

# Sand Dune Destruction Due to Increased Human Impacts along the Bulgarian Black Sea and Estonian Baltic Sea Coasts

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## ABSTRACT

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As a result of rapid coastal zone urbanization, many sand dunes in Europe are currently at risk of degradation by their overuse, misuse or poor management. In this context, using examples from the coastal zones in Bulgaria and Estonia, the present paper is designed to illustrate and analyze critical problems of dune destruction caused by expanding human impact. Sand beaches and associated dune systems are under increasing pressure as the population along the coastlines of both countries is continuously growing. The primary focus of the study is to assess the current state of dunes in the subject countries and to identify the leading human-induced threats to the natural dune systems. Two case study sites were selected: an area around the Sunny Beach Resort and the Nessebar Peninsula, on the southern Bulgarian coast, and an area of Võsu Resort on the southern coast of the Gulf of Finland, northern Estonia. Available data from field surveys, topographic maps, aerial photographs and orthophotos taken at different times were used in order to identify changes in dune landscape. Data processing and analysis were performed in GIS environment. Despite different types of sand dunes and different management measures along the Bulgarian and Estonian coastlines, the results obtained clearly show irreversible alterations to the dune areas and human-induced reduction of the area of dune landscape in general. Nevertheless, the extent of identified damage to the dunes is different in Bulgaria and Estonia. Given the pace and scope of such damage, there is an urgent need to work out recommendations for dune preservation and their proper management in both countries.

**ADDITIONAL INDEX WORDS:** *anthropogenic impacts, sandy beaches, coastal protected areas, tourism*

## INTRODUCTION

Sand dunes are important coastal features as unique ecosystems with richly diverse plant communities. Among other things, they play an important role in sediment balance, but they are highly vulnerable to wave erosion. Due to the changing global climate and expanding coastal urbanisation, sand dunes are exposed to many natural and anthropogenic hazards leading to their progressive degradation. Human impacts could be most damaging because natural recovery of dune ecosystems is either very slow or not possible at all (Doody, 2004). Thus, sand dunes at certain sites in Europe are presently at risk of destruction by their overuse, misuse or poor management. As sea level rises and coastlines become subject to more rapid changes. The role that sand dunes perform in the environment and their sensitivity must be better understood (Fisher, 2004).

In 2010, a joint research project between Bulgaria and Estonia was initiated to study dune changes. Therefore, the main goal of the present paper is to illustrate critical issues of dune landscape destruction under accelerated human impacts through an analysis of two sand dune sites located in the Estonian and Bulgarian coastal zones. The sand beaches and associated dune systems are under increasing pressure as the population along the coastlines of

both countries continues to grow (Palazov and Stanchev, 2006; Ratas *et al.*, 2008). The study aims to assess the current state of sand dunes at the two study sites and to identify the anthropogenic factors that are most damaging to natural dune systems. The results are based on the analysis of two study sites from both countries: an area around the Sunny Beach Resort and the Nessebar Peninsula along the southern part of the Bulgarian coast (Fig. 1) and an area of Võsu Resort in Lahemaa National Park on the southern coast of the Gulf of Finland, northern Estonia (Fig. 2).

## CASE STUDIES DESCRIPTION

### Sand Dunes along the Bulgarian Black Sea Coast

The Bulgarian Black Sea coast is distinguished with large sand dunes located at the northern and middle parts, and with numerous dune complexes along the southern part of the coast. Although widely distributed, the dunes have been poorly explored and described from geologic and geomorphic points of view. There is a lack of information on the genesis of dunes; they are insufficiently categorised; and their morpho-dynamic behaviour

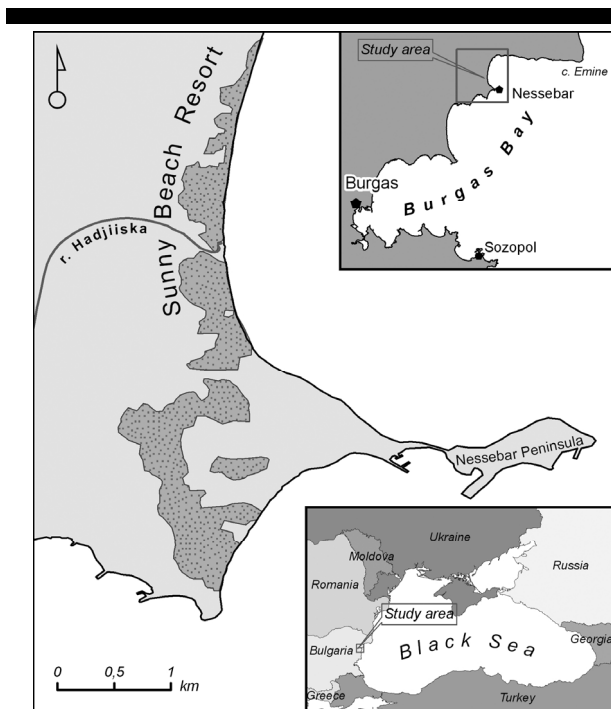


Figure 1. Location of the Bulgarian study area.

has been inadequately studied. It has been suggested that the dunes along the Bulgarian coast developed over the late Holocene (in the last 7,000-5,000 years). They began to form as the climate became warmer and more humid. Floods on the continent strongly eroded the soil cover and produced huge quantities of river sediments. Over the 3,000 year period following the changing climate conditions, strong winds formed the dunes by moving the accumulating marine sands in a westerly direction. Such a process of marine sands movement landward favoured the development of dunes at many sites along the ancient western Black Sea coast. In the low-lying areas, such as between Nessebar Peninsula and Sunny Beach Resort, the aeolian deposits spread far west from the shoreline forming a large strip of several parallel dunes (Gergov, 2001).

At one time, the dune formations along the Bulgarian coast were fairly wide spread, but at present only about 10% of the country's 412 km coastline contains sand dunes (Stancheva, 2010). Dunes vary in type, sand composition and size (between 2 m and 50 m) and they are characterised with typical psammophyte vegetation (Tzonev *et al.*, 2005). Dune systems occur behind larger beaches or in small inlets between erosion coastal sections, where their development has been favoured by the dominant wind direction and ready supply of sediment. Typically, such beach-dune systems or separated dunes consist of beaches, foredunes, parallel mobile and more stabilised or fixed dunes, which are located landward. Dunes in the northern portion of the Bulgarian coast are more sparsely shaped but they embrace wider areas in comparison with the dunes along the southern portion of the coast. The latter are more numerous and have been formed in the inlets between small rocky capes and lagoons. This type of dune distribution is determined primarily from the strength and angle of prevailing winds and the crenulation of the coastline. The northern coast is open and lightly crenulated therefore the dunes embrace wide-ranging areas, while the strongly crenulated

and bay-shaped southern coastline contributes to the formation of numerous inlet dune systems (Fig. 1).

Even though most sand dunes in Bulgaria are subject to some form of legal protection due to their high conservational value as unique habitats (Council Directive 92/43; NATURA, 2000), they have been exposed to increased human pressure, like Kamchia River habitat (grey dunes with wet dune slacks and forested dunes). Together with many other coastal regions, the Bulgarian shoreline has also experienced a real-estate boom driven by an expanding hotel industry and market for second homes. Large hotels have been placed directly on the dunes, especially in the most urbanised areas. Not only are coastal dunes popular sites for hotel building and other intensive recreational uses, but in addition they are also subject to illegal sand extraction (Stancheva, 2010). As a result of such pressures, vast areas have been damaged in order to develop hotels and recreational sites, including the area in the vicinity of the famous Sunny Beach Resort and Nessebar Peninsula, along the southern portion of the Bulgarian Black Sea coast (Fig. 1). In addition, numerous permanent structures installed along the coastline to prevent erosion or protect bays obstruct the movement of sand that could regenerate the dunes. These structures, together with a deficit of new sedimentary material, have severely decreased the capacity of the sand dunes to recovery themselves naturally.

### Sand dunes along the Estonian Baltic Sea Coast

The coastal dune landscapes in Estonia are associated with sandy beaches, which exist along about 16% of the nearly 3,800 km long coastline of the country. They are mostly developed along the south-western and north-eastern parts of the mainland and on Hiiumaa Island. Sandy beaches are quite rare in northern

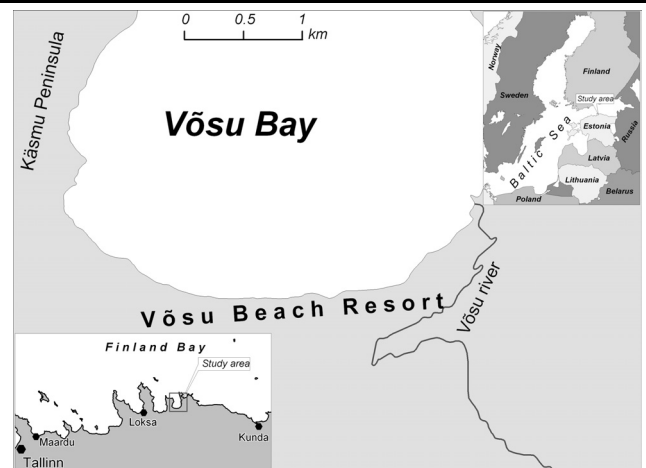


Figure 2. Location of the Estonian study area.

Estonia. Unlike in Bulgaria, the dune systems here are usually smaller. The largest dunes, up to 20-25 m in height, formed during the transgressive phases (Baltic Ice Lake, Ancylus Lake and Litorina Sea) of the Baltic Sea, approximately 11,000-7,000 years ago (Raukas, 1997). A major portion of the dunes (perhaps about 5-15 m in height) formed during the regressive sea conditions in different phases of the Limnea Sea. The shallow sea and strongly indented coastline were the result of land uplift (which today is about 2.8 mm per year according to Vallner *et al.*, (1988) that did not provide favorable conditions for substantial alongshore drift of sand. That is why small ridge-like dunes are the most common

dune type in Estonia. In temperate climatic zones, most dunes become quickly overgrown with vegetation, and loose sand areas are quite rare. The most dynamic areas are sandy beaches and foredunes bordered by beaches. The changes to these areas depend primarily on their openness to prevailing winds and waves. The dunes in Estonia are mainly covered with forest. The forests in the coastal zone have many extremely important environmental functions including protection against erosion. For centuries the character of coastal forests has been affected by heavy storms as well as by forest fires. Among other things, wooded areas were used for grazing. Grazing often destroyed the vegetation and caused sands to move. Moving sand dunes could be stabilized by plants, such as *Pinus sylvestris*, *Pinus mugo* and *Alnus glutinosa*. At the same time, large parts of Estonia's coastal forests have been protected from development for centuries.

Socio-economic conditions, political developments, and differences in the forms of land ownership have all played a large role in the use and development of Estonia's coastal dune areas. Originally, such areas were primarily covered with forest due to sandy soils poor in nutrients and unsuitable for crop fields. At the end of the 19th century, some places with aeolian landscape like in Võsu became summer resorts in Estonia.

As part of the militarized border zone of the former Soviet Union, the coastal zone of Estonia (together with its coastal dunes) was mainly uninhabited and economically unused between 1945 and 1990. During the last few decades, the dune forests in the vicinity of towns have been replaced by private residential areas with numerous summerhouses. Today, coastal dunes are popular areas for recreation, but they are highly fragile ecosystems that can be easily destroyed by, among other things, foot traffic or off-road vehicles. Most often the damaged forests are close to popular beaches or large settlements. The main problem today is a decrease of natural habitats due to afforestation, recreation and building. Nevertheless, major parts of Estonia's dune vegetation are protected today and are well represented in the list of the European Union Habitats (e.g., Council Directive 92/43).

## DATA AND METHODS

The analysis of the studied dune landscapes both in Bulgaria and Estonia is based on the data of field surveys and measurements as well as from maps, aerial photographs and orthophotos from various times in order to identify alterations in shoreline positions, dune contours and areas. In addition, a number of digital photos were collected for a more detailed description and visualisation of the main dune types around the both study sites. Geographic Information System (GIS) technology was used in data processing and interpreting the results.

Two types of data available from different periods were used for the Bulgarian study area: i) 1:25,000 topographic maps (published in 1970) and ii) Digital Globe satellite images from 2005 freely available from Google Earth (<http://www.digitalglobe.com/>). Area change analysis in GIS environment has been used to identify the alterations of sand dune landscape for the period of investigation.

Various study methods have been used for landscape diversity investigations in Estonia. Compilation of landscape (locality) maps (1:10,000) and landscape profiles have been the initial basis for further research. Large scale topographic maps (1:10,000), aerial photographs and orthophotos taken at various times have been used to identify changes in shoreline contours and land use. This retrospective method makes it possible to follow the changes in land use since the beginning of the 20<sup>th</sup> century and in some cases from even earlier times. An analysis of the trend of landscape changes contributes to our understanding of the degree of tolerance and resistance of a landscape to exploitation.

## RESULTS AND DISCUSSION

### Case of Sunny Beach Resort – Nessebar Peninsula (Bulgarian Coast)

The study area is about a 10 km long coastal section between one of Bulgaria's most famous sea resorts, Sunny Beach Resort, and the Nessebar Peninsula, along the southern portion of the Bulgarian Black Sea coast.

The Nessebar Peninsula is situated south of Cape Emine. It is a small peninsula in the northern part of the deepest bay along the Bulgarian coast, the Burgas Bay (Fig. 1). Dune systems and beaches are distributed along the coast of two small bays, situated in the northern and southern parts of the Nessebar Peninsula. The larger dune fields are mostly situated at the areas of Sunny Beach Resort and the town of Nessebar and a larger part of beaches is mainly in the Sunny Beach Resort (Matova, 2000). The resort is centered around the mouth of the Hadjiiska River, and its northern edge stretches to the foothills of the Stara Planina Mountains. From a geomorphic point of view, this area is a firth, which was filled in with sediments over the Holocene (Popov and Mishev, 1974; Matova, 2000). The beach of the resort is one of the largest along the Bulgarian coast with a length of almost 6.0 km and an average width of 53 m. It is composed of fine-grained sands rich in quartz. In the near past the beach was characterised with a typical dune landscape shaped by the dominant NE and N winds. Before human intervention, there were beach dunes reaching a height of 11 m (Popov and Mishev, 1974). There are many other wide dune areas located landward. However, large parts of the dunes were destroyed in the course of developing the resort's hotels. The Hadjiiska River crosses the southern part of the beach. Numerous marshes used to exist between the dunes near the river (Matova, 2000), but in recent years the pressure to fill-in these wetlands to accommodate the growing tourist industry has led to significant and continuing losses of such marshes.

The Sunny Beach Resort (Fig. 3) was one of the famous Bulgarian Black Sea resorts established in the 1950s, and since that time its tourism-based infrastructure has only grown larger. According to the official data from the National Statistical Institute (Sandeva *et al.*, 2006), in 2005 the number of hotels in

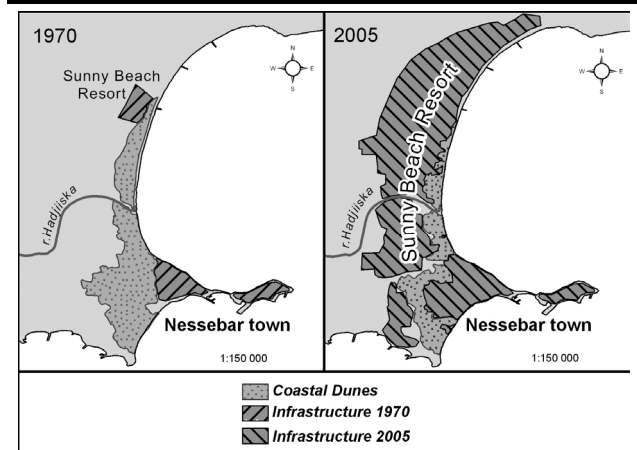


Figure 3. Changes in dune areas between 1970 and 2005.

the resort was 120 with 51 251 bed places. In 2005 the total number of functioning hotels for the entire country was 1 230, while 120 (almost 10%) of them were located in the Sunny Beach Resort (Palazov and Stanchev, 2006). Moreover, the coastal

population in the municipality of Nessebar has doubled over the period between 1934 and 2008, from 11838 to 21142 inhabitants. Based on the most recent Census data, the population of Nessebar town increased from 2333 residents in 1965 to 8677 in 2001 (NSI, 2002).

Located to the north of the Nessebar Peninsula is a longer dune complex with a smaller area (Fig. 1 and Fig. 3). South of the Nessebar Peninsula is a dune complex with a larger area (over 1 km<sup>2</sup>), but under continuous disruption due to the increasing growth of the Nessebar town to the west. Changes in the area and contours of the dune complexes were analyzed over a 35 year period based on topographic maps in scale 1:25,000 from 1970 and modern satellite image data from 2005 (Fig. 3). The initial maps show the dune complexes at a time prior to the development that existed later. The results obtained clearly show the alterations of dune areas and contours and reduction of the area of dune landscape. In the 1960-70s, the sand dune area of the studied coastal section was 2.26 km<sup>2</sup>, while this area has decreased to 1.25 km<sup>2</sup> in 2005 (Fig. 3). On the other hand, the area that has been subject to development has significantly grown: from 0.77 km<sup>2</sup> in 1970 to 6.5 km<sup>2</sup> in 2005.

Natural factors which could cause dune destruction are mainly related to insufficient sediment supply and erosion. As a low-lying territory, the studied area is also exposed to a high risk of flooding from extreme storm surges that cause beach inundation and sand dune erosion (Palazov *et al.*, 2007).

However, human impact constitutes the primary threat to the sand dunes in the study area. The most significant influence from tourism development began at the end of the 1990s and has been expanding steadily since 2005. It continues today. The principal sources of human impact are rapid coastal urbanization (i.e., hotel and residential construction, roads, parking structures, and other related infrastructure), unregulated camping and “temporary” construction on the dunes, a lax regulatory environment that tolerates the re-zoning of protected sand dunes to “agricultural” areas (thereby allowing for easier transition for development), and the existence of permanent structures that impair the ability of the dunes to regenerate themselves. Notwithstanding the protected status of the coastal area in the Sunny Beach Resort, many dune fields have been levelled or reduced, and the active dune areas have dramatically decreased (Tzonev *et al.*, 2005). The steady development of the area on and around the dune complexes impairs the possibility for a natural recovery, and there are no sand dune restoration projects on the horizon.

Our research suggests that dunes situated around rapidly urbanizing areas tend not to regenerate themselves once they are damaged or destroyed. Therefore, there is an urgent need to establish measures to protect sand dunes and safeguard the ecosystems that they support. Indeed, at Sunny Beach Resort, it is an open question as to whether scientists and coastal land use planners will be able to preserve what is left of the dune complexes that still exist there.

### Case of Võsu Resort (Estonian Coast)

Võsu, one of the best known resorts in northern Estonia is a small borough (ca 6 km<sup>2</sup>) about 80 km east of Tallinn. Võsu is situated on the southern coast of Käsnu Bay (part of the Gulf of Finland). The bay is open to northern winds. The area consists of a sandy beach (about 1.2 km long and ca. 50 m wide) and ridge-like dunes covered with forest (Fig.4). The Võsu River flows through the resort. The dunes are mostly covered with dry pine forests, which are fragile ecosystems that can be easily destroyed through by foot traffic or off-road vehicles. Founded in the 19th century, Võsu is one of the oldest summer resorts in Estonia. At that time,

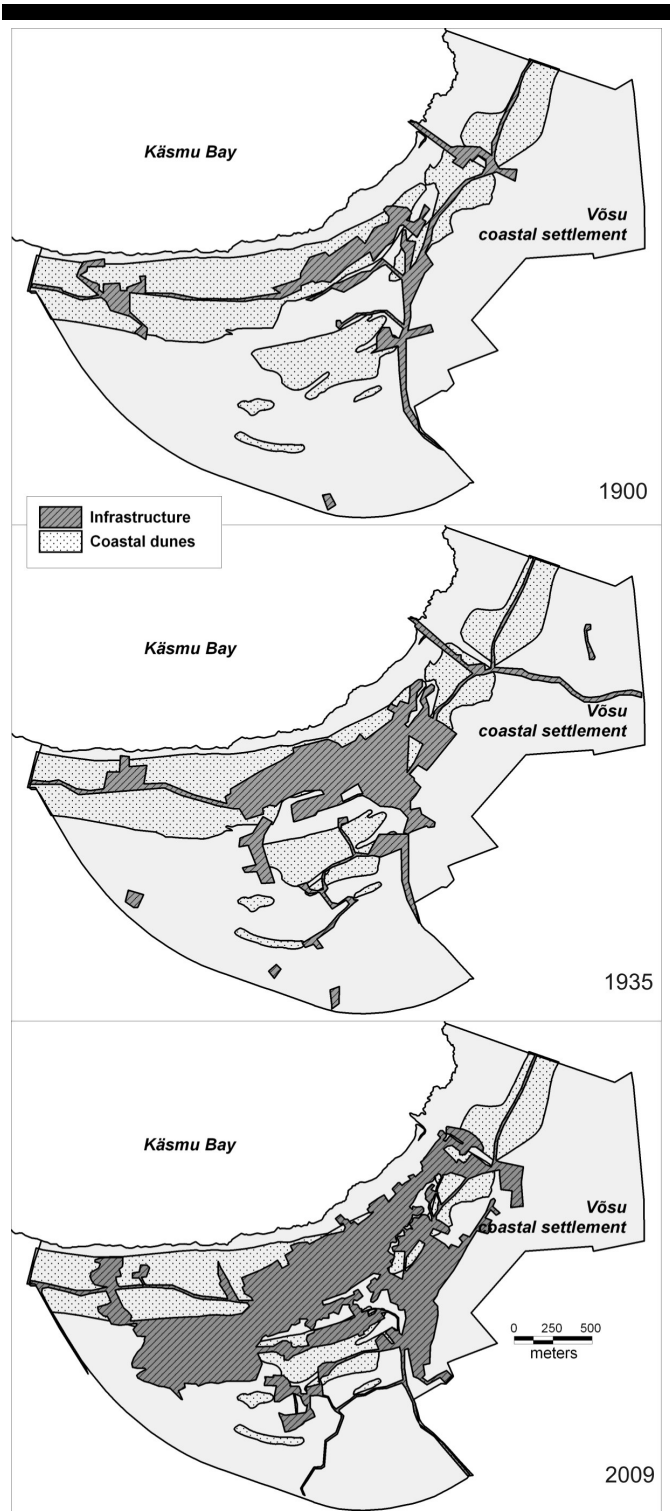


Figure 4. Changes in dune areas between 1900 and 2008.

it was a small coastal village. The most famous period for the resort was before the First World War. It became a favorite holiday destination for wealthy guests from Tallinn, Tartu, St. Petersburg and Moscow. At that time, it roughly doubled in size, servicing between 2,000 to 3,000 summer guests each year.

The next period of expansion occurred during the Soviet period (the second half of the 20<sup>th</sup> century). At that time, the number of permanent local inhabitants reached approximately 600, and about 500 holiday houses, camps and summer cottages were built. About 3,500 people spent their summer vacation there, and up to 1,500 people visited Vösu daily. As the town expanded, it pushed out primarily in the south-western direction.

After regaining independence in 1991, the number of vacationers decreased along with the resources available for new construction. Only about 1,200 vacationers a day were counted in the middle of the 1990s.

Still, during hot weather, the number of visitors to Vösu could spike as it drew in visitors from people living in nearby towns such as Rakvere, Tapa, and Tallinn. On some hot summer days, the number of people on the beach exceeded 4,000.

The major environmental issue at the Vösu Resort over recent decades is the reduction of the forested area adjacent to the beach and the destruction of the field layer of the forest including in Natura 2000 habitats. The results of the analysis of changes in land cover pattern in the study area (1.6 km<sup>2</sup>) clearly show this. About 70% of the study area was covered with forest in the beginning of the 20th century while the residential area occupied only 8%. By the end of the past century the forested area decreased considerably (to about 55%) and the residential area increased (to about 30%) (Fig. 4). The structure of the land cover has not changed significantly during the last decade. Serious problems occur also on the beach where strong storms of recent decades and inadequate management have led to a catastrophic retreat and destruction of the beach. Lately, the importance of protecting what remains at Vösu has been recognized, and some regulations have been passed to help restore and preserve the natural ecosystems there.

The development of the Vösu Resort in the future is closely related to the development of the adjacent areas, which has received much attention in recent years. As the area will continue to face development pressures associated with tourism – e.g., marine, conference, spa and nature tourism – a comprehensive management plan is needed in order to reconcile the various competing development interests with the preservation of the unique natural environment that still exists there.

## CONCLUSIONS

The results obtained from the study demonstrate a progressive reduction of sand dunes mostly due to accelerated urbanization and increased anthropogenic pressure. Different types of human impacts have been identified over the recent years in both case studies: expanding coastal habitation and tourism/real-estate boom in the section between the Sunny Beach Resort and Nessebar Peninsula, and reduction of forested area and loss of valuable habitats in the coastal area of the Vösu Resort. In conclusion, there is an urgent need to establish recommendations for dune preservation and their proper management both in Estonia and Bulgaria, including regulations for the sustainable use of coastal land for tourism. In this regard, the study outcomes would provide additional information to facilitate public awareness on human-induced risks for sand dune systems, as well as to support a generation of indicators for relevant use and conservation of these valuable resources.

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