Scientific Papers. Series B, Horticulture. Vol. LXVI, No. 2, 2022
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

EVOLUTION OF THE MARINE DUNES OF AGIGEA IN THE CONTEXT OF BIODIVERSITY CONSERVATION

Anca-Roxana STRUGARIU, Vladimir Ionuț BOC

University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Horticulture, 59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: anca.roxana.strugariu@gmail.com

Abstract

The paper aims to present the evolution of coastal landscape, as well as the defining component of it, sand dunes. The current situation of sand dunes, their impact on ecosystems, the threats and difficulties they face, along with the importance of their conservation were analyzed.
The introduction is based on the statistical data gathered from numerous international reports regarding the environment, specifically the sustainability of coastal and marine zones. The information was processed and compared during the materials and methods phase to the analyzed site, which is unique for Romania, hosting the only natural reserve of marine dunes in the country, the protected area "Marine Dunes of Agigea". The analysis focused on the physical environment, land use, history and heritage, flora and fauna. As for the results and discussions, a synthesis of the analysis and a diagnosis, vision and mission were elaborated, while the conclusion of the paper is summing up a sustainable landscape planning and management strategy.

Key words*: coastal ecosystems, green infrastructure, natural habitat, protected areas, sand dunes.*

INTRODUCTION

Coastal areas are considered to be zones where land and sea influence, meet and interact. The coastal strip varies depending on the nature of the environment, the marine and terrestrial interactions of coastal processes and management needs (European Environment Agency, 1999).
The dunes are an integral part of the coastal environment. Not only do they provide a reserve of sand used by waves during storms, but they form the basis of important ecosystems, supporting valuable plant and animal communities. On sandy shores, in addition to limiting the intrusion of waves to land, coastal dunes act as a barrier to flooding and ensure an important morphological and ecological transition from the marine to the terrestrial environment (Kidd et al., 2001).
Coastal areas occupy less than 15% of the Earth's surface, but they are home to more than 60% of the world's population. Since 1992, at the United Nations Conference on Environment and Development, it has been found that if this trend continues, by 2025 it could be that 75% of the population will live in coastal areas. Most of the potential global coastal ecosystems threatened by unsustainable development (Figure 1) are located in the northern temperate zone and the northern equatorial zones, with Europe having 86% of its coastal areas at either high or moderate risk (Bryant et al., 1995).

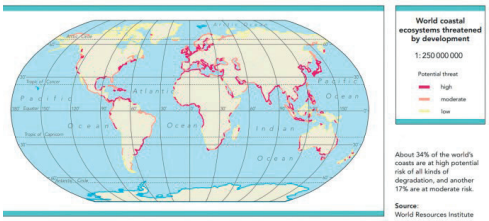

Figure 1. World coastal ecosystems threatened by development. Source: European Environment Agency, Coastal and marine zones, 1999

According to this image and the same source, about 34% of the world's coastal areas have a high-risk potential for all types of degradation, and another 17% of coastal areas have a moderate risk.
Coastal areas are not static. They can change shape quickly, and coastal erosion, due to human activities or natural causes, is a common phenomenon.
In the European Union 25% of the coast is subject to erosion, while 50% is stable, 15% is

degraded, and for the remaining 10% evolution is unknown (Corine, 1998).
In Europe alone, a net loss of 25% of coastal dunes has been reported since 1900, and about 55% of the remaining coastal dune area has lost its natural character (Delbaere, 1998).
The population density and land cover in coastal areas in Europe and Mediterranean Sea are shown below (Figure 2).

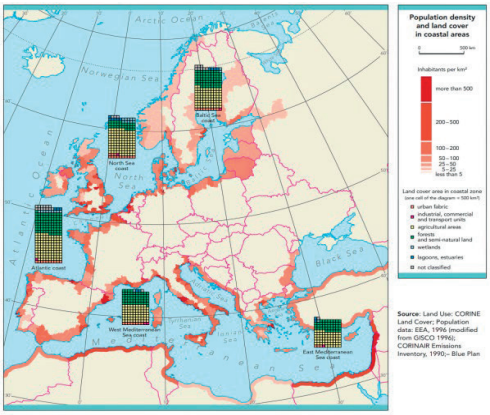

Figure 2. Population density and land cover in coastal areas. Source: European Environment Agency, Coastal and marine zones, 1999

In Israel, for example, about 70% of the population is located in a 1 to 3 km strip along the 190 km Mediterranean coastline.
Beneath (Figure 3) the main factors affecting coastal and marine ecosystems are presented.

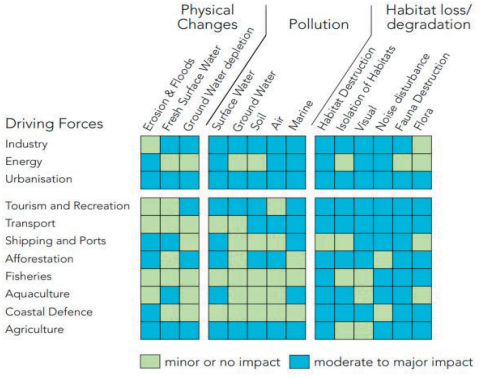

Figure 3. The driving sources and their impacts in coastal areas. Source: European Environment Agency, Coastal and marine zones, 1999

In this context, the paper presents an analysis of the Marine Dunes of Agigea, a protected natural area established in 1939, hosted by the Marine Biological Station "Prof. Dr. Ioan Borcea" which was founded in 1926, in order to put into evidence, the evolution of the site.
The main objective is the conservation of habitats and protected areas, being imperative to protect the natural area of sand dunes. Another goal of the project is to incorporate the history of the site into a sustainable solution that maximizes the existing potential.
The protected natural area "Marine Dunes of Agigea" is the only marine dune reservation in Romania. It is part of the Natura 2000 network of protected areas as a site of community importance with the code ROSCI0073.
The protected site is part of category IV of the International Union for Conservation of Nature, meaning protected areas that are subject to active management interventions for the protection and conservation of natural habitats, flora and fauna characteristics.

MATERIALS AND METHODS

The analysis is focused on assessing with the intervention site and understanding it, so that the solution responds in a clear and concise way to the current situation.
The study was based on several methods of theoretical research, such as consultation, information, documentation and synthesis of bibliography and specialized materials, but also practical research through field visits, field photographs and on-site observations.
The aim of the paper is to identify and solve the needs and issues that the studied area faces. The proposed solution seeks to transform the station into an attractive spot, dedicated to both locals and tourists, especially during the summer, while maintaining the priority research function.
The physical environment analysis (Figure 4), was necessary for the study of winds and currents in the process of formation and stabilization of dunes.
As dunes form as a consequence of the deposition of sand by the waves, its transport carried by the wind inland and stabilized by vegetation, therefore the direction and speed of the wind play a key role, and the dunes recede and grow as they change (Mascarenhas, 1998).

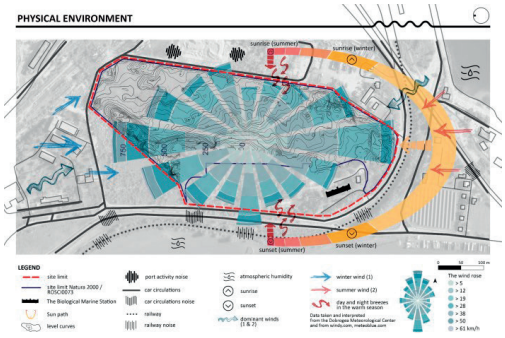

Figure 4. The physical environment analysis

As for the Marine Dunes of Agigea, with the construction of the Port of Constanța South - Agigea, between 1967-1984, the sand dunes were separated from the sea by a concrete road, a railway and a road bridge leading to the ferry terminal. Currently, the site is at a distance of about 200 meters from the sea shore, which over time has led to a series of changes in ecological, microclimatic and edaphic conditions, followed by significant changes in the composition and structure of the vegetation (Management Plan ROSCI0073, 2011).

The historical analysis (Figure 5) reveals that in 1926 was established the Marine Zoological Station "King Ferdinand I" by a royal decree. The site was spread over an area of 9 ha with 1 km of sea, in the immediate vicinity of the coast, an area made up of "land with the sands (dunes) on which during the war some barracks were built by the Germans, now almost complete ruin" (Borcea, 1929).

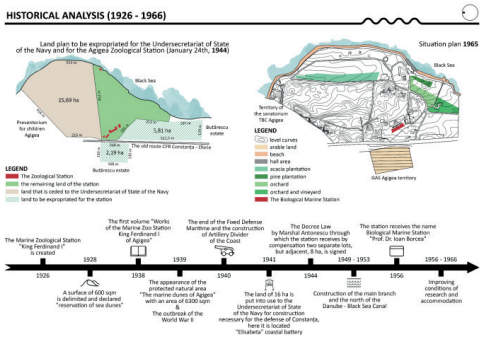

Figure 5. The historical analysis, 1926-1966

At the initiative of Prof. Dr. Ioan Borcea, director of the Zoological Station, a protection zone with an area of 6300 m² has been delimited since 1928 and is declared a "marine dune reservation", which becomes a Nature Monument by Decision of the Scientific Bureau of the Commission "Flora of Romania", published in the Journal of the Council of Ministers no. 142 in 1939.

In the same year, 1939, the protected natural area "Marine Dunes of Agigea" appears, but as a result of the outbreak of the Second World War, Marshal Ion Antonescu decides to fortify the coastal defensive line and part of the site is put into use by the Secretariat of State of the Navy that places here the coastal battery "Elisabeta".

On January 24th 1944, the law decrees signed by Marshal Antonescu, the "State Leader" of Romania, were published in the Official Gazette of Romania, which decides the legal frameworks of an event fulfilled from 1940-1941, when the almost 16 hectares were used for constructions necessary for the defense of Constanța. It is specified that the Zoological Station receives by compensation two separate, but adjacent, plots of land of 8 hectares from the close estate named "Butărescu", while the Ministry of Defense bears the costs of compensation.

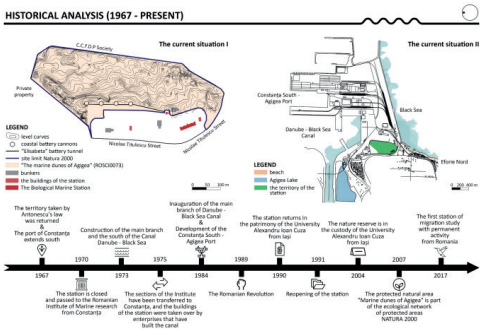

Figure 6. The historical analysis, 1966-present

Research increased in the following decades (Figure 6), but in 1970 the station ceased teaching and went on to research, library and museum under the auspices of the Institute of Marine Research until 1990. During this time, the dune reserve suffered severe damage caused by the construction near of some objectives such as: the Constanța South - Agigea Port, the Danube - Black Sea Canal, the road that separates it from the Black Sea coast, but also by increasing the noise level, due to grazing, the invasion of steppe and ruderal

species, unlimited access of vehicles on their way to new construction areas (Management Plan ROSCI0073, 2011).
Since June 28th 1990, the reservation has been under the tutelage of the Marine Biological Station "Prof. Dr. Ioan Borcea", administered by the "Alexandru Ioan Cuza" University of Iași. From March 2004, the university exercised the custody attributions of the protected natural area (Management Plan ROSCI0073, 2011).

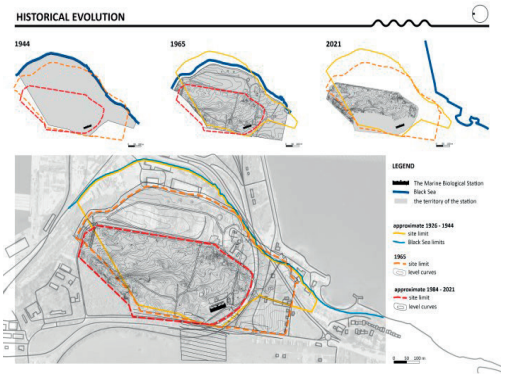

Figure 7. The historical evolution analysis

The historical evolution analysis (Figure 7) shows the administrative boundaries of three different eras of the station. It is noticeable the way in which the site has undergone territorial changes, shrinking significantly and moving considerably away from the Black Sea with the industrial and urban development.
Regarding the flora of the site, in the reservetion, there are two types of priority natural habitats according to the Natura 2000 classification. They were identified based on the 10 characteristic plant associations (Figure 8).

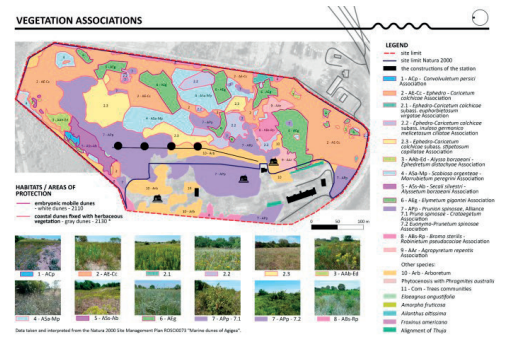

Figure 8. Plant associations

The embryonic mobile dunes (white dunes) and the coastal dunes fixed with herbaceous vegetation (gray dunes) are considered to be of great conservative importance because they shelter communities of rare or very rare plants at the European Community level and national level (Management Plan ROSCI0073, 2011).
Of the associations, only 6 are specific to coastal sands, the others being woody plants and ruderal associations. To the 10 plant associations is added an atypical phytocoenosis with *Phragmites australis* located in a depressed area in the northwest corner of the reserve (Management Plan ROSCI0073, 2011).
The mixed reservation, botanical and zoological, currently houses over 120 species of vascular plants. It is famous especially due to the large local populations of some rare species in Romania, such as: *Alyssum borzaeanum*, *Ephedra distachya*, *Convolvulus persicus*. Other floristic rarities present in the reservation area are: *Silene thymifolia*, *Leymus racemosus* subsp. *sabulosus*, *Dianthus leptopetalus*, *Astragalus varius*, *Salvia aethiopis*, *Seseli campestre*, *Echinops ritro* subsp. *ruthenicus*, etc. (Făgăraș et al., 2008).
Of the 241 taxa registered in the floristic inventory of the protected natural area "Marine Dunes of Agigea" we analyzed in a table 152 species (Figure 9, Figure 10, Figure 11), including planted specimens, located in the administrative space, outside the dune reservation.

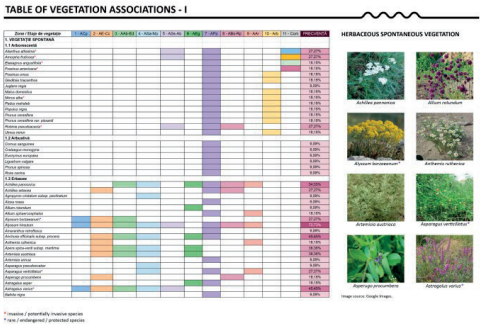

Figure 9. Table I - Plant associations

To the 10 associations were added other 2 components, the arboretum and the wood communities. In the table, we assigned to each column the color from the plant association (Figure 8) in order to see if the species are found in several associations.

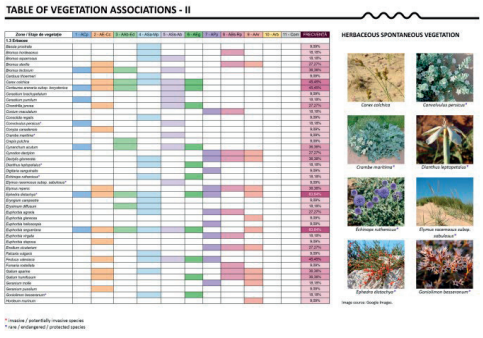

Figure 10. Table II - Plant associations

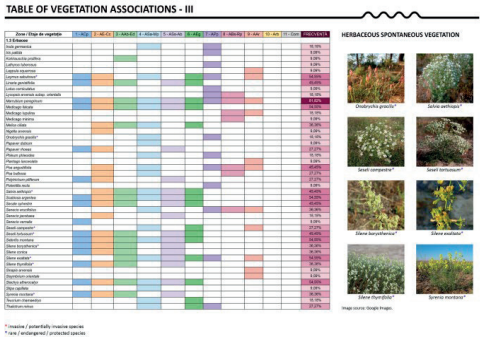

Figure 11. Table III - Plant associations

Moreover, we were able to determine the frequency of the species depending on the number of plant associations in which they are found (Figure 12).

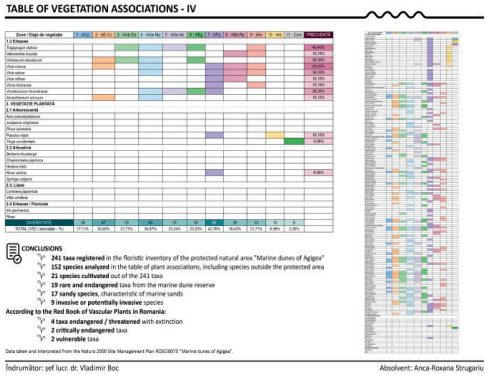

Figure 12. Table IV - Plant associations

As for the fauna of the site, according to the faunal inventory, 442 registered species were reported, of which 353 species are invertebrates and 89 species are vertebrates.

RESULTS AND DISCUSSIONS

The synthesis of the analysis (Figure 13) resulted in the presence of the research point with a vast environmental diversity, but not sufficiently exploited. The studied site is located on the outskirts of Agigea, in an industrial area and not frequented by tourists due to the vicinity of the Constanța South - Agigea Port. In fact, accessibility in the area is reduced and direct access to the Marine Biological Station "Prof. Dr. Ioan Borcea" is difficult. The station is not valued, and its history is not known to the general public.

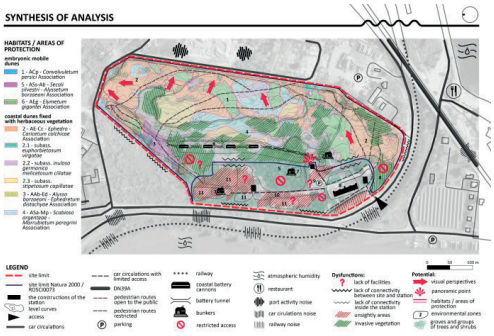

Figure 13. The synthesis of analysis

The spaces at the site level are not arranged and not coherent from a functional organizational point of view. At the ecological level, there are many invasive and potentially invasive specimens that are spreading in conservation areas. From a functional point of view, many areas within the station are tough to access or even have restricted access. There is a physical barrier between the site and the station, represented by the concrete fence that surrounds the station.

The lack of connectivity between the site and the station, as well as the lack of connectivity inside the station, along with the lack of facilities, unsightly areas and the expansion of invasive vegetation, are some of the dysfunctions reported.

However, the potential of the site is high, with many visual perspectives to the port, industrial landscape, which can be interpreted as a type of tourism. Also, Villa Turn, the building made by Marshal Antonescu during the Second World War is a panoramic point with direct views on

habitats and protection areas, respectively dunes, but also on plant associations.

As a diagnosis (Figure 14), the station is a unique natural setting, not integrated in the territorial context. It represents a research point that offers favorable conditions to studies, with floristic and faunal diversity. From the functional point of view, it is noticeable the reduced accessibility and lack of diversity of facilities and functions. Aesthetically, multiple environments are present, being predominant those with natural character. Economically, there is a high potential for tourism due to the location between Constanța and Eforie Nord.

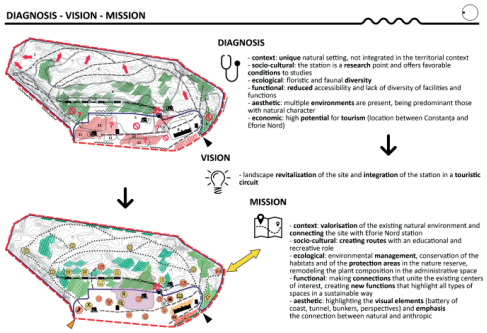

Figure 14. Diagnosis - Vision - Mission

The vision involves the landscape revitalization of the site and the integration of the station in a touristic circuit. The mission is to enhance the existing natural environment and to connect the site with Eforie Nord. Another objective is to create routes with an educational and recreational role. Ecologically, an environment management is recommended, for the conservation of the habitats and for the protection areas in the nature reserve, remodelling the vegetation structure/planting design in the administrative space. Functionally, the project aims to make connections between the existing centres of interest, creating new functions that highlight all types of spaces in a sustainable way. Aesthetically, is it important to call attention to the visual elements (battery of coast, tunnel, bunkers, perspectives).

The macro strategy (Figure 15) illustrates the improvement of connectivity by proposing a bicycle track from the train station, Agigea Ecluză, to the station. This route can also be travelled on a pedestrian alley. On the route there is proposed a street tree alignment, but also various stopping points and bike rental spaces. This route is also addressed to the locals, therefore solving the urban fragmentation of the railway line, which seems to separate the "village hearth" from the new subdivisions from Lake Agigea, near the opening of the Danube - Black Sea Canal in the sea, creating two different entities.

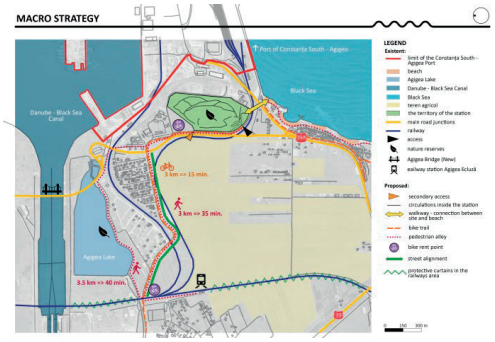

Figure 15. Macro strategy

The strategy at the level of the research station (Figure 16), aims to reorganize the functions, to correlate them with each other.

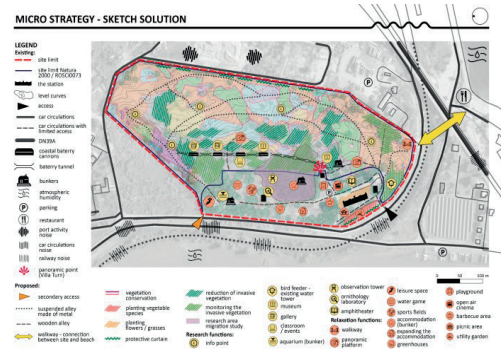

Figure 16. Micro strategy

A secondary access is proposed in the northwest corner of the site, where there are currently several concrete spaces, which will be used and revitalized. In the southern part of the site, a walkway is proposed, a connection between the station and the beach, where there are also two restaurants, and this intervention could facilitate pedestrian access between the two spaces.

The walkway will be located above the railway and below the national road DN39A, the road bridge leading to the ferry terminal.

The general solution (Figure 17) presents a composition designed to interconnect existing points of interest with the proposed functions and interventions, as well as with primary and secondary access.

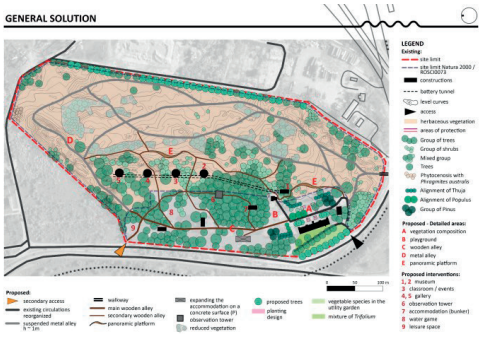

Figure 17. General solution

The vegetal composition is preserved in general, with the mention that the invasive or potentially invasive trees and shrubs on the territory of the dunes in the reserve are reduced, and the surrounding woody vegetation is monitored.

The proposed interventions are meant to highlight the visual elements, but also to emphasize the connection between natural and anthropic. Another proposal is the revitalization of the coastal battery "Elisabeta" by reorganizing the tunnel and its cannons. This space will consist of a museum, a lecture or event room, as well as a gallery, hosting various exhibitions.

In the reservation is encouraged the expansion of existing sandy plant associations in order to conserve the existing habitats and protected areas.

In front of the main building, a planting design concept is proposed (Figure 18).

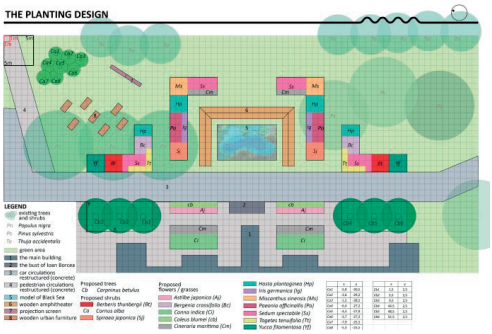

Figure 18. The planting design

In this area, there is the model of the Black Sea, used for teaching purposes. Consequently, we suggest creating an amphitheater around it, including an outdoor cinema area with urban furniture.

It is also shown the seasonal variation (Figure 19) of the decorative features of the proposed plants. They were chosen taking into account the flowering period, the period of decoration, habitus, color, perfume.

The playground (Figure 20) is proposed in front of the Villa, in a space where research does not prevail. It is made entirely of wood, to make a connection of children with nature.

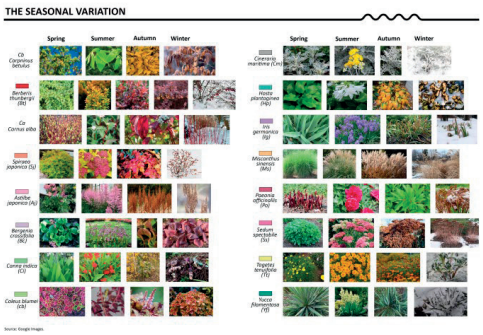

Figure 19. The seasonal variation

Figure 20. Playground

We proposed two panoramic platforms (Figure 21) of organic shapes, made of wood, which will be viewpoints. These platforms are connected to the wooden and metal alleys. The spaces are characterized by the research function, along with the role of walking, contemplation, and relaxation.

Figure 21. Panoramic platforms

The connection between the administrative space and the natural reserve is made through wooden alleys (Figure 22), slightly raised above the ground level, but also through the already existing concrete spaces, restructured and reintegrated within the solution.

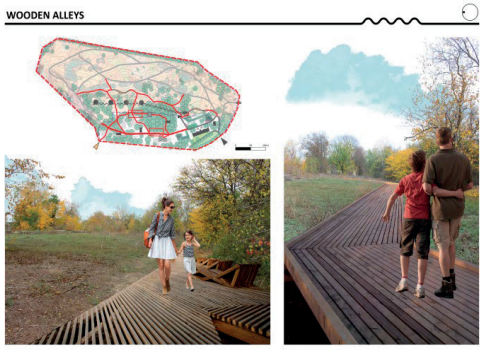

Figure 22. Wooden alleys

Within the protected natural area "Marine Dunes of Agigea", interventions are minimal in order to not endanger habitats and protection areas, with more emphasis on their conservation and the application of environmental management measures. The access to the reservation is made on a suspended alley (Figure 23), at about 1 meter high, made exclusively of metal grid, so that the wind can continue to circulate in normal parameters, without any opaque surface that would complicate this essential aspect. We mention the fact that we started from the initial structure of the existing paths, but we created a firmer and more sinuous route. The alley has information points, located at the intersection of associations or where flora or fauna rarities are present.

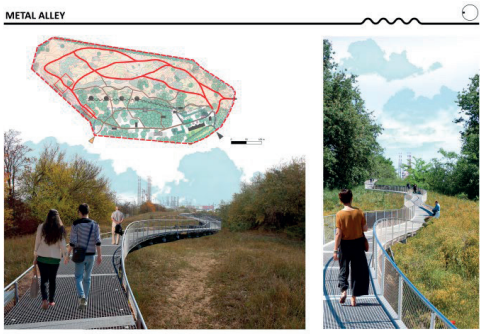

Figure 23. The metal alley in the reservation

CONCLUSIONS

As a conclusion and recommendation, we created a simulation, a staging of works (Figure 24), in case of starting the project in 2022.

Staging of works (simulation in case of starting the project in 2022)

	2022			2023			2024		
	01.03-30.05	01.06-31.08	01.09-30.11	01.03-30.05	01.06-31.08	01.09-30.11	01.03-30.05	01.06-31.08	01.09-30.11
Vegetation reduction									
Vegetation composition									
Playground									
Wooden alley									
Metal alley									
Panoramic platform									
Expanding the accommodation									
Tunnel revitalization									
Bunkers revitalization									
Other interventions									

Figure 24. Staging of works

Regarding the protected natural area "Marine dunes of Agigea", it is recommended to monitor the dune habitats in order to be signaled in advance of any major change in the structure and composition of flora and fauna.
From an ecological point of view, it is recommended to eliminate or reduce, followed by monitoring, invasive and potentially invasive species from the marine dune reserve. Removing them could facilitate the expansion of protected areas and significantly improve their conservation value, as these species contribute greatly to the sanding and humidification of the sands, the stabilization of the dunes and their ruderalisation. Another recommendation is to replace the concrete wall with a type of fence that allows better airflow (Management Plan ROSCI0073, 2011).
The implementation of conservation management measures should lead to an improvement in the current conservation status of dune habitats and representative species, by eliminating threats and creating conditions for

the expansion of sand dunes, specific to marine dunes, for which the nature reserve has been established and declared a Natura 2000 site (Management Plan ROSCI0073, 2011).

As a spatial structure, marking and respecting the visiting routes proposed in the solution could limit the access of a large number of people, but also avoid their trampling of dunes, specific vegetation, floristic rarities, and disturbance of wildlife species in the nature reserve.

Last but not least, the connection with the neighborhoods is a priority, as the station is already located on the outskirts of Agigea. The integration of the station in the urban regulation plans would reduce its isolation and would facilitate its development as a touristic and recreational point.

REFERENCES

Borcea, I., 1929. Staţia Zoologică Marină de la Agigea (Constanţa). *Lucrările I Congres al Naturaliştilor din România, Cluj, 1928. Dare de samă şi comunicări*. Cluj, RO: Editura Societăţii Naturaliştilor din România.

Bryant, D., Rodenburg, E., Cox, T., Nielsen, D., 1995. *Coastlines at Risk: An Index of Potential Development Related Threats to Coastal Ecosystems*. WRI Indicator Brief - World Resources Institute, Washington, D.C., 1995.

Delbaere, B. C. W., 1998. *Facts and figures on European biodiversity*. State and trends 1998-1999. European Centre for Nature Conservation, Tilburg.

Făgăraş, M. (coord.), Skolka, M., Anastasiu, P., Cogălniceanu, D., Negrean, G., Bănică, G., Tudor, M., Samoilă, C., 2008. *Biodiversitatea zonei costiere a Dobrogei dintre Capul Midia şi Capul Kaliakra*. Constanţa, RO: Editura Ex Ponto.

Kidd, R., NSW Department of Land and Water Conservation, 2001. *Coastal Dune Management: A Manual of Coastal Dune Management and Rehabilitation Techniques*. Coastal Unit, DLWC, Newcastle.

Mascarenhas, A., 1998. *Study of goa and its environment from space a report on coastal sand dune ecosystems of goa: Significance, uses and anthropogenic impacts*. Technical report, Dona Paula 403004, Goa.

European Environment Agency, 1998. *Europe's Environment: Second Assessment*. European Environment Agency, Copenhagen. Office for Official Publications of the European Communities & Elsevier Science Ltd.

European Environment Agency, 1999. *Coastal and marine zones: Environment at the turn of the century, Chapter 3/14*. European Environmental Agency, Copenhagen.

Blue Plan, 1998. Mediterranean Commission on Sustainable Development, Tourism and Sustainable Development in the Mediterranean Region, Blue Plan, Conference at Antalya.

Corine Coastal Erosion Project, 1998. Corine Coastal Erosion Atlas. Luxembourg: Office for Official Publications of the European Communities.

Plan de management ROSCI0073 „Dunele marine de la Agigea", 2011.

European Union for Coastal Conservation, 1997. The European Coastal Code – EUCC, Draft 2. A Contribution to Action Theme 5 of the Pan European Biological and Landscape Diversity Strategy.

MISCELLANEOUS


EX·TERRA·AVRVM