (Fig. 1.1.) is the most common species of the genus in Holiivskyi National Nature Park. This is due to the wide range of ecological conditions in which *Epipactis helleborine* grows in contrast to other orchid species. This species may well withstand the moderate effects of anthropogenic loads.

Epipactis helleborine can be found singly throughout the Holiivskyi National Park, but *Epipactis helleborine* has the largest numbers and livestock in areas with the lowest anthropogenic recreational load, namely on forested islands in the swampy valley of the Vita River in the southern part of the park. It is estimated that approximately 70 specimens of *Epipactis helleborine* were identified in early July. The flowering period of *Epipactis helleborine* is almost all summer.

Epipactis helleborine is a tall orchid, its height can reach 80 cm in length. It is rich in broad ovate leaves of greenish-purple color with well-marked arcuate veins, as well as numerous flowers gathered in a dense bouquet. The stem with the fruits of *Epipactis helleborine* can be seen when the plant blooms, until late autumn [10].

Pulsatilla pratensis

A plant 10-30 cm tall with a thick rhizome and basal leaves, which is a perennial herbaceous plant - *Pulsatilla pratensis* (Fig. 1.2.). Flowering stalk with a veil of green, fused

at the base of the leaves, has single flowers at the top. The flower is hanging, dark purple, bell-shaped, blooms before the leaves bloom in April-May. Leaves appear after flowering. They are collected at the stem in a basal rosette. Fluffy fruitlets consist of many achenes. *Pulsatilla pratensis* is common in Ukraine in most regions, mainly on meadow-steppe and steppe slopes, as well as in pine forests.



Fig. 1.2. *Pulsatilla pratensis*

In the National Natural Park Golosivsky *Pulsatilla pratensis* increased significantly less, the lower representative of birth. Roslina grows in the main foxes in the open parts of the NPP and the Svyatoshinsky-Belichansky massif, especially loves open cuts, knots and young plantings. *Pulsatilla pratensis* is listed in the Red Book of Ukraine [11].

1.2.2. Water bodies

The territory of the Holiivskyi National Nature Park belongs to the Dnieper River basin.

The hydrographic network of the Holiivskyi National Nature Park consists mainly of small rivers of the Irpin River basin - Koturka, Nyvka, Lyubka, a tributary of the Dnieper

Vita (with Shaparnya Lake), Holiivskyi forest streams with cascades of ponds - Holiivskyi, Kitaiivskyi, Gori. Numerous temporary watercourses drain the Holiivskyi National Nature Park, which has an active current only during summer and autumn heavy rains and snowmelt. Snowmelt and summer-autumn heavy rains are tied to the central part of the park, which is characterized by an extensive system of ravines and dissected relief. Three cascades of ponds have been created on the territory of Holiivsky Forest. They are located in the valleys of streams.



Fig. 1.3. Lake Didorivka

There is a five-pole Orikhovatsky cascade in Holiivskyi Park. The first from the west to the east pond is the smallest (0.16 ha). The area of the next three is about 1 hectare. The largest pond with an area of 2.3 hectares is located near Holiivska Square. Floating water nut included in the Red Book of Ukraine grows on one of the ponds of the cascade. Floating water nut and yellow pitcher formations included in the Green Book of Ukraine are also noted on this reservoir. The arrow-leaf arrowhead included in the Green Book of Ukraine is found on the banks of the Orikhovatsky watercourse.

In the central part of the Holiivsky Forest is the Holiivsky Cascade of 5 ponds. The name Didorivka (Fig. 1.3.) has the first (upper) stage of the cascade. Its area is 2.6

hectares. The recreational zone of the Holiivskyi National Nature Park is equipped here. The other three ponds (1.0 ha, 2.3 ha, 3.6 ha) are located downstream and are separated only by dams. On the Didorovsky stream downstream there is another pond on the border of Holiivsky forest with low-rise buildings. On the northern shore of one of the ponds of the cascade - Mitkin - one of the springs is declared a hydrological natural monument of local significance Holy Healing Spring.

In the eastern part of the Holiivsky Forest is the Kytayivs'kyi Cascade (Fig. 1.4.). The territory of the Holy Trinity Monastery is located north of the cascade. Post office ponds of the Kytayivs'kyi Cascade - from 1 to 1.6 hectares. The Upper Lake has been declared a hydrological natural monument of local significance.



Fig. 1.4. Verkhniy Kytayivs'kyi stav

Vita is the largest river in the southern part of Holiivskyi National Nature Park. Its length - about 14 km, flows into the Dnieper near the island of Zhukov. Together with the Vita (or Siverka) stream, the length of the river is 30 km. Its basin area is the largest of the small rivers of Kyiv, such as Nyvka, Darnytsia, Gorenka and others, and is 244 km².

The beginning of the Vita River is located at the level of the Dnieper floodplains. This

results in a very low flow rate. It also causes significant wetlands in the valley.

Lake Shaparnya (Fig. 1.5.) is the largest body of water in the Goloseevsky National Natural Park and is located in the Vita River basin. Lake Shaparnya has a semi-artificial origin. Lake Shaparnya is about 30 hectares in size. Within the boundaries of the Lesniki tract, there is a swampy basin of the Vita River and Lake Shaparnya. Ecosystems close to natural have been preserved here, the greatest variety of landscapes is observed and the largest number of species and plants from the Red Book of Ukraine is found. In the lake basin of Shaparnia there are groups from the Green Book of Ukraine - *Salvinia* floating, water lily, snow-white water lily [12].



Fig. 1.5. Lake Shaparnya

1.2.3. Soils

On the territory of the Park the ground cover is quite pinnate. Soils on the territory of Holiivskyi National Park have undergone significant changes due to intensive anthropogenic factors and impacts on areas of permanent intact soil cover. This cover is preserved only in the forest-park zone of Holiivskyi National Park.

There are no significant differences in the state of soil formation factors on the territory of Holiivskyi National Park due to climatic reasons. The nature of sedimentary

rocks is quite important for better soil formation. Sedimentary rocks make up the surface, the nature of vegetation, as well as the relief of the surface.

On the border of three natural regions: the outskirts of the Dnieper Upland, the Dnieper Lowland, the Polissya Lowland is the Hosiivsky National Nature Park. The closest location of the park to these natural regions has led to the existence of three groups of soil cover with many of their differences.

In the conditions of positive balance of moisture on forest and forest-like loams, on the most part of the territory of the Park, soils were formed, they contain a significant amount of calcium carbonate. Also served on sandy pine terraces.

Sod-podzolic soils are widespread in the southern part of Hosiivskyi National Park. They are common on the first floodplain terrace of the Dnieper under pine and pine-oak forests. Hidden-podzolic soils are found on sandy hills.

Light gray forest soils, gray forest soils, predominate in the northern part of Hosiivsky Forest under the canopy of oak and hornbeam forests. Also on elevated areas of the plateau and in the upper parts of the slopes of the beams. Light gray forest soils were formed in places with poorly developed grass cover. They are characterized by lower thickness of the humus horizon (20-22 cm), the presence of a continuous eluvial layer, high density of the illuvial horizon. gray forest soils cover watersheds. These soils contain a small amount of humus (1.5-2.5%), the depth of the humus horizon does not exceed 32-38 cm, well-defined illuvial horizon, deep boiling line (130-160 cm), have an acidic reaction, small reserves of nutrients substances. These two groups are quite suitable for fruit and berry plantations, they are combined into one agricultural group.

Undeformed sands that are subject to deflation and need afforestation are found in the Chapaivka area.

Meadow soils and sod soils are often found in floodplains. In the riparian parts of the floodplains, sod soils predominate. Meadow soils are found in the central and, in part, terraced parts of the floodplains.

Meadow soils are formed on a loamy basis. In terms of humus content (3-6%) meadow soils exceed turf soils. Turf and meadow soils are used on the farm and this is usually limited to pastures and hayfields.

Meadow-chnozem soils are found in lake-like depressions. Meadow-chnozem soils have a significant content of humus (3-6%). Meadow-chnozem soils are suitable for efficient agricultural use [8].

1.3. Ecological problems of the Holsiivskiy forest

Holsiivskiy Forest is a unique ecosystem, a forest in the city. He is being cared for, as will be seen in the second chapter. Where from 2001 to 2018 (sampling time), it was preserved and there is only some deforestation. Among the main reasons are global warming, which is affecting forests around the world due to rapid industrialization. There have been many large-scale fires in the world in the last decade, killing many species of plants and animals. As for the Goloseyevsky forest, he was more fortunate than the forests of the Amazon and Australia. The staff of the Holsiivskiy forest adheres to all norms and tries to do everything necessary to further mitigate the negative impacts on the Holsiivskiy forest ecosystem. However, we should not forget about invasive plant species that are not typical for this region, for example, we can take the plant Sosnowski's hogweed (*Heracleum sosnowskyi* Manden) (Fig 1.6.).



Fig. 1.6. Sosnowski's hogweed (*Heracleum sosnowskyi* Manden)

Sosnowski's hogweed is a relict and well-adapted to survival but alien to Ukraine

plant originating from the Caucasus [13]. Is a toxic plant that causes skin burns in humans. It spreads very quickly. It is dangerous for people and thus an environmental problem.

There is also a problem of radiation nature [14-15], namely through the state specialized enterprise "Radon Association", because this enterprise is located near the Holosiivskyi National Nature Park.

Among the tasks of this enterprise is the collection and temporary storage of radioactive materials, but as noted: minimizing the likelihood of adverse effects of radioactive materials temporarily stored at the Enterprise, the environment and personnel [16]. But this is very dangerous, especially in today's conditions, namely because of Russia's military aggression against Ukraine.

1.4. Conclusions to Chapter 1

As a result of overview of the Holosiivsky forest ecosystem I can summarise the following. The concept of ecosystem is very important today. An ecosystem is a system consisting of biotic and abiotic components that interact and function together as a whole [17]. The Holosiivskyi forest ecosystem is special because of diverse vegetation cover, special water bodies. There is a five-pole Orikhovatsky cascade in Holosiivskyi Park. The arrow-leaf arrowhead included in the Green Book of Ukraine is found on the banks of the Orikhovatsky watercourse. The beginning of the Vita River is located at the level of the Dnieper floodplains. This results in a very low flow rate. It also causes significant wetlands in the valley. Species effects are consistent with climate impact, resource availability and disturbance regimes, affecting ecosystem properties.

About ecological problems of the Holosiivskyi forest we can say that the staff of the Holosiivskyi forest adheres to all norms and tries to do everything necessary to further mitigate the negative impacts on the Holosiivskyi forest ecosystem and there is also a problem of radiation nature, namely through the state specialized enterprise "Radon Association", because this enterprise is located near the Holosiivskyi National Nature Park, it is very dangerous, especially in today's conditions, namely because of Russia's military aggression against Ukraine.

CHAPTER 2

REMOTE ASSESSMENT OF THE HOLOSIIVSKYI FOREST ECOSYSTEM

2.1. Research methods

In this thesis we used two software to decrypt images, namely Google Earth software and online Google Earth Engine software. As well as the use of the SENTINEL-2 satellite and the 'THE' Hansen dataset.

Google Earth

Google Earth is a Google project in which satellite (or at some points aerial photographs) images of the entire earth's surface were placed on the Internet. Photos of some regions have an unprecedented high resolution [18-19].

Google Earth Engine

Google Earth Engine is a geospatial data service. With Earth Engine, you can perform large scale geospatial processing powered by Google Cloud Platform. The goal of Earth Engine is:

- To provide an interactive platform for the development of geospatial algorithms at scale
- Delivering high-impact data-driven science
- Achieve significant progress in solving global problems associated with large geospatial data sets [20].

SENTINEL-2

The European Space Agency's family of remote sensing satellites, created as part of the Copernicus Global Environment and Security Monitoring Project. Satellites designed to monitor the use of land, vegetation, forest and water resources, can also be used in disaster management [21-22].

'THE' Hansen dataset

The Hansen et al. (2013) Global Forest Change dataset in Earth Engine represents forest change, at 30 meters resolution, globally, between 2000 and 2014. Since then, the

product is updated annually [23-24].

2.2. Remote assessment of the forest ecosystem. Practical Part

2.2.1. Searching for and importing cloud-free Sentinel-2 imagery

a) Open up the GEE interface

Open Google Earth Engine by going to this address in the Chrome browser:

<https://code.earthengine.google.com>

b) Define your area of interest (Holosiivskyi National Nature Park)

With the help of geometry tools, the name of the point "campus" of Holosiivskyi National Nature Park was created. After creating a geometry point, you will see it added to the Encoding panel as a variable (var) under the Import (Image) heading.

The resulting point was renamed "campus" by clicking the name of the import (which by default is called "geometry") (Fig. 2.1.).

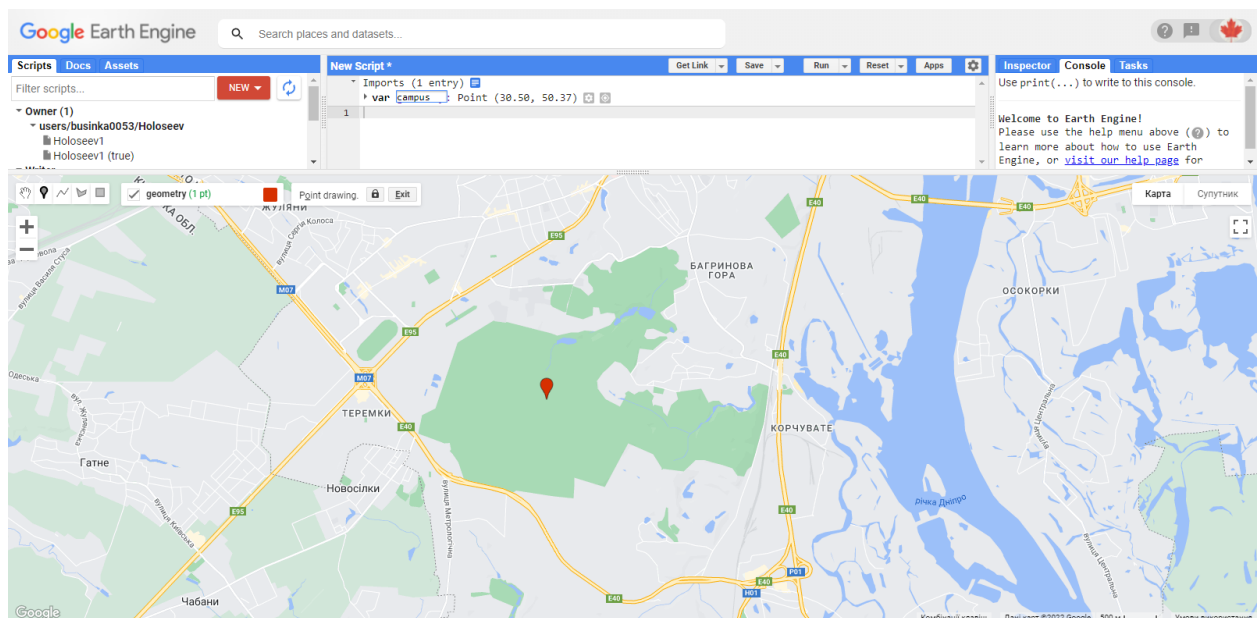


Fig. 2.1. Renamed "campus" from default "geometry"

c) Queried the archive for Sentinel-2 imagery

The search bar looked for "Sentinel-2". In the results section we see "Sentinel-2: Multi-spectral Instrument (MSI), Level-1C" - click on it and then click "Import". (Fig. 2.2.).

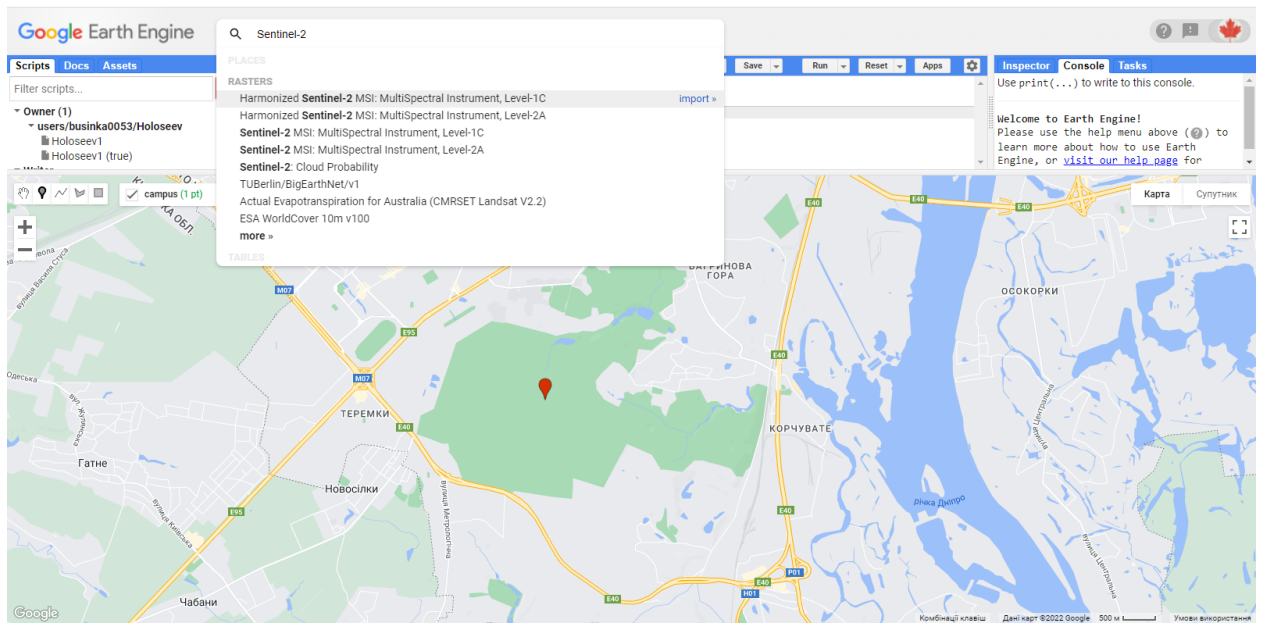


Fig. 2.2. The search bar looked for "Sentinel-2"

After clicking the "Import" button Sentinel-2 will be added to our Import in the "Encoding" panel as a variable. It will be listed under our campus geometry point with the default "imageCollection". It was renamed to "sent2" by clicking on imageCollection and entering "sent2" (Fig. 2.3.).

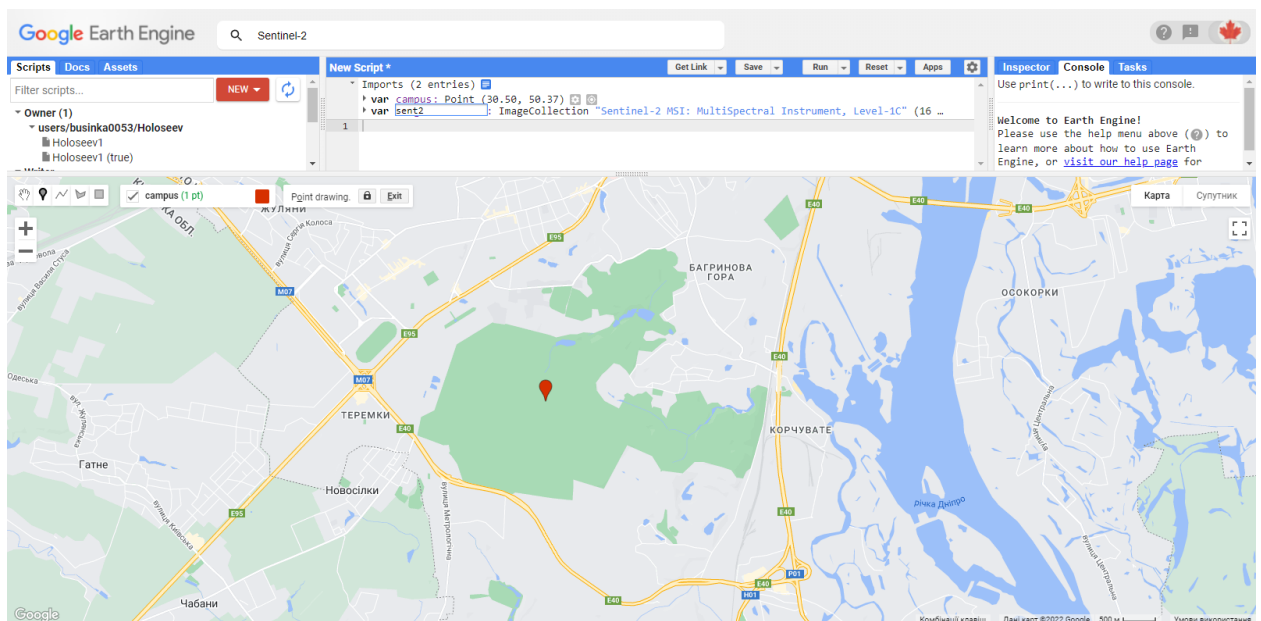


Fig. 2.3. Renamed field of name to "sent2"

It is important to understand that our script now has access to the complete collection of Sentinel-2 images (that is, to each image collected to date). We do not want to download

all these images for this work - we want the only free image over Holosiivsky National Nature Park. Thus, we can now filter the image collection by several criteria, such as time received, spatial location, and cloudiness.

d) Filtering image collections

To achieve this, we used some coding. In the JavaScript programming language, two backslashes (//) point to comment lines and are ignored at the actual processing stages. We used // to write notes in our code so that we (and others who might want to use our code) could understand why we did certain things.

// This is our first line of code. Let's define the image collection we are working with by writing this command

```
var image = ee.Image(sent2
```

// We will then include a filter to get only images in the date range we are interested in

```
.filterDate("2020-07-01", "2021-09-30")
```

// Next we include a geographic filter to narrow the search to images at the location of our point

```
.filterBounds-campus)
```

// Next we will also sort the collection by a metadata property, in our case cloud cover is a very useful one

```
.sort("CLOUD_COVERAGE_ASSESSMENT")
```

// Now lets select the first image out of this collection - i.e. the most cloud free image in the date range

```
.first());
```

```
// And let's print the image to the console.
```

```
print("A Sentinel-2 scene:", image);
```

The entire code snippet above was copied and pasted into the GEE Code Editor's New Script field. Then click "Run".

This code snippet will search the entire Sentinel-2 archive, find images above the Holosiivsky National Nature Park, sort them according to the percentage of clouds, and then

return the latest free image. Information related to this image will be printed on the console, where it will be listed as "Scene 2" with some details about this scene (Fig. 2.4.).

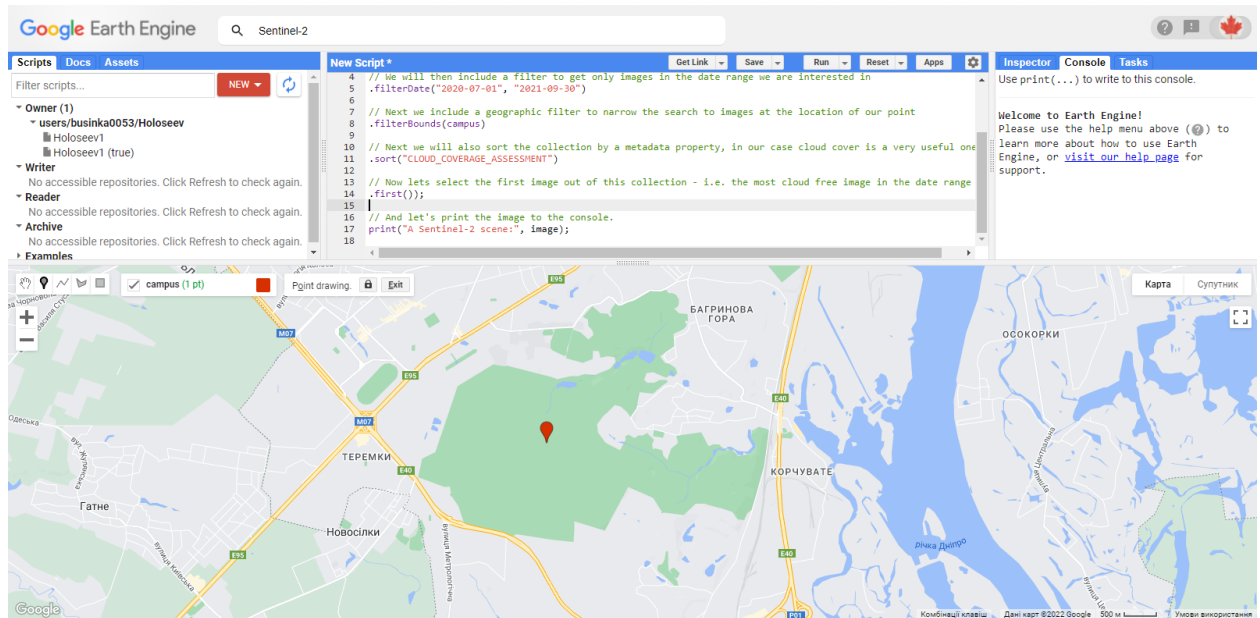


Fig. 2.4. Code snippet

2.2.2. Adding images to the map view

Now, to really see this image, we need to add it to our display medium. It was determined how we wanted to display the image. It started with a true color presentation, inserting the following lines under the ones we've already added, and clicking "Run."

a) Defining true-colour visualisation parameters

// Define visualization parameters in a JavaScript dictionary for true colour rendering.

Bands 4,3 and 2 needed for RGB.

```

var trueColour = {
  bands: ["B4", "B3", "B2"],
  min: 0,
  max: 3000
};

```

// Add the image to the map, using the visualization parameters.

```
Map.addLayer(image, trueColour, "True-colour image");
```

This code specifies that bands 4, 3, and 2 must be used in composite RGB for true

color images. After the appearance of the image on the map, Holoziivskyi National Nature Park was enlarged and explored.

b) Exploring imagery

We see great detail in the image of the Sentinel-2, which has a resolution of 10 m for selected ranges. The (+) and (-) symbols in the upper left corner of the map can be used to zoom in and out (also possible with the scroll wheel / mouse trackpad). Clicking the left mouse button brings up the "hand" to pan to move around the image. Hovering the "Layers" button in the upper right corner of the map panel shows that you can see the available layers, and allows you to adjust the opacity of different layers (Fig. 2.5.).

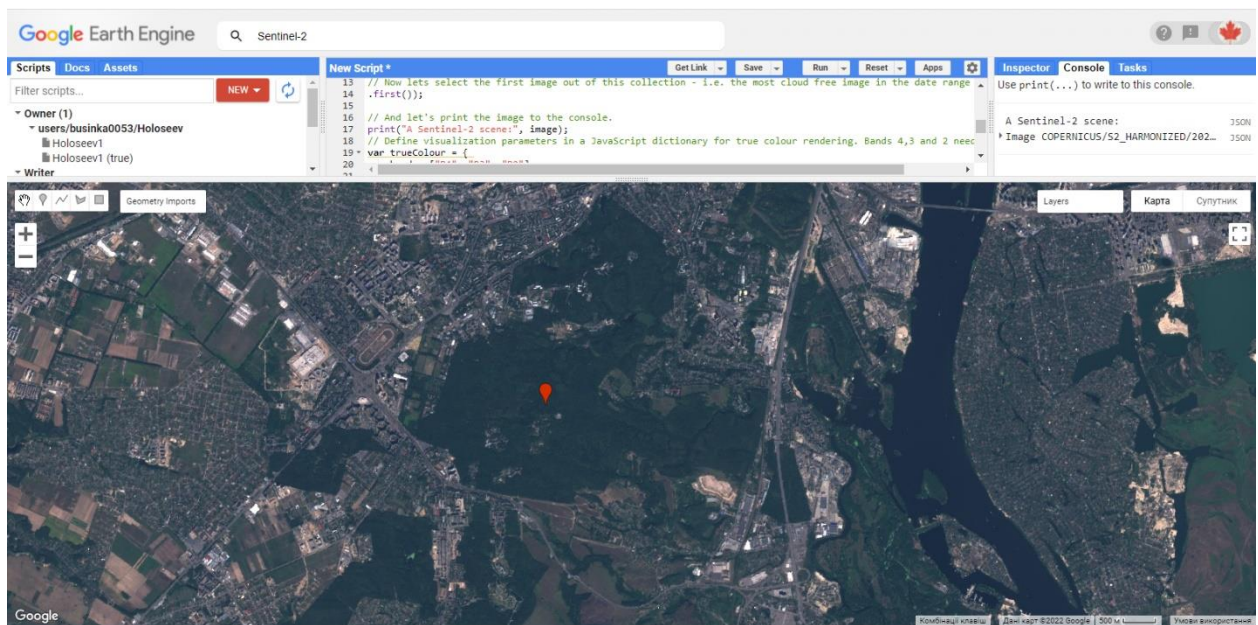


Fig. 2.5. Exploring imagery

To find out more information in certain places, we can use the tool "Inspector", which is located on the console panel - tab on the left. Click the Inspector tab, then click on the image on the map. Wherever you click the image, the range values at that point will be displayed in the Inspector window. Click on several different spot types (sports fields, mangrove forests, ocean, beach, houses) to see how the spectral profile changes.

c) Defining false-colour visualisation parameters

We looked at a false color composite - for this we needed to turn on the near infrared range (band 8). The following lines have been inserted under the ones you have already added and "Run" has been clicked.

```
//Define false-colour visualization parameters.
var falseColour = {
  bands: ["B8", "B4", "B3"],
  min: 0,
  max: 3000
};
// Add the image to the map, using the visualisation parameters.
Map.addLayer(image, falseColour, "False-colour composite");
```

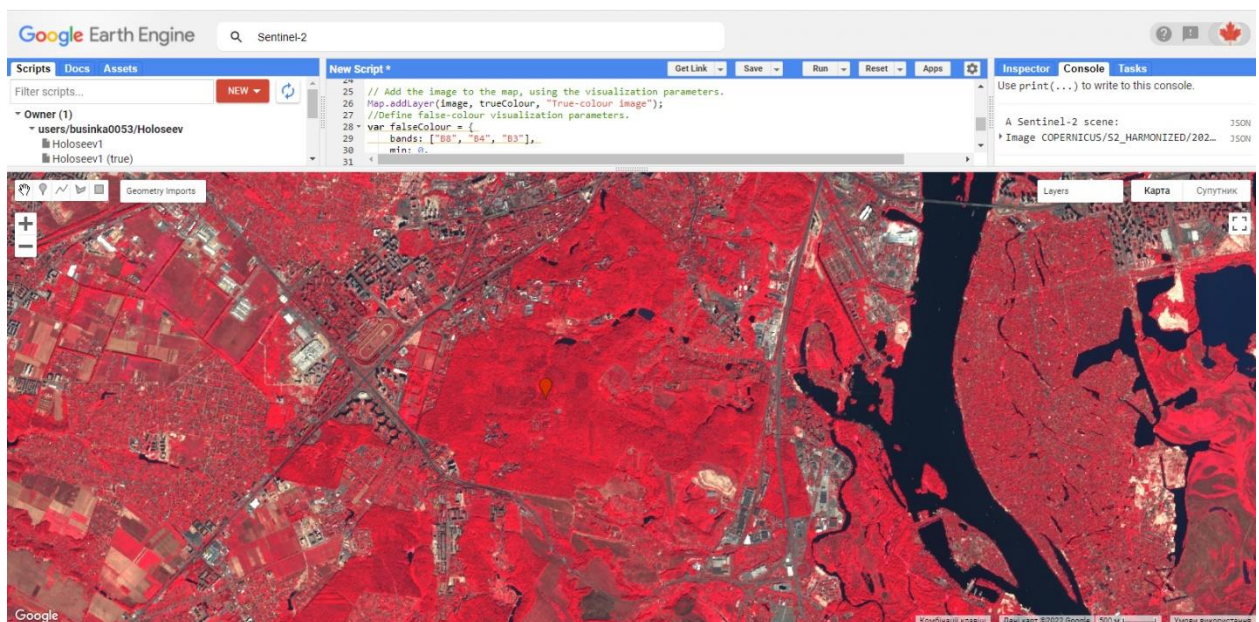


Fig. 2.6. False-colour visualisation parameters

False-colour composites place the near infra-red band in the red channel, and we see a strong response to the chlorophyll content in green leaves. Vegetation that appears dark green in true colour, appearing bright red in the false-colour (Fig. 2.6.).

2.2.3. Deriving indices from band combinations (NDVI)

Normalized Differential Vegetation Index (NDVI) is a simple quantitative indicator of the amount of photosynthetic active biomass (commonly referred to as the vegetation index). One of the most common and used indices to solve problems that use quantitative estimates of vegetation.

Calculated by the following formula:

$$\text{NDVI} = (\text{NIR} - \text{RED}) / (\text{NIR} + \text{RED}) \quad (2.1)$$

Where

NIR - 760-900 nm, reflective infrared region of the spectrum,

Red - 630-690 nm, visible red region of the spectrum.

According to this formula, the vegetation density (NDVI) at a certain point in the image is equal to the difference between the intensities of reflected light in the visible and infrared range divided by the sum of their intensities. The calculation of NDVI is based on the two most stable (independent of other factors) parts of the spectral curve of vascular plants. In the visible region of the spectrum (0.4-0.7 μm) is the maximum absorption of solar radiation by chlorophyll of higher vascular plants, and in the infrared region (0.7-1.0 μm) is the region of maximum reflection of cellular structures of the leaf. That is, high photosynthetic activity (usually associated with dense vegetation) leads to less reflection in the visible region of the spectrum and more in the infrared. The ratio of these indicators to each other allows you to clearly separate and analyze plants from other natural objects [25-26].

Paste the following lines below the ones you've already added, and click "Run" (Fig. 2.7.).

```
//Define variable NDVI from equation
var NDVI = image.expression(
  "(NIR - RED) / (NIR + RED)",
  {
    RED: image.select("B4"), // RED
```



```

NIR: image.select("B8"), // NIR
BLUE: image.select("B2") // BLUE
});
Map.addLayer(NDVI, {min: 0, max: 1}, "NDVI");

```

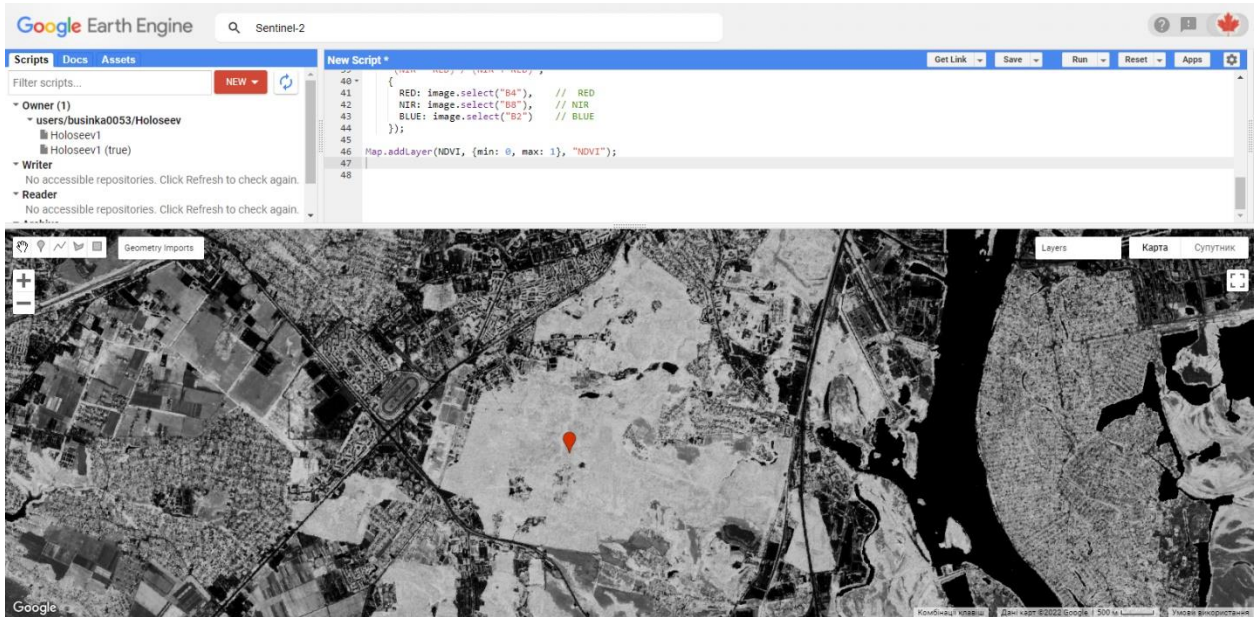


Fig. 2.7. NDVI calculation

NDVI values range from 0 to 1, and the higher the value the more "vigorous" the vegetation. We can make a better interpretation of the results map of NDVI by defining a colour palette to use instead of black>white (Fig. 2.8.).

```

Map.addLayer(NDVI, {min: 0, max: 1, palette: ['brown', 'yellow', 'green']}, "NDVI
colour");

```

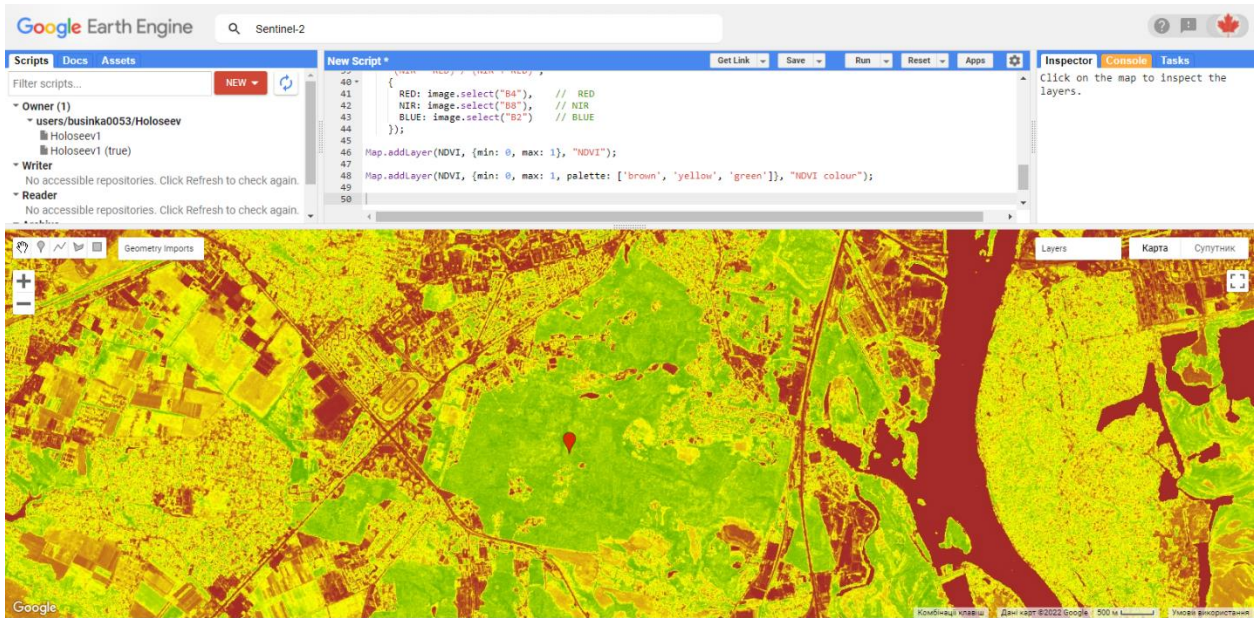


Fig. 2.8. Different colour palette instead of black>white

Next, we determine the NDVI index for forests, artificial surfaces, and water bodies.

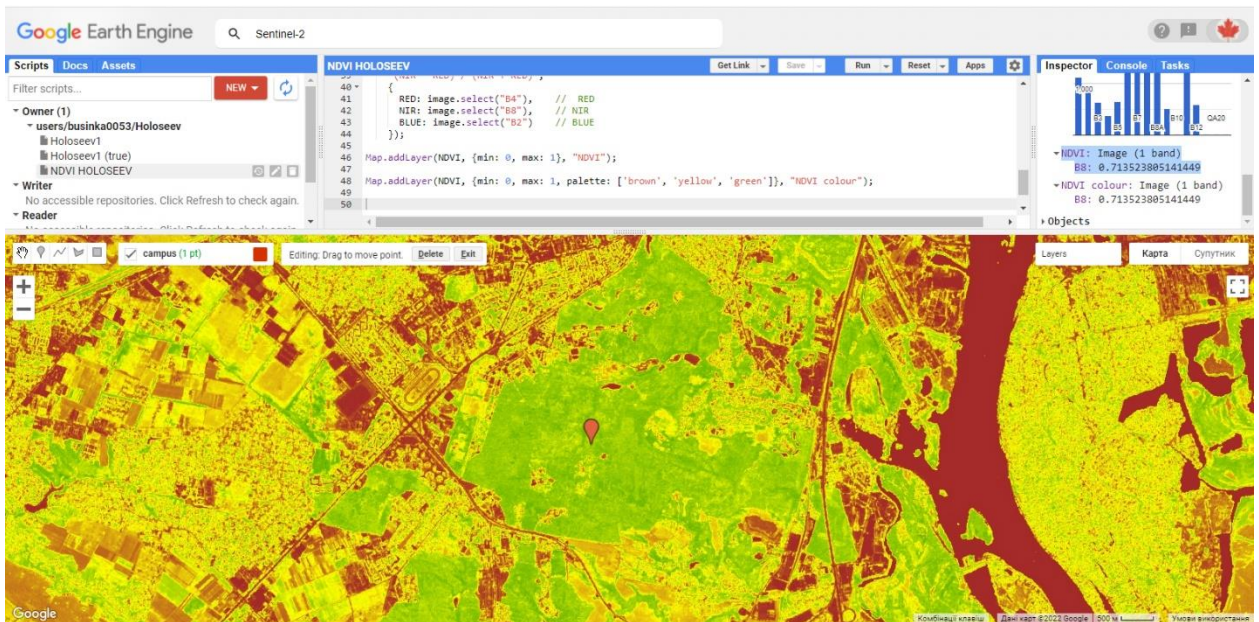


Fig. 2.9. Index NDVI of “forest” surface

Forest surface NDVI: Image (1 band)

B8: 0.713523805141449 (Fig. 2.9.)

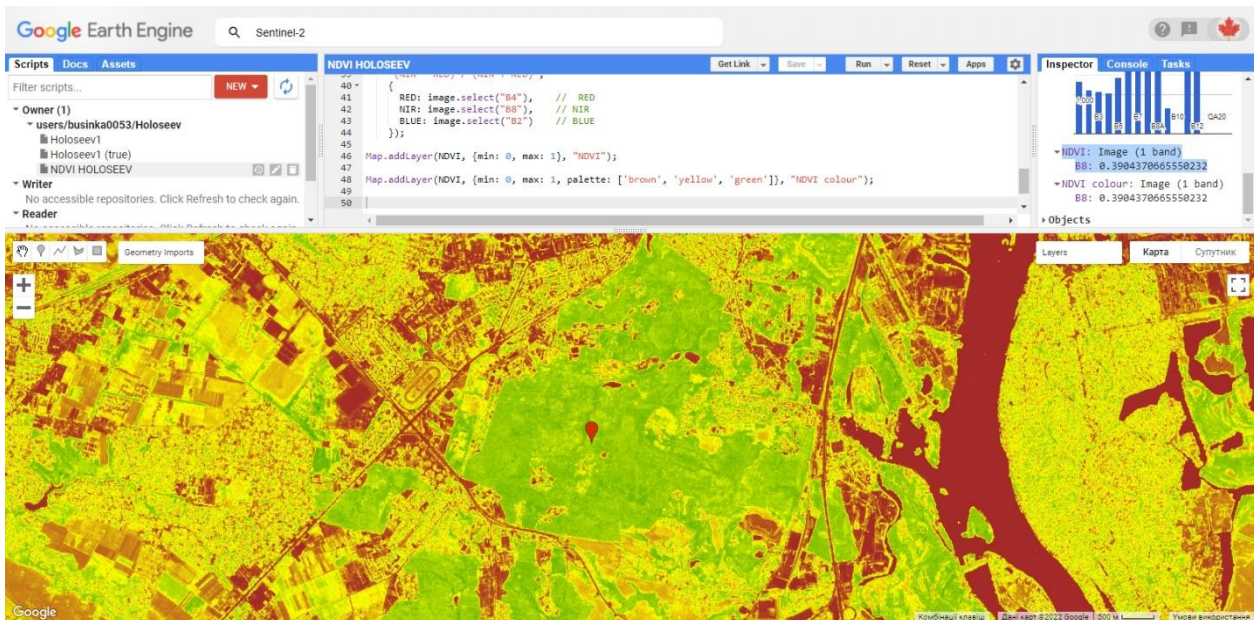


Fig. 2.10. Index NDVI for Artificial surface

Artificial surface NDVI: Image (1 band)

B8: 0.3904370665550232 (Fig. 2.10.).

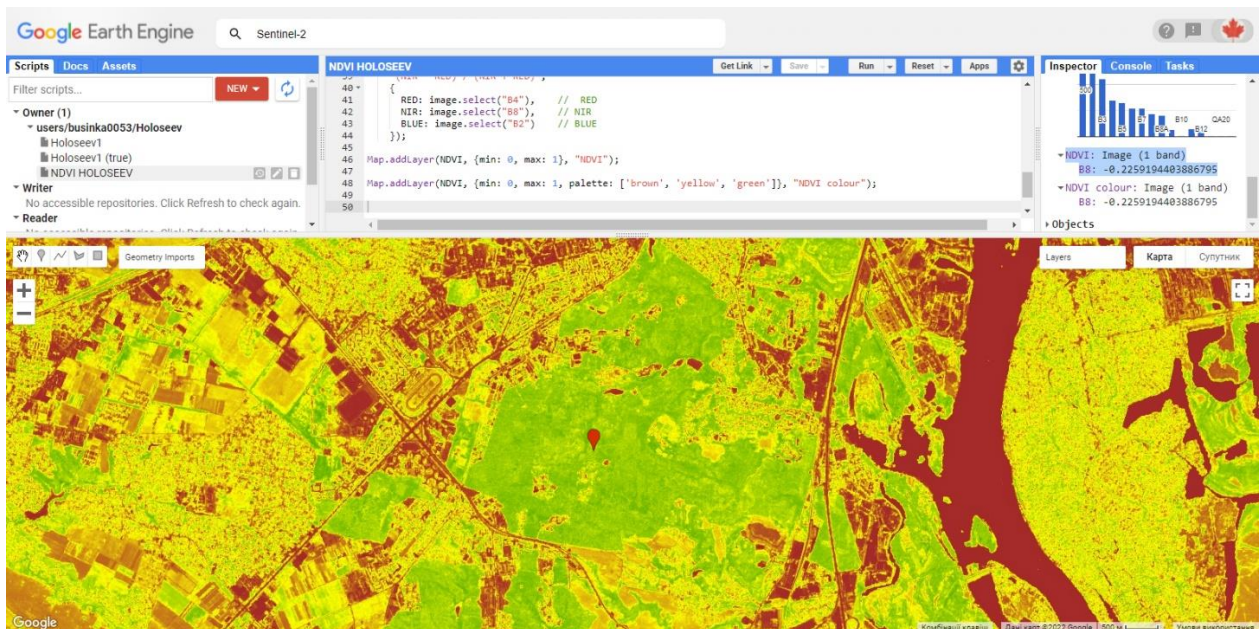


Fig. 2.11. Index NDVI for Water surface

Water Surface NDVI: Image (1 band)

B8: -0.2259194403886795 (Fig. 2.11.).

In this first part of practical part in second part of diploma we use Java scripts [27].

2.2.4. Working with 'THE' Hansen dataset

We started by adding the 2018 update Hansen et al. to the map. We have copied the following code into a code editor:

```
var gfc2018 = ee.Image('UMD/hansen/global_forest_change_2018_v1_6');  
Map.addLayer(gfc2018);
```



Fig. 2.12. Multi-band image with red, green, and blue, respectively

When a multi-band image is added to the map, the first three bars of the image are selected as red, green, and blue, respectively, and stretched according to the data type of each bar. Our image will look red, because the first three stripes are treecover2000, loss and profit. The band treecover2000 is expressed as a percentage and has values much higher than the loss (green) and gain (blue), which are binary ($\{0, 1\}$). Therefore, the image is displayed mostly red (Fig. 2.12.).

a) Next, we mapped the forest cover in 2000 as a grayscale image, we used the treecover2000 range specified in the second Map.addLayer () argument (Fig. 2.13.):

```
Map.addLayer(gfc2018, {bands: ['treecover2000']}, 'Tree cover in 2000');
```



Fig. 2.13. Forest cover in 2000 as a grayscale image

b) We showed the forest cover in 2018 as a composite RGB image, we used bands 5, 4 and 3 (Fig. 2.14.). We used the script:

```
Map.addLayer(gfc2018, {bands: ['last_b50', 'last_b40', 'last_b30']}, 'False colour');
```



Fig. 2.14. Forest cover in 2018 as a composite RGB image

c) Another visualization of the Global Forest Change dataset shows the forest area in 2000 in green, the loss of forest in red, and the increase in forest in blue. In particular, we will lose the first band (red), treecover2000 the second band (green) and get the third band (blue): We used script for green color:

```
Map.addLayer(gfc2018, {bands: ['loss', 'treecover2000', 'gain']}, 'Green');
```

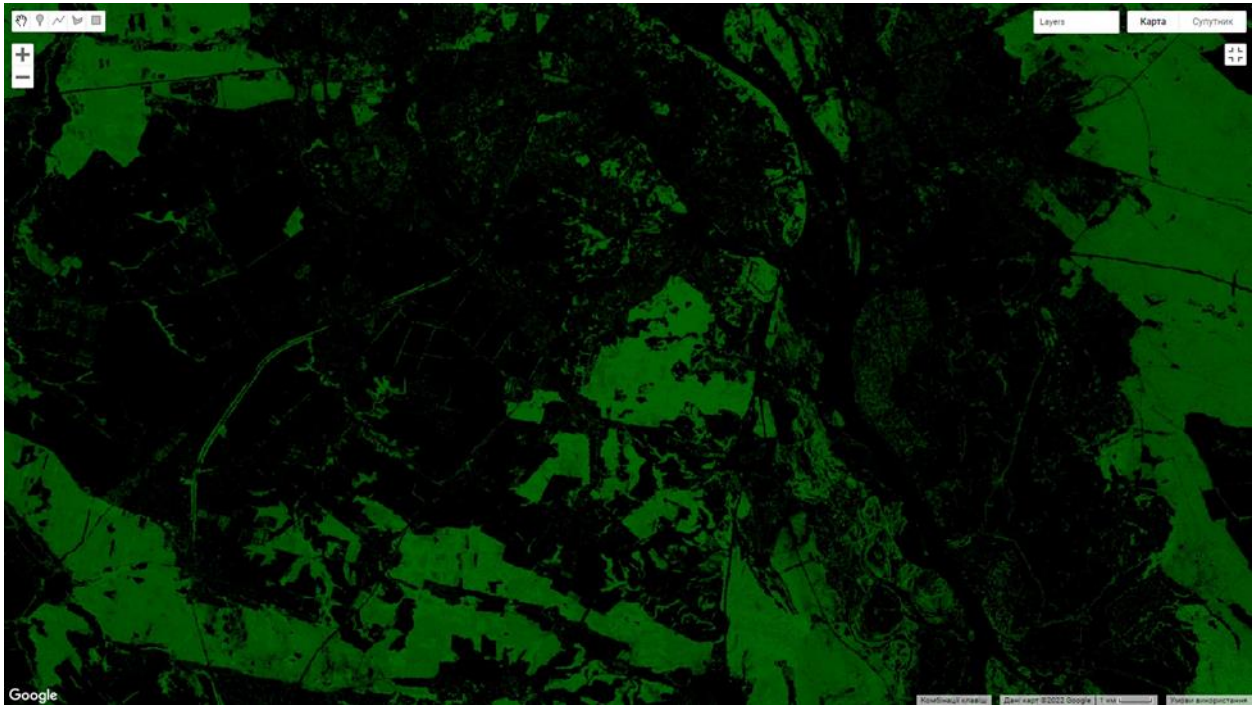
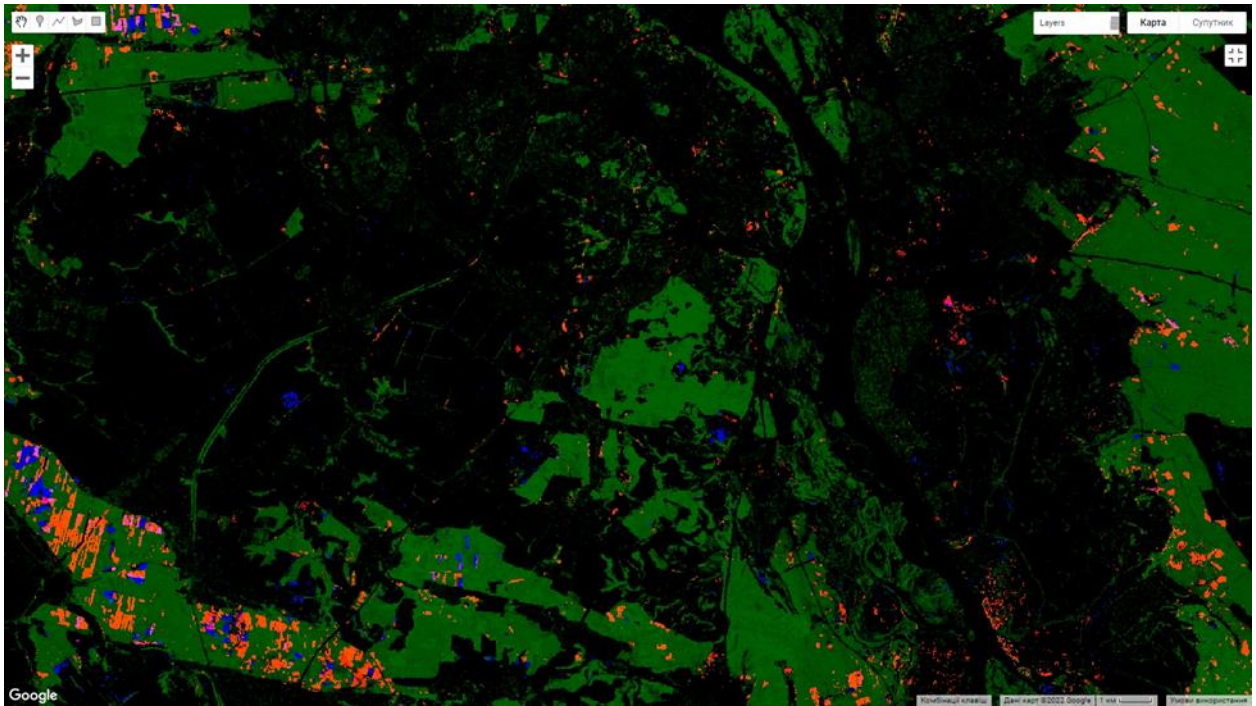


Fig. 2.15. Another visualization of the Global Forest Change dataset in green colour

The values of the range of loss and gain are binary, so they are barely visible in the image.

d) We made the loss of the forest bright red and the growth of the forest bright blue. To fix this, we used the max rendering option to set the range to which the image data is stretched. The max rendering parameter takes a list of values that correspond to the maxima for each band (2.16.). We used this script:

```
Map.addLayer(gfc2018, {  
  bands: ['loss', 'treecover2000', 'gain'],  
  max: [1, 255, 1]  
}, 'Forest cover, loss, gain');
```



2.16. The loss of the forest bright red and the growth of the forest bright blue

This causes the image to be green where there is a forest, red where there is a loss of forest, blue where there is an increase in forest, and purple where there is both magnification and loss. However, a closer look shows that this is not entirely correct. Instead of the loss being marked in red, it is orange. This is because the bright red pixels blend with the main green pixels to form orange pixels. Similarly, the pixels where there is a forest, loss and gain, are pink - a combination of green, bright red and bright blue.

2.2.5. Palettes and Masking

a) We displayed each image in a different color, we used the `Map.addLayer()` palette option for single-band images. Palettes allow you to set the color scheme with which the image will be displayed (Fig. 2.17.). We used the script:

```
Map.addLayer(gfc2018, {
  bands: ['treecover2000'],
  palette: ['000000', '00FF00']
}, 'Forest cover palette');
```

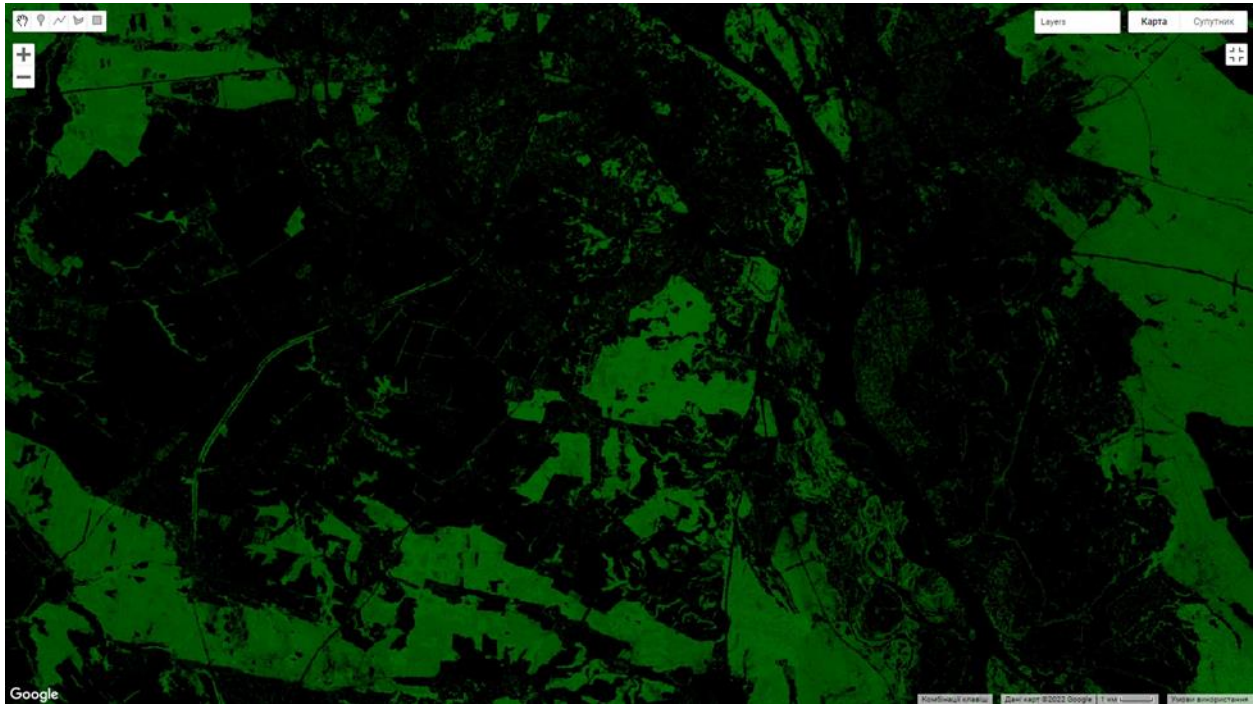


Fig. 2.17. Image in a different color with palette option for single-band images

b) The image above is slightly dark. The problem is that the `treecover2000` range has a byte data type ([0, 255]), although the values are actually percentages ([0, 100]). To make the image brighter, we set the minimum and / or maximum settings, respectively. The palette is then stretched between these extremes (Fig. 2.18.). We used the script:

```
Map.addLayer(gfc2018, {  
  bands: ['treecover2000'],  
  palette: ['000000', '00FF00'],  
  max: 100  
}, 'Forest cover percent');
```

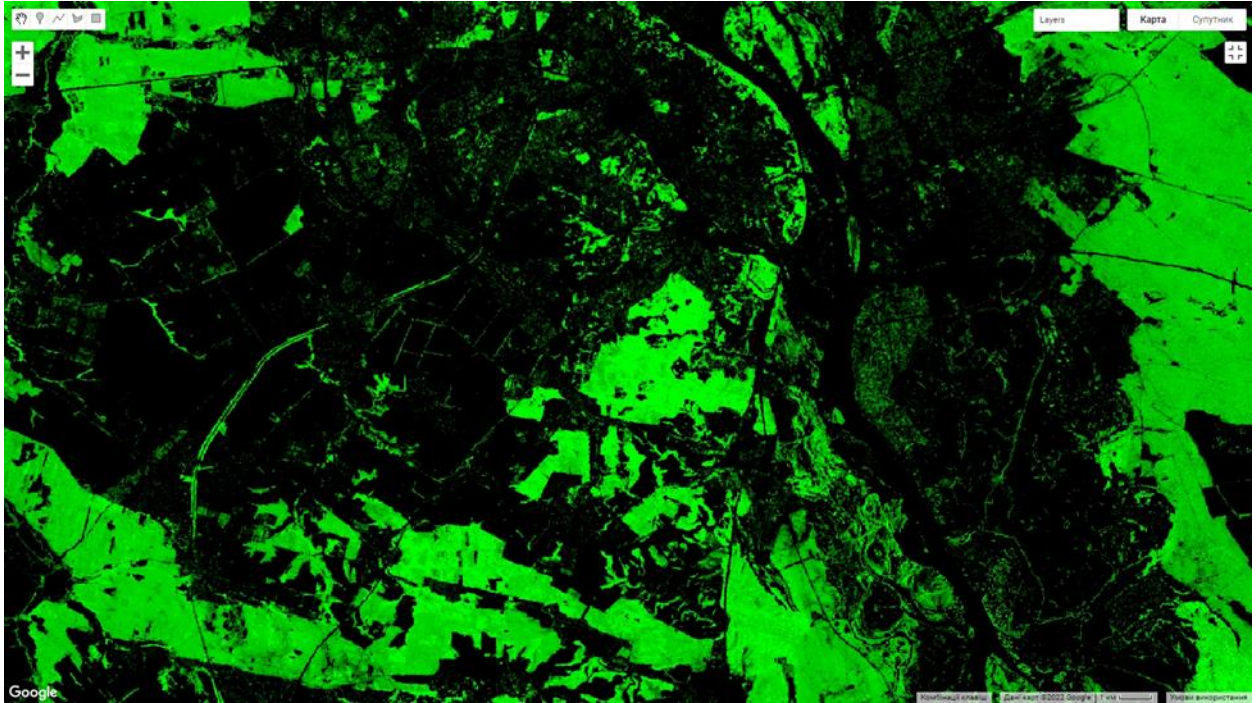



Fig. 2.18. The image brighter visualization

All images shown had large black areas if the data was zero. For example, there are no trees in the ocean. To make these areas transparent, we masked their values. Every pixel in Earth Engine has both a value and a mask. The image is displayed with the transparency specified by the mask, with zero being completely transparent and one being completely opaque.

c) We masked the image with ourselves. We have masked the treecover2000 strip with us, all areas where the forest cover is zero will be transparent (Fig. 2.19.). We used the script:

```
Map.addLayer(gfc2018.mask(gfc2018), {
  bands: ['treecover2000'],
  palette: ['000000', '00FF00'],
  max: 100
}, 'Forest cover masked');
```

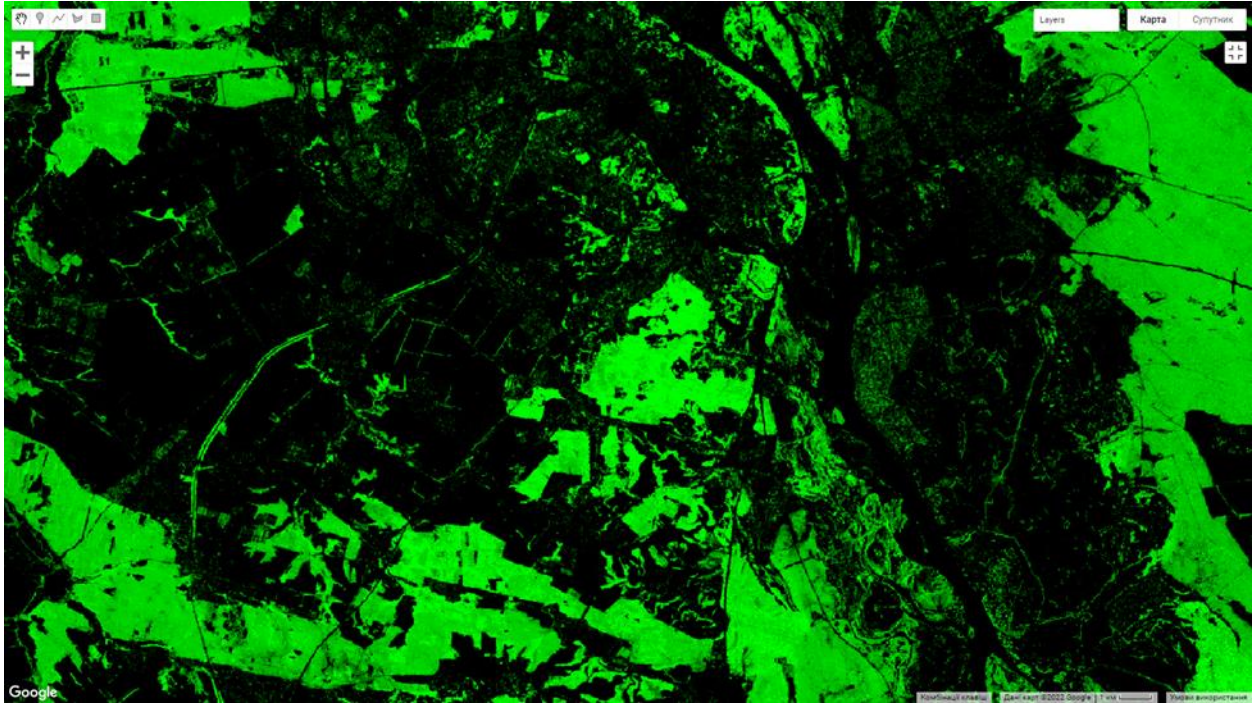


Fig. 2.19. The image masked with ourselves

d) We did a visualization of Hansen's data, which shows all the trajectories of change. We collected everything together with one small difference. Instead of specifying the bands parameter in the Map.addLayer call, we created new images using select () (Fig 2.20.). We used the script:

```
//Whole script
var treeCover = gfc2018.select(['treecover2000']);
var lossImage = gfc2018.select(['loss']);
var gainImage = gfc2018.select(['gain']);
// Add the tree cover layer in green.
Map.addLayer(treeCover.updateMask(treeCover),
  {palette: ['000000', '00FF00'], max: 100}, 'Forest Cover');
// Add the loss layer in red.
Map.addLayer(lossImage.updateMask(lossImage),
  {palette: ['FF0000']}, 'Loss');
// Add the gain layer in blue.
Map.addLayer(gainImage.updateMask(gainImage),
  {palette: ['0000FF']}, 'Gain');
```

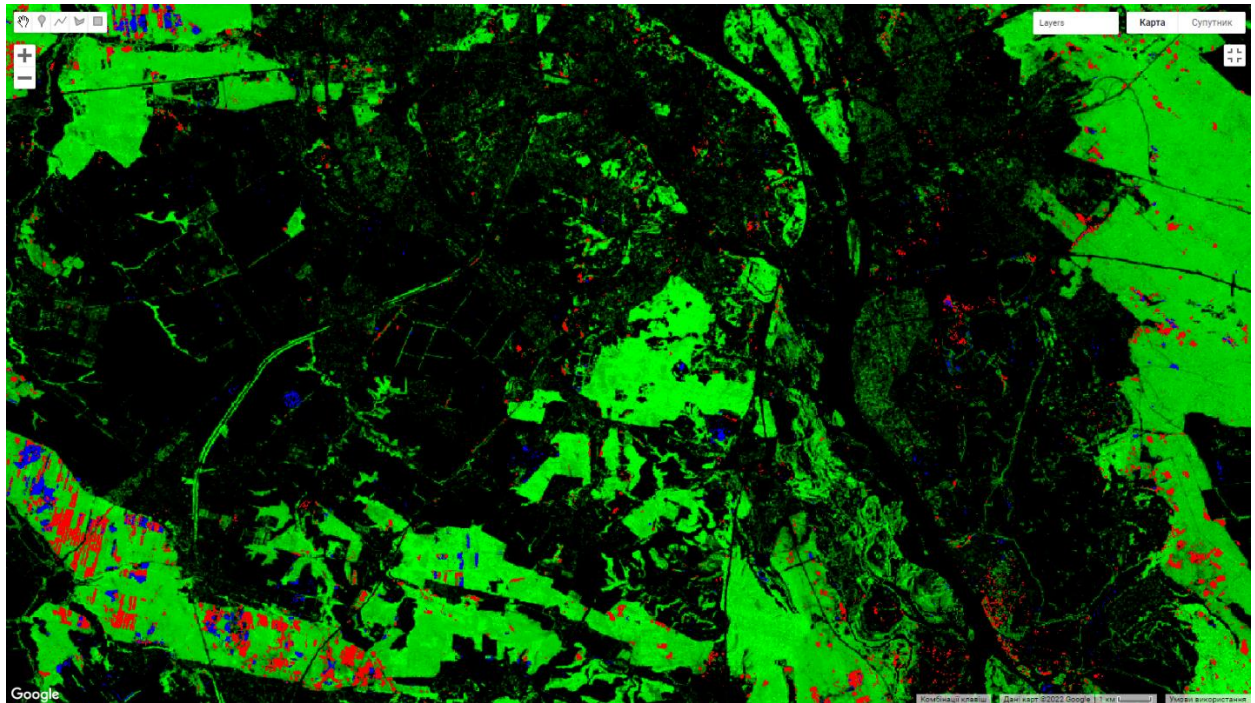


Fig. 2.20. Visualization of Hansen's data, which shows all the trajectories of change

We noticed that there are three `addLayer ()` calls. Each call to `addLayer ()` adds a layer to the map. Hovering over the Layers button in the upper right corner of the map opens these layers. Each layer can be turned off or on using the check box next to it, and the opacity of the layer can be affected by the slider next to the layer name.

We noted that the layer that shows pixels with both loss and gain is missing. It is missing because we needed to know how to do some calculations for image ranges before we could calculate which pixels show both loss and gain.

2.2.6. Charting yearly forest loss

The calculation of the total area of forest lost in the region of interest can be achieved using the `reduceRegion` method. However, if we want to calculate the losses for each year, we need to use a grouped reducer.

To group the Region output (), we specified a grouping range that defines groups by integer pixel values. Next, we showed how:

a) We added a `lossYear` bar to the original image. Each pixel in the `lossYear` range contains values from 0 to 18, which indicate the year in which the loss occurred

b) We used a grouped reducer, specifying the grouping band index (1) so that the pixel areas were summed and grouped according to the value in the lossYear range.

c) We analyze trends for each country

For our visualization we used this script:

```
// Load country boundaries from LSIB.
var countries = ee.FeatureCollection('USDOS/LSIB_SIMPLE/2017');
// Get a feature collection with just the Malaysia feature. Country codes here:
https://en.wikipedia.org/wiki/List\_of\_FIPS\_country\_codes#I
var malay = countries.filter(ee.Filter.eq('country_co', 'MY'));
// Get the loss image.
// This dataset is updated yearly, so we get the latest version.
var gfc2018 = ee.Image('UMD/hansen/global_forest_change_2018_v1_6');
var lossImage = gfc2018.select(['loss']);
var lossAreaImage = lossImage.multiply(ee.Image.pixelArea());
var lossYear = gfc2018.select(['lossyear']);
var lossByYear = lossAreaImage.addBands(lossYear).reduceRegion({
  reducer: ee.Reducer.sum().group({
    groupField: 1
  }),
  geometry: malay,
  scale: 30,
  maxPixels: 1e9
});
print(lossByYear);
```

d) We ran the code above and saw that the annual area of forest loss is printed in an attached list called groups. We formatted the source data a bit so that the result was a dictionary, with the year as the key and the loss area as the value. We use the format () method to convert year values from 0-18 to 2000-2018.

For our visualization we used this script:

```
var statsFormatted = ee.List(lossByYear.get('groups'))
```

```

.map(function(el) {
    var d = ee.Dictionary(el);
    return [ee.Number(d.get('group')).format("20%02d"), d.get('sum')];
});
var statsDictionary = ee.Dictionary(statsFormatted.flatten());
print(statsDictionary);

```

- e) We received annual figures of losses, we prepared a schedule. We used the `ui.Chart.array.values ()` method. This method takes an array (or list) of input values and an array (or list) of labels for the X axis.

For our visualization we used this script:

```

var chart = ui.Chart.array.values({
    array: statsDictionary.values(),
    axis: 0,
    xLabels: statsDictionary.keys()
}).setChartType('ColumnChart')
.setOptions({
    title: 'Yearly Forest Loss',
    hAxis: {title: 'Year', format: '####'},
    vAxis: {title: 'Area (square meters)'},
    legend: { position: "none" },
    lineWidth: 1,
    pointSize: 3
});
print(chart);

```

Our result interpreted on the graph (2.21.-2.22.):

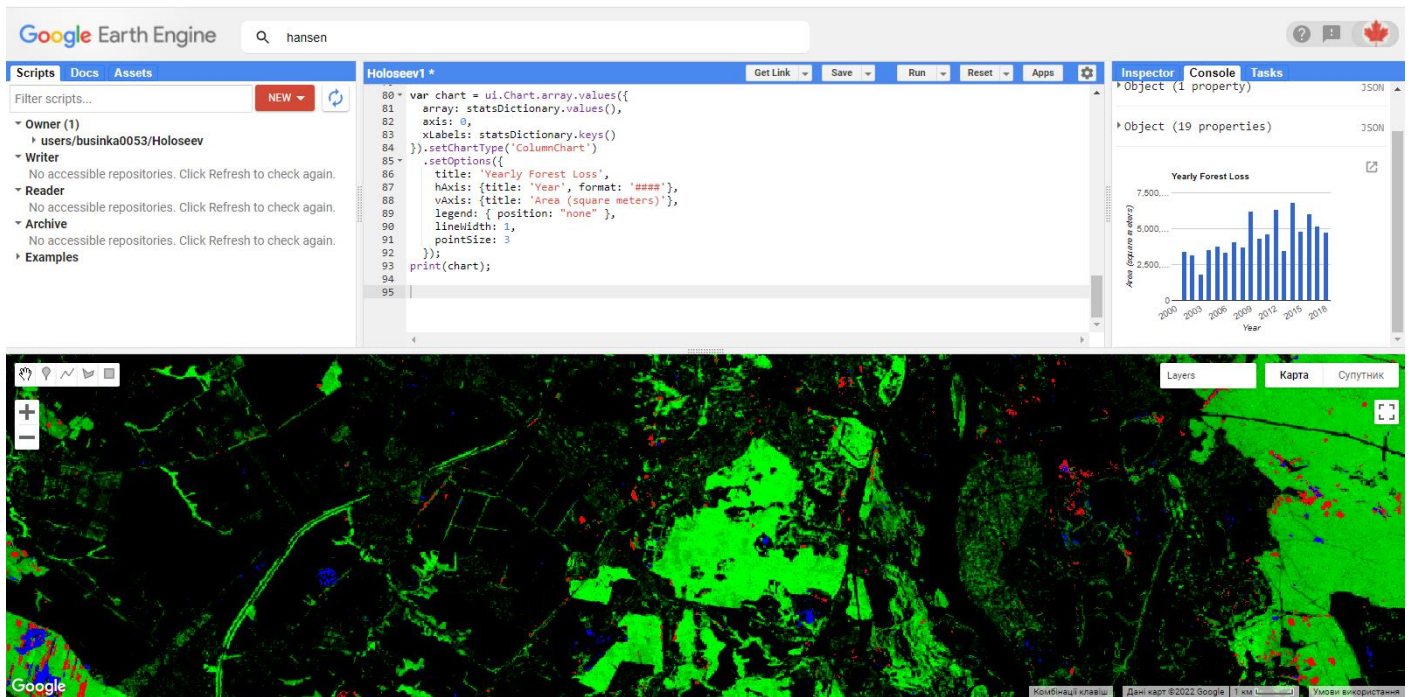


Fig. 2.21. Result of our action

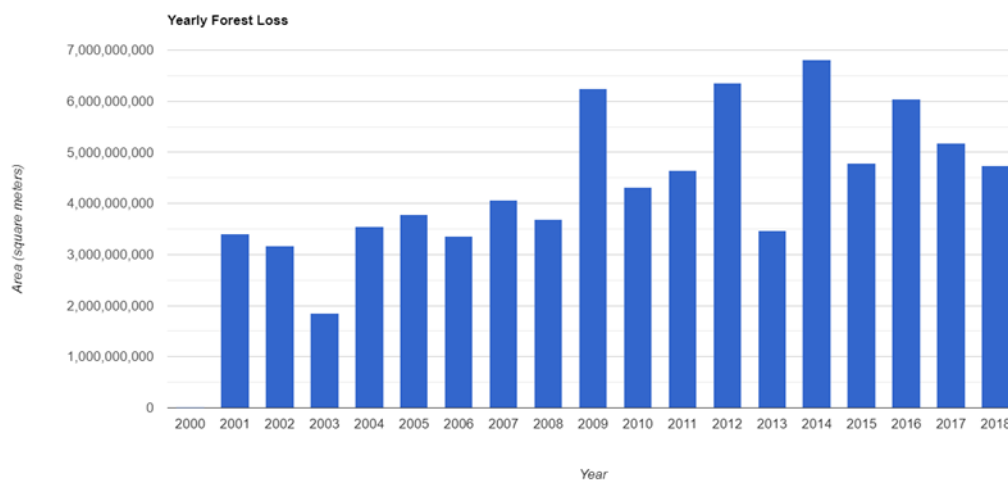


Fig. 2.22. Annual figures of losses for region of interests

In this second part of practical part in second part of diploma we use Java scripts [24].

2.2.7. Google Earth image of the Holiivskyi forest

Compared the difference between changes with Hansen Dataset and Google Earth images on 2018 (Fig.2.23.). With results the territory of Holiivskyi forest with blue indicator was artificial object with artificial planting vegetation.

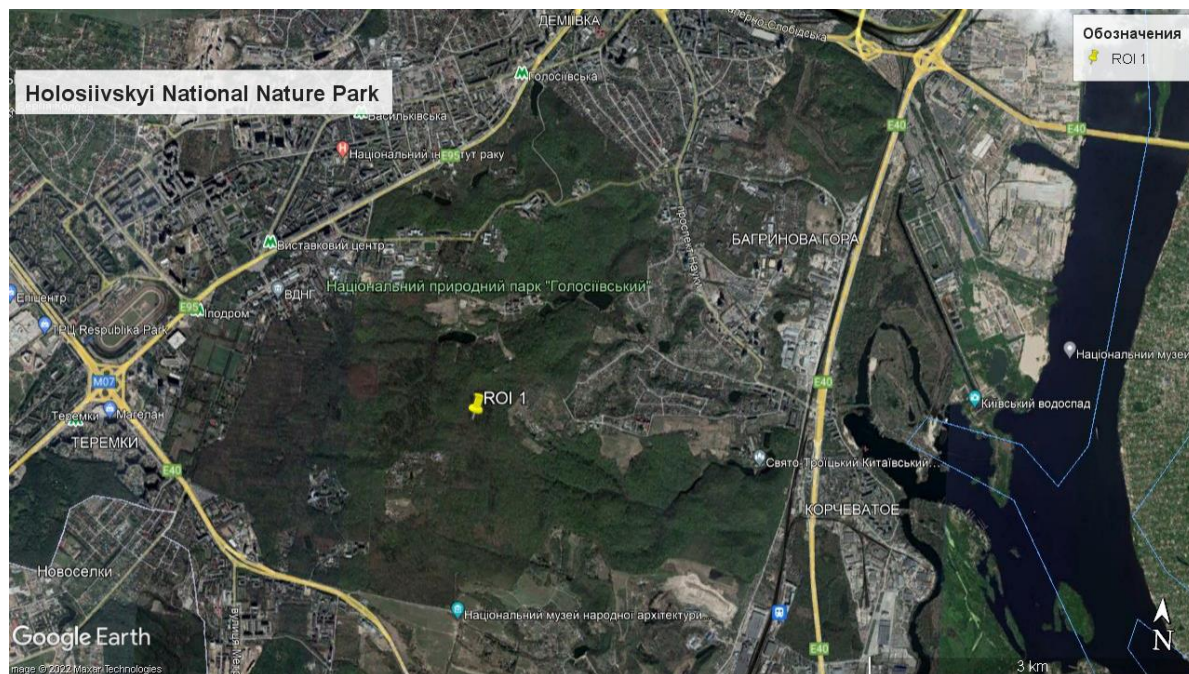


Fig.2.23. Google Earth image of Holiivskyi forest (01.09.2018)

2.3. Conclusions to Chapter 2.

From the results of the 1st part of the practical part, we calculated the NDVI index for the Holiivskyi Forest. With this index we can see the vegetation surfaces that are depicted in the processed image. According to calculations to the point "Forest" surface index was 0.713523805141449, which means that with a value of variation from 0.6 to 0.8 - these are temperate forests (high index). For the artificial surface the index was 0.3904370665550232, which means that it is an artificial surface with light vegetation, the magnitude of the variation is from 0.2 to 0.5 and this is the average value of the index. If the NDVI index is less than 0.1 this is a low index value. In our case it is a water surface with an index value of (-0.2259194403886795), and it is a very small index value.

The space images of the Holosiivsky Forest in The Hansen Dataset with the topic Patterns of Historical Deforestation in the Google Earth Engine software in the period from 2001 to 2018, and the image from Google Earth in the period from September 1, 2018 were analyzed. According to the results: The change of the forest remained unchanged, only in a small area deforestation is visible in the period from 2001 to 2018, which can be said that the Holosiivskyi forest is taken care of.

A table was also made in the Google Earth Engine application with annual forest losses for region of interests between 2001 and 2018. According to these data, the peak of deforestation occurred in 2014 (about 7 billion square meters). The lowest peak was in 2003 (about 2 billion square meters). All data are in square meters. The increase in deforestation in recent years has been caused by climate change and increasing forest fires, as well as anthropogenic factors such as deforestation.

CONCLUSIONS

Various sources of information on the Holosiivsky Forest Ecosystem were analyzed: As a result of overview of the Holosiivsky forest ecosystem I can summarise the following. The concept of ecosystem is very important today. An ecosystem is a system consisting of biotic and abiotic components that interact and function together as a whole. The Holosiivskyi forest ecosystem is special because of diverse vegetation cover, special water bodies. There is a five-pole Orikhovatsky cascade in Holosiivskyi Park. The arrow-leaf arrowhead included in the Green Book of Ukraine is found on the banks of the Orikhovatsky watercourse. The beginning of the Vita River is located at the level of the Dnieper floodplains. This results in a very low flow rate. It also causes significant wetlands in the valley. Species effects are consistent with climate impact, resource availability and disturbance regimes, affecting ecosystem properties.

About ecological problems of the Holosiivskyi forest we can say that the staff of the Holosiivskyi forest adheres to all norms and tries to do everything necessary to further mitigate the negative impacts on the Holosiivskyi forest ecosystem and there is also a problem of radiation nature, namely through the state specialized enterprise "Radon Association", because this enterprise is located near the Holosiivskyi National Nature Park, it is very dangerous, especially in today's conditions, namely because of Russia's military aggression against Ukraine.

As a result of the practical part, the following tools for studying forest ecosystems have been mastered: Google Earth software and online Google Earth Engine software. As well as the use of the SENTINEL-2 satellite and the 'THE' Hansen dataset. Cheaper and more accessible methods need to be used to monitor the state of ecosystems because it is profitable in terms of resource savings.

From the results of the 1st part of the practical part, we calculated the NDVI index for the Holosiivsky Forest. With this NDVI index we can see the vegetation surfaces that are depicted in the processed image. According to calculations to the point "Forest" surface index was 0.71, which means that with a value of variation from 0.6 to 0.8 - these are

temperate forests (high index). For the artificial surface the index was 0.39, which means that it is an artificial surface with light vegetation, the magnitude of the variation is from 0.2 to 0.5 and this is the average value of the index. If the NDVI index is less than 0.1 this is a low index value. In our case it is a water surface with an index value of (-0.23), and it is a very small index value. And as a result the correspondence of the NDVI index to the index of surface.

On the example of the Holosiivsky forest, a comparison was made of how forest cover changed between 2001 and 2018. A table of global historical deforestation was also made in the Google Earth Engine application with annual forest losses in the region of interests between 2001 and 2018. According to these data, the peak of deforestation occurred in 2014 (about 7 billion square meters). The lowest peak was in 2003 (about 2 billion square meters). All data are in square meters. The increase in deforestation in recent years has been caused by climate change and increasing forest fires, as well as anthropogenic factors such as deforestation.

The 'THE' Hansen dataset is an important part and database where you can see changes in forest cover, deforestation or reforestation, over a period of time. This is a very important research method, as well as cheap, because it is a free database and program Google Earth Engine. The space images of the Holosiivsky Forest in The Hansen Dataset with the topic Patterns of Historical Deforestation in the Google Earth Engine software in the period from 2001 to 2018, and the image from Google Earth in the period from September 1, 2018 were analyzed. According to the results: The change of the forest remained unchanged, only in a small area deforestation is visible in the period from 2001 to 2018, which can be said that the Holosiivskyi forest is taken care of.

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