ASSESSMENT OF FOREST ECOSYSTEM SERVICES AND GENERALLY BENEFICIAL FOREST FUNCTIONS IN PARK FOREST MARJAN IN SPLIT

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ABSTRACT

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Client: Association for Nature, Environment and Sustainable Development Sunce

Made by: Professor Ivica Tikvić, PhD (University of Zagreb, Faculty of Forestry)

Collaborators in production: Gabrijela Medunić - Orlić M. Eng. Chem., Marija Nazlić, MSc. Educ., Matea Špika, MSc. Management of Protected Areas (Association for Nature, Environment and Sustainable Development Sunce)

Srđan Marinić and Robertina Tomić (Society Marjan)

Lukrecija Butorac, PhD (Institute for Adriatic Crops and Karst Reclamation)

Antonela Čmrlec, BA and Robert Koharević, M. Eng. (Public Institution for the Management of Park Forest Marjan)

Slađana Pavlinović, PhD (University of Split, Faculty of Economics)

An entire study with detailed explanations of ecosystem services and different ways of assessment is available at Association Sunce website (www.sunce-st.org) and Society Marjan website (http://drustvomarjan.hr/).

INTRODUCTION

Ecosystem services are processes and states by which ecosystems and organisms functioning in them enable direct and indirect benefits for life on Earth. Those services enable and advance the life of organisms on Earth, that is, they are a condition of life for the man, but also for all other organisms on Earth. Park Forest Marjan (PFM) with its various ecosystems provides numerous services and benefits to the inhabitants of Split and visitors of the forest park.

According to the historical data, the forests in the area of the present Park Forest Marjan were completely destroyed due to improper exploitation from the 17th to the 19th centuries. The consequence of that was erosion and appearance of bared karst. At the end of the 19th century systematic artificial afforestation began at the initiative of Split professor Juraj Kolombatović and with the contribution of the Society Marjan.

Forest ecosystems are the most represented ecosystems in PFM. They make about 2/3 of the park forest. The main species is the Aleppo pine (*Pinus halepensis* Mill.), while the second most represented species is the cypress (*Cupressus sempervirens* L.). The average age of the Aleppo pine trees is around 90 years.

Forest ecosystem services of Park Forest Marjan

In total, 28 forest ecosystem services have been defined and described in Park Forest Marjan.

Definition, description and explanation of PFM ecosystem services		
1.	Providing natural space for relaxation	Forest ecosystems represent a natural space for relaxation needed for people's everyday life activities. Relaxation in nature reduces psychological and mental pressure, refreshes the spiritual state of a man, provides a rest from noise, and restores a man's natural balance
2.	Natural space for socializing	In forest ecosystems, man often finds a place to socialize with other people. This service differs from providing a natural space for relaxation because a person can rest alone, while socializing involves at least two people. Socializing often includes certain organized activities.
3.	Natural space for entertainment	Certain entertainment activities (fun games for children, concerts and other organized entertainment events) are often organized in forest ecosystems.
4.	Natural space for recreation	Forest ecosystems represent a natural space for different forms of physical activity aimed at maintaining and increasing the physical shape and dealing with various forms of recreation in nature (walking, running, cycling, rolling, rock climbing and so on).
5.	Natural space for sports activities	In forest ecosystems, different sports activities can take place (cross races, cycling races, automobile mountain races and others).
6.	Natural space for educational activities	Forest ecosystems represent a natural space for different forms of educational activities of people, aimed at increasing the knowledge of nature.
7.	Natural space for recuperation	Forests and landscapes with forest vegetation create a much more relaxed psychological state in humans. It is considered that the public health benefits of forests are substantial, especially with regards to stress.
8.	Natural and cultural space for tourist visits	Forests are valuable destinations for tourists who wish to rest or exercise because they protect against harmful UV radiation, mitigate microclimatic conditions (increase air humidity, reduce extreme temperatures) and provide a comfortable space for rest and sport activities. All the forests located along the Adriatic coast have a tourist function (from the islands to the Dinaric Alps).
9.	Aesthetic function in landscape and environment	Forest ecosystems represent a valuable and indispensable aesthetic element of the landscape and the environment. By their existence in landscapes, the forests contribute to the beauty of nature and the environment, and by observing such landscapes, a man enjoys the beauty of nature and enriches his psyche and mind without the mediation of conceptual thinking and practical meaning.

10.	Increase of the quality of life of citizens living near the park forest	The increasing urbanization can contribute to reducing the quality of life in urban areas. Thus, noise and other stressful and adverse factors in urban areas affect the psychological state of people. Therefore, more and more people in cities spend their free time in natural areas and forests, where the intensity of noise and other adverse factors is minimal.
11.	Increase of the value of land and real estates in a park forest and its vicinity	Forest ecosystems increase the value of land and real estates in urban areas. The reason for that is because the living conditions in facilities near the forest are more favourable.
12.	Protection against wind	Forest ecosystems protect objects from wind action. Forests can reduce the impact and wind power, as well as prevent the aeolian erosion.
13.	Protection against soil erosion	Forest vegetation protects the forest soil from aquatic and aeolian erosion with its crowns, by deposition of organic residues on soil and roots. Forest soil on sloping terrain is potentially permanently exposed to erosion risk if it is not covered by forest vegetation. In case of destruction of forest vegetation (improper cutting, wildfires), erosion of forest soil can occur, which can cause damage to infrastructure, facilities and agricultural land.
14.	Protection against streams	Forest ecosystems regulate the surface drainage of water and drainage of water in watercourses. Disappearance of forest causes streams which can cause great damage. An example is Senjska draga where streams used to take place due to the disappearance of forests. Thanks to refforestation the streams have disappeared, watercourses on Medvednica rarely cause streams in Zagreb, because the forests regulate the drainage of water.
15.	Creating a favourable microclimate	The forests microclimate affects people's health in a good way, especially vulnerable people's health in some parts of the year (e.g. summer). All forests have a climatic function because they alleviate climatic extremes and enrich the air with oxygen and water vapor and thus have a beneficial effect on the climate of nearby settlements and agricultural areas. The influence of forests on the climate can be observed from a distance of 60 km.
16.	Production of oxygen	When conditions are favourable, the process of creating organic matter called the photosynthesis takes place in forest ecosystems. In addition to organic matter, photosynthesis also creates oxygen that goes into the atmosphere through the leaves. Oxygen is the second most represented gas in the atmosphere (21%).
17.	Creating clean and fresh air	Forest ecosystems improve air quality by purifying air from dust, smoke, pollen and other substances and enriching the air with natural gas and water vapor through respiration and evapotranspiration processes.

18.	Receiving pollution from air	Forests affect the purification of air from pollution. By the leaf area index (LAI), the forests receive large amounts of dry and wet deposition from air. Thus, the forests improve the air quality, which is good for human health. In forests, these substances are decomposed, and that is why watercourses and underground streams have clean water.
19.	Disintegration of air pollution	Forest ecosystems accumulate significant amounts of pollution from air and from flood waters by dry and wet deposition. Those substances are decomposed in the forest soil by the action of microorganisms and the aid of organic matter.
20.	Protection against harmful UV radiation	Leaves and branches of forest trees alleviate the adverse effect of harmful UV radiation on human health. According to some studies, forests can represent the so-called UV factor of 6 to 10, which means that only 1/6 to 1/10 of harmful UV radiation in the forests is not absorbed but comes to the surface of the soil and skin of humans.
21.	Binding of carbon dioxide	In the process of photosynthesis, forest trees use carbon dioxide from the air and create oxygen that goes into the air. This way, forest trees reduce the amount of carbon dioxide in the air and alleviate the so-called greenhouse effect i.e. the presence of one of the greenhouse gases in the atmosphere.
22.	Regulating the flow and surface drainage of water	Forests affect the quality of drinking water because they are the largest natural water purifiers on land. Evidence of this are clear and clean streams in mountain areas despite the constant polluting rainfall. Forests affect the gradual flow of water, prevent erosion, streams, landslides etc.
23.	Purification of precipitation water	In forest ecosystems, the polluted ground water is purified physically, chemically and biologically. Forest ecosystems are the largest natural purifier of precipitation water in the world.
24.	Creating fertile forest soil	The processes of producing fertile forest soil constantly take place in forest ecosystems. The forest soil is created under the influence of vegetation, climate, microorganisms, water and foundations.
25.	Protection of natural goods in forests	In forest ecosystems, various natural goods are produced that man uses for his own needs. They include mushrooms, medicinal plants, fruits, animals (wild game) etc.
26.	Providing living conditions for different natural plant species	Forest ecosystems which are managed by natural principles are the best systems for protection of natural plant species. This particularly applies to endangered and rare species, because their survival depends on the preservation of natural habitat conditions and ecosystems.
27.	Providing living conditions for different natural animal species	Forest ecosystems are the best ecosystems for protection of natural animal species.
28.	Providing living conditions for different natural microorganism speciesv	The largest number of microorganisms develop in forest ecosystems. In the ecosystems that are managed by natural principles, microorganisms find favourable natural conditions for life and these ecosystems are the best systems of protection of natural species of microorganisms.

Ranking and financial evaluation of PFM ecosystem services

Based on the results of 10 polls on the ranking of PFM ecosystem services, the following results were obtained.

The most important services of PFM forest ecosystems were:

1. Creating clean and fresh air,
2. Natural space for recreation and
3. Providing natural space for relaxation.

Very important services of PFM forest ecosystems were:

4. Production of oxygen,
5. Natural space for educational activities and
6. Protection against soil erosion.

Important services of PFM forest ecosystems were:

7. Aesthetic function in landscape and environment,
8. Regulating the flow and surface drainage of water,
9. Natural and cultural space for tourist visits and
10. Increase of the quality of life of citizens living near the park forest.

Similar results were obtained on the basis of a survey conducted by agency Hendal on a sample of 700 citizens of Split, which was engaged by the Association Sunce within the same project "Responsible for Nature", which sought to gain insight into the attitudes of the citizens of Split about the Park Forest Marjan and its value.

Based on the results of the ranking of PFM ecosystem services, it has been established that the services of creating clean and fresh air and providing natural space for recreation are the two most important services of the PFM ecosystem and those selected for financial evaluation. Given the great significance of other most important forest ecosystem services for PFM, the study also carried out a financial evaluation for the 5 most important services of the PFM ecosystem.

Assessment of the economic value of ecosystem service is carried out on the basis of certain quantification and clear definition of these services, including the definition of an unambiguous service name, definition of service, explanation of service, determination of service users, determination of direct benefits of the service, indirect benefits of the service, service measurement values, assessment of service measurement values and financial evaluation of services. Evaluation of ecosystem services was calculated using the following methods:

- methods of evaluation of forest ecosystem services;
- existing methods of evaluation of forest ecosystem services;
- methods of uncovered tendencies;
- methods of expressed tendencies;
- cost and revenue methods;
- methods of transfer of use.

Assessment of the services of creation, purification and refreshment of air in PFM forest ecosystems

Service name	Service of creation, purification and refreshment of air
Service users	• People who inhale the air in PFM forest ecosystems • People who inhale the air in the area around the PFM • Plants, animals and microorganisms that use the air in PFM • Plants, animals and microorganisms that use the air around the PFM
Direct benefits	• Annual amount of purified fresh forest air inhaled by people in PFM • Annual amount of purified fresh forest air inhaled by people around the PFM • Annual amount of purified fresh forest air that goes into the atmosphere and other ecosystems.
Indirect benefits	The natural air in the atmosphere ensures balanced thermal properties for all organisms on Earth, alleviates the appearance of climate change due to polluted air, filters harmful UV rays of the Sun and has a beneficial effect on population health, increased population work efficiency, reduced health care costs, increased vitality of forests, increased biodiversity in urban areas and support for natural balance in urban areas.

Measurement values of direct benefits of the air purification service				
The number of people inhaling the purified air	The number of hours of inhaling the purified air in PFM	The total amount of purified fresh forest air in PFM	The amount of inhaled purified air in PFM	The amount of inhaled purified air around the PFM
Indicators of the measurement values of direct benefits of the air purification service				
The total number of people who visit PFM annually and inhale the purified air	The annual total number of hours of inhaling the purified fresh forest air in PFM	The total annual amount of purified fresh forest air that is produced in PFM and goes into the atmosphere and other ecosystems	The total annual quantity of inhaled purified fresh forest air in PFM	The total annual quantity of inhaled purified fresh forest air near PFM

Assessment of the measurement values of direct benefits of the air purification service		
Measurement value name	Calculation of assessment	Assessment of the measurement value
The annual number of persons in PFM	4.000 daily x 365 days	1.460.000 osoba
The annual number of hours of inhaling in PFM	1,5 h x 1.460.000 persons	2.190.000 h
Inhaled air in PFM	6 l/min x 60 x 2.190.000 h	788.400 m^3
Inhaled air near PMF	6 l/min x 60 x 2.190.000 h	788.400 m^3
Totally inhaled air in and around PFM	Amount in PFM + near PFM	1.576.800 m^3
Purified air in PFM	Height of trees x surface of PFM 10 m x 3.000.000 m	30.000.000 m^3
The annual amount of created natural air	Over the annual amount of oxygen produced (21%) and biomass growth	7.620m^3

Financijska procjena direktnih koristi usluge pročišćavanja zraka		
Assessment criteria	Assessment indicators	Assessment of the financial value of the service (kn/ha)
Based on the total price of managing and maintaining the natural space of Park Forest Marjan	Annual price of PFM management around 7.000.000 kn There are 28 functions (services) in total The percentage of management cost for one function is 100/28 = 3,57% The financial value of one function is 0,0357 x 7.000.000 kn = 249.970 kn The financial value of one function per ha 249.970 000 kn/200 ha = 1.250 kn	1.250

Based on the assessment of the price of annual amount of created air in PFM	Technical gases (O2, N2, CO2) have the relation 1 m^3 = 1,311 kg **7.620 m3 x 1.311 = 10.000 kg** 1 kg O2 = 10 kn/kg **10.000 kg x 10 kn = 100.000 kn** The financial value of one function per ha **100. 000 kn/200 ha = 500 kn/ha**	500
Based on the comparative price of air purification in small spaces	Air conditioners in homes (100 m^2 of surface) spend 140-350 (250 on average) kWh for 350 h of work. That is 0,71429 kW/h Annually there are 8760 hours (365 days x 24 h). If the device works only during the day (x 0,5) it consumes **8760 h x 0,5 x 0,71429 = 3128 kWh/god.** The price of 1 kWh is 0,5 kn **3128 kWh x 0,5 kn/kWh = 1.564 kn godišnje.** On the surface of PFM of 200 ha there would be about 20,000 pieces of such devices **(200 ha x 10.000 m^2) / 100 m^2 = 20.000** **1.564 kn x 20.000 = 31.285.714 kn** Per hectare of PFM that would be **31.285.714 kn /200 ha = 156.428 kn/ha**	156.428
Based on the comparative price of air purification per volume of space	The space in shopping malls is purified by large air conditioning and air purification systems. If we analyse a shopping mall of the surface of 10.000 m^2 and the volume of 50.000 m^3, which works from 08.00 to 20.00 hours (12 hours of providing air conditioning and air purification services) and consumes around 10 kWh/m^2 annually per average price of 0,50 kn per kWh, which is 50.000,00 kn annually (the total amount of electricity for all needs in an apartment of about 100 m^2 is about 5.000 kn/year). If we multiply that amount by 600 (30 mil. m^3/50.000 m^3) we get **50.000 x 600 = 30.000.000 kn** Per hectare of PFM that would be **30.000.000 kn /200 ha = 150.000 kn/ha**	150.000

Assessment of the recreation service in PFM forest ecosystems

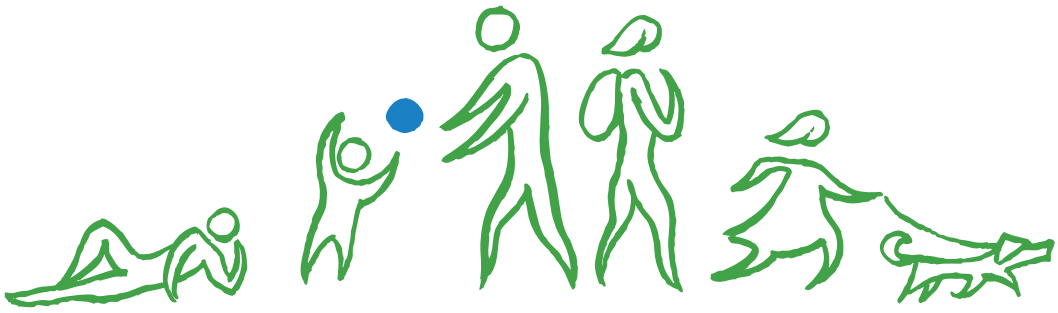
Service name	Recreation service of forest ecosystems
Service users	• People who exercise recreation in the forest ecosystems of PFM
Direct benefits	• The total number of people who exercise recreation annually in forest ecosystems • The total number of people who exercise various forms of recreation annually • Total annual duration of all forms of recreation in hours • Total annual duration of certain forms of recreation in hours
Indirect benefits	Increase of the mental and physical health of the population, increase of the work efficiency of the population, reduction of health care costs, increase of conservation of forests in urban areas, increase of biodiversity in urban areas, support of the natural balance in urban areas.

Measurement values of direct benefits of the ecosystem recreation service			
Space for recreation in PFM	Types of recreation in PFM	Number of persons exercising recreation in PFM	Duration of recreation in hours in PFM
Indicators of the measurement values of direct benefits of the ecosystem recreation service			
Track length Track width Surface	Walking, running, cycling, roller skating, rock climbing, mountaineering, walking in nature.	Daily, on weekends, weekly, monthly, per seasons, annually.	Daily, on weekends, weekly, monthly, per seasons, annually.

Assessment of the measurement values of direct benefits of the ecosystem recreation service		
Measurement value name	Calculation of assessment	Assessment of the measurement value
Track length	3 300 m x 5 times	16.500 m
Track width	1 to 5 m – average 3,5 m	3,5 m
Track surface	16.500 m x 3,5 m	57.750 m2
Annual number of persons	4.000 daily* x 365 days x 0,5 50% recreation: 50% relaxation	730.000 persons
Annual duration (h)	1-2 h daily – average 1,5 h 1,5 h x 730 000 persons	1.095.000 h
Walking	50% x 730 000	365.000 persons
Running	20% x 730 000	146.000 persons
Cycling	20% x 730 000	146.000 persons
Roller skating	7% x 730 000	51.100 persons
Rock climbing	2% x 730 000	14.600 persons
Hiking in nature	1% x 730 000	7.300 persons

Financial assessment of direct benefits of the forest ecosystem recreation service		
Assessment criteria	Assessment indicators	Assessment of the financial value of the service (kn/ha)
Based on the total price of managing and maintaining the natural space for recreation of Park Forest Marjan	Annual price of management 7.000.000,00 kn There are 28 functions (services) in total The percentage of management cost for one function is 100/28 = 3,57% The financial value of one function is 0,0357 x 7.000.000 kn = 249.970kn The financial value of one function per ha 249.970 000 kn/200 ha = 1.250 kn	1.250
Based on the costs of maintaining the PFM	The PFM space maintenance surface for recreation covers: the surface of asphalt roads, the surface of stone paths, the surface of macadam and the surface of tracks on the forest roads. In total: 57.750 m^2 = 5,775 ha The surface of forest in recreation zones is: (two tree height x length of road and track) 2 x 10 m x 16.500 m = 330.000 m^2 = 33 ha 5,775 ha + 33 ha = 38,775 ha 200 ha /38,775 ha = 12,92% Percentage of maintained PFM surface for recreation x 50% yr. maintenance price of PFM (management cost for recreation) 0,1292 x 3.500.000 kn = 452.317 kn The financial value per ha 452.317 kn/200 ha = 2.262 kn	2.262
Based on the comparative price of using space for recreation in a fitness centre	Organized recreation at a fitness centre costs 200-300 kn per month, it lasts 2 hours a week, which is 8 hours per month, hourly price is 250/8=31,25 kn. Recreation at a fitness centre has basic costs (electricity, heating in the winter, cooling in the summer, equipment, people working at the fitness centre) that recreation in nature does not have. Therefore, the average price of recreation at a fitness centre should be reduced by these costs. In this assessment it is reduced by 3 times. The assessment of the price of recreation in nature would then be around 10 kn/hour. 1.095 000 h x 10,00 kn = 10.950.000 kn The financial value per ha 10.950.000 kn/200 ha = 54.750 kn	54.750

Based on the comparative price of using space for recreation in the city	Space for recreation in the city could be a sports hall, a recreational balloon, a recreation playground etc. The price of renting certain sports facilities ranges from 50 to 250 kn/hour (average 150 kn). If we analyse a sports facility of the surface of 1000 m^2 which works from 08.00 to 20.00 hours (12 hours of providing the service) at an average rent price of 150 kn per hour, it can earn about 650 000 kn annually. If we reduce that amount three times for the basic costs and the tax we get about 200.000 kn annually. In PFM on the surface of 57.750 m^2 we have about 58 areas of the size of a sports facility of 1.000 m^2 58 x 200 000 kn = 11.600.000 kn The financial value per ha 11.600.000 kn/200 ha = 58.000 kn/ha	58.000
By using the travel cost method	730.000 persons use PFM for recreation annually. Some people arrive to PFM by foot, some by bicycle, and some by car of public transport. Persons who are driven to PFM pay between 20 and 30 kn for transportation. It has been estimated that 50% of persons are driven to PFM. 365.000 osoba x 25 kn = 9.125.000 kn The financial value per ha 9.125.000 kn/200 ha = 45.625 kn/ha	45.625

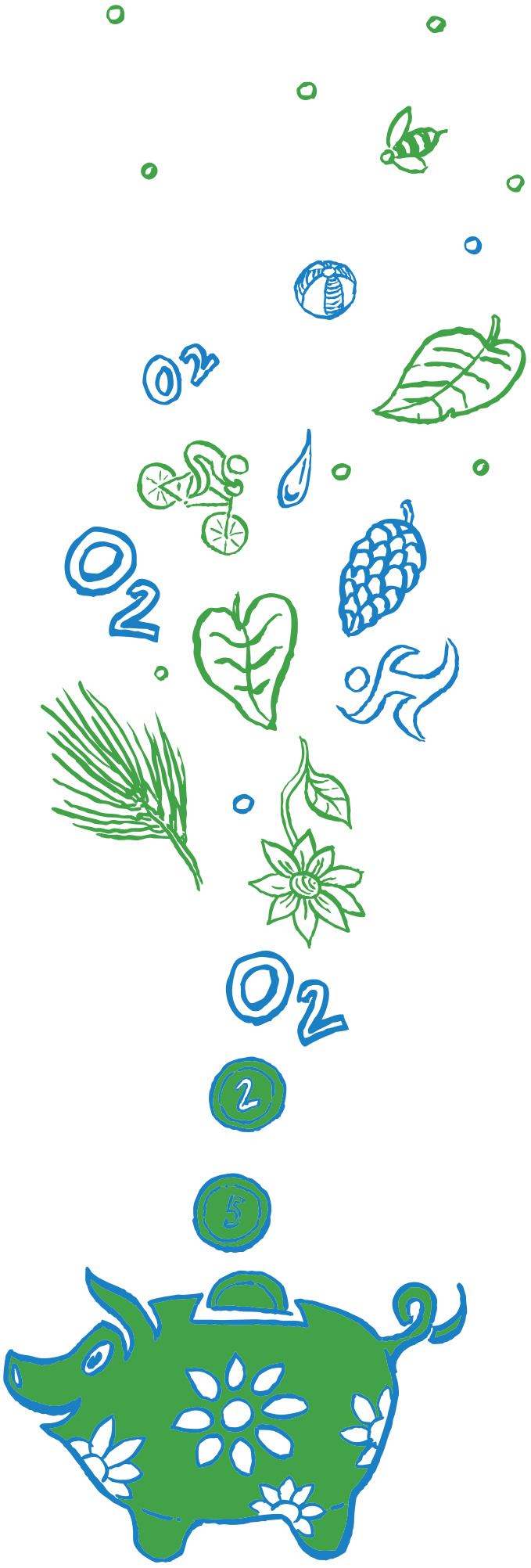


Results of the assessment of the financial value of PFM forest ecosystem services

The first assessment of all forest ecosystem services of Park Forest Marjan was made in the study based on the assessment of the financial value of the 5 most important forest ecosystem services. These assessments were rated according to the value in 5 degrees (the 1st degree had the highest value, and the 5th degree had the lowest value). Then, each service was assigned a certain ranking according to the expected value of that service. After that, all 1st level services were associated with the highest assessment of the financial value of the service obtained by assessing the 5 most important forest ecosystem services. **Based on the summary of all data, the total value of all PFM forest ecosystem services was approximately 141.6 million kn, while the average assessment of PFM forest ecosystem services per hectare amounted to approximately 708.000 kn.**

While the forest ecosystem services refer to all forest functions, generally beneficial forest functions (GBFF) refer only to those forest functions that benefit all people. The assessment of the GBFF value of Park Forest Marjan was made on the basis of the GBFF rating in the PFM management programme, the assessment of the value of the GBFF of Mediterranean forests and on the basis of the GBFF fee. The GBFF value according to the management programme was assessed at about 402.000 kn and the GBF of Mediterranean forests at around 308.000 kn per ha per year; i.e. 80.420.600 kn for the entire Forest Park under the first and 61.718.964 kn under the second assessment.

The obtained higher value of PFM forest ecosystem services per unit area compared to GBFF assessments per unit area is logical, due to the higher number of forest ecosystem services (28) compared to the number of generally beneficial forest functions assessed (9).



Conclusion

As a valuable natural resource, forests on one hand have clear and easily demonstrable market values and benefits (e.g. wood), while on the other hand they have hard to prove non-market benefits the value of which is not easy to determine (e.g. protection of biodiversity, aesthetic and spiritual value of forests).

We are witnesses to an increasing number of disturbances in forest ecosystems both in Croatia and in the world, such as natural disasters, excessive climate events, environmental pollution, climate change, harmful biotic factors etc. In order for the forests to fulfil all of their functions and optimally provide all ecosystem services, it is necessary to properly govern and manage them.

The need to determine the value of natural resources in the decision-making processes or the choice between the different ways of using those resources and their protection has encouraged the development of evaluation methods. However, still no single method is able to encompass all values of a natural resource; it is necessary to combine several different methods as well as to involve different experts in such assessments.

By ranking the PFM forest ecosystem services, the three most important services of PFM forest ecosystems were defined: creating clean and fresh air, natural space for recreation and providing natural space for relaxation. The following very important services of PFM forest ecosystems were the production of oxygen, natural space for educational activities and protection against soil erosion.

For the first time, a financial assessment of the 5 most important PFM forest ecosystem services was carried out within the study, which amounted to 24.4 million kn, or 122,000 kn per ha. The amount per hectare for various ecosystem services ranged between 700 kn and 77.000 kn.

Furthermore, the assessed total value of all PFM forest ecosystem services was 141.6 million kn, while the average assessment of PFM forest ecosystem services per hectare amounted to approximately 708.000 kn.

The GBFF value according to the management programme was assessed at about 402.000 kn and the GBF of Mediterranean forests at around 308.000 kn per ha per year.

The GBFF fee paid by all legal entities in the Republic of Croatia for the 28 Park Forest Marjan forest ecosystem services is assessed at 40,000 kn per year, or 200 kn per hectare per year.
It is about 7 kn per ha per year for one service, or about 0.6 kn per ha per month for one service of the Park Forest Marjan forest ecosystem. The fee for generally beneficial forest functions (forest ecosystem services) should be proportionately allocated for the management of Park Forest Marjan as well.

The value of ecosystem services applies only to the forest ecosystem services that make up 2/3 of the Park Forest Marjan. The actual value of PFM ecosystem services is therefore higher than the assessed value. Forest and other ecosystems in the Forest Park Marjan need to be thoroughly defined and mapped for future assessments of ecosystem services and detailed management plans for all parts of the Park Forest Marjan.

Assessments of the economic values of ecosystem services might play an important role in ecosystem protection and management plans as well as in reducing the adverse human impact on ecosystems and their services, on which the wellbeing of present and future generations depends. Park Forest Marjan represents the most valuable part of nature in the city of Split and its surface should not be reduced due to the services it provides to all residents of the city of Split and other visitors. Protection and management of the Park Forest Marjan should be focused on maintaining and improving all ecosystem services in the Park Forest.

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