**Geo-Ecology of Dunes along the Mediterranean Coast of Israel**

1. **Brief Description**

Coastal dunes are essential for human beings as they provide several ecosystem services, such as protecting the coast from erosion and supporting groundwater storage and tourism. Despite these services, coastal dunes have been damaged and almost disappeared due to human beings' progressive deterioration of the coastal landscapes. NASA satellite imagery of Earth at night emphasizes the contours of the continents due to the intense glittering lights along the coasts, indicating that more than half of the world's population lives along coasts. Thus, unsurprisingly, coastal dunes are currently listed among the most endangered ecosystems worldwide (Defeo et al., 2009) coastal dune). The situation is similar in the Mediterranean Basin, recognized as the second-largest global Biodiversity Hotspot, encompassing terrestrial and marine environments. Mulen & Salman (1996) were the first to report that between 1960-1990, almost 75% of the Mediterranean coastal dunes had been damaged or destroyed.

The European Threatened List of Habitats (2016) classified the European coastal habitats, especially the coastal dunes, as "threatened". The damage to the coastal dunes is especially noticeable on the coast of the Mediterranean Basin, where the coastal dunes have experienced a widespread decline in extent and quality, with common threats being from intensive urbanization, infrastructures, tourism, and the spontaneous spread of invasive alien species. The fate of the coastal dunes in this region is particularly uncertain, where the consequences of climate change, sea-level rise, and extreme events are predicted to be especially severe.

Several studies have been conducted in several countries in the Mediterranean basin, mainly in Europe (Italy, Greece, France, and Spain), in coastal dune ecology, with a significant part of them being done in Italy. The studies focus mainly on vegetation-related issues, perennial vegetation, and a database of a few years. Recently, a study has been done on 75 kilometers of coastal dune systems located along the Tyrrhenian and Adriatic coasts of Central Italy based on vegetation data from 10-15 years. The results reveal significant plant community structure and composition changes due to species loss. Together with the disappearance of 23% of historical plots and substantial losses in focal species, these results suggest that intense degradation processes occur in coastal dune habitats, particularly on the upper beach and on shifting dunes, within a short period of 15 years.

Israel lies in the eastern Mediterranean Basin with a coastline along the Mediterranean Sea with a length of 195 km. The situation of the dunes is no different from that described above. More than half of the population lives along the Mediterranean coast, with a density ranging from 2,000 to 16,000 people per square kilometer. The highest density is found in the Central District. In addition to residential buildings, this area is home to extensive transport infrastructure, industrial facilities, power plants, desalination plants, sewage treatment plants, ports, and more. Over the years, vast dunes along the coasts have given way to built-up areas, and the sand has been used for construction. From the establishment of the State of Israel until the end of the 20th century, 20 million cubic meters of sand were torn off the coast: about 10 million cubic meters were mined for construction between the years1949-1964, and more than 10 million cubic meters have been trapped to date in ports, marinas, breakwaters and around every body of water built along the coastline. The coastal dunes are also a highly sought-after tourist resource by being adjacent to the sea and large urban centers. The dimensions of development and tourist activity on the Israeli Mediterranean coast have intensified over the years. The most crucial coastal dunes nature reserves are the Caesarea dune area and the coastal dunes south of Tel Aviv – Palmachim, Nizzanim, Zikim, and Netiv Ha'asara. These nature reserves occupy only 32 square kilometers, about 90% on the southern coastal plain.

Roads and built-up areas fragment these reserves. The lack of spatial contiguity between the nature reserves and the intensive construction near them affects the ecosystems that characterize the coastal dunes and threaten their integrity and continuity. Geomorphological and ecological studies have been carried out over the years at various sites along the coast, especially in one of the largest and most relatively preserved nature reserves until recently, Nizzanim LTER nature reserve. Data on plants and animals (arthropods, reptiles, and rodents) have been collected in Nizzanim for 15 years. This book aims to present all the information on the geo-ecology of the coastal dunes accumulated from studies done in this region. All books about coastal dunes generally focus mainly on the geomorphology and vegetation of diverse habitats in the coastal area, including shifting and fixed dunes. No such book is offered below, which focuses only on the shifting' semi-fixed and fixed dunes and includes four different taxa (plants, arthropods, reptiles, and rodents) that vary in time and space, depending on the dune state of fixation. The book includes 11 chapters that include geomorphology, soil, plants and animals, conservation, and the management of coastal dunes.

1. **Outline / Table of Content**

**Introduction**

**Acknowledgments**

**Chapter 1**

**Structure and Geomorphological Processes of Coastal Dunes**

This chapter describes dune types on the coast along the Mediterranean Sea coast in Israel, their characteristics, their creation processes, the source of the sand, and the periods of their invasion into our region.

**Chapter 2**

**Soil Development Processes and Characteristics**

This chapter describes dune soil formation processes during their fixation from shifting dunes to fixed dunes. There is a reference to soil structure and measures of texture, soil moisture, field capacity, hydraulic conductivity, and soil organic matter. The reference is at the macro level (shifting, semi-fixed, and fixed dunes) and at the micro level (differences in soil properties under shrubs and in the open spaces between the shrubs).

**Chapter 3**

**Main Dune Areas on the Coastal Plain**

This chapter describes the changes that have occurred since 1980 and until today in the size of the dune areas along the coast of Israel, their characteristics, and their ecological uniqueness.

**Chapter 4**

**Flora and Vegetation**

This chapter focuses on perennials and annual plants. The chapter begins with the perennial plants, their uniqueness, their impact on the dune fixation, and soil properties changes during dune fixation (Environmental Engineers). Below there is a description of the perennial communities. An extended sub-chapter is dedicated to *Artemisia monosperma*, a dominant psammophytic dwarf shrub distributed in the East Mediterranean region and Arabian Peninsula, considered a keystone species. This chapter continues with the annual plants' importance and uniqueness in the sandy dune habitats and the degree of their communities' affinity to the level of sand mobility determined by the Sendiness Index developed for this purpose. This index can be used for the same purpose for other taxa. Likewise, the spatial distribution and the temporal stability of the annual plant communities are described. An additional sub-chapter is dedicated to the annual plant's seed bank.

**Chapter 5**

**Arthropods**

The chapter focuses on arthropods in sandy dunes. The chapter begins with a brief overview of studies done worldwide on arthropods, especially beetles, in dunes and continues with the studies carried out in Israel until 2000. From here, the chapter continues with all the knowledge accumulated in Israel since then, which resulted from the studies carried out mainly in the LTER sand reserve of Nitzanim for 12 consecutive years. The chapter describes the relationship between the dune types (mobile' semi-fixed, and fixed) and the patch types (under the shrubs and in the open among the shrubs) and arthropod communities and their affinity to the dune mobility state, using Sandiness Index. A summary table with the list of endemic species in the Levant accompanies this sub-chapter with details of the species, the characteristic habitat for each species, its geographical distribution, and its Sandiness Index. Another sub-chapter is dedicated to two flagship species, one of which characterizes mobile dunes and the other stabilized dunes and to the unique ants characteristic to the coastal sands in Israel.

**Chapter 6**

**Reptiles**

The chapter focuses on the reptiles in the coastal sand dunes of Israel. It begins with an overview of the adaptations developed by the reptiles to the limiting factors characteristic of the dunes. It compares the distribution patterns of the reptiles in the coastal dunes to those in other sandy areas in Israel. Two tables in this chapter: One presents a list of the reptile species found in Nizzanim LTER nature reserve, the distribution of each species and its prevalence rate in each of the dune types (mobile, semi-fixed, and fixed dunes), and the second a list of reptile species with a high affinity for sand with details about each of the species (distribution, food, activity times, conservation status, etc.). Another sub-chapter presents a detailed review of studies on three characteristics of lizards in the coastal sands (*Acanthodactylus scutellatus*, *A. schreiberi,* and *Varanus griseus*).

**Chapter 7**

**Rodents**

The number of rodents in the coastal sands in Israel is low and amounts to four main species, one of which is endemic to Israel. In this chapter, there is an overview of each species' association with the dune mobility state, their relationships in areas where their ecological range overlap, and the temporal stability of the rodent community

**Chapter 8**

**Human Impact and Climate Change on Coastal Dune Ecosystems**

This chapter deals with various human influences on the coastal dunes, which cause their disappearance from the landscape and fundamental changes in their geomorphological properties and plants and animal composition characteristic to coastal dunes in the remaining dunes. This chapter has several sub-chapters: reduction of sand areas over the years, fixation of mobile dunes by native vegetation, invasion and spread of invasive species (mainly *Acacia saligna* and *Heteroteca subexilaris*, two dominant species that cover aversively the coastal dunes and on which quite a few studies have been conducted on them), the effects of off-road vehicles and climate change.

**Chapter 9**

**Ecological-Economical Losses Due to the Loss and Fixation of Coastal Dunes**

This chapter deals with the ecosystem services the coastal dunes provide to humbling. The chapter describes several surveys conducted at several coastal dune sites in Israel that aimed to evaluate the importance of these services as perceived by people who visit and do not visit those sites.

**Chapter 10**

**Policy, Planning, and Conflicts between Stakeholders**

This chapter deals with conservation policy, planning, and conflicts between stakeholders that affect the state of the dunes and the landscape of the coastal dunes in Israel

**Chapter 11**

**Conservation and Management of Coastal Dunes**

This chapter deals with the conservation policy and management of coastal dunes in Israel. This chapter has four sub-chapters: restoration management of coastal dunes ecosystem, which is based on the mechanical removal of local woody vegetation from some of the dunes to turn them into shifting dunes; grazing by goats and camels to remove the local vegetation, mainly of the dominant dwarf shrub species *Artemisia monosperm*, the third discusses the rehabilitation of trails created spontaneously by pedestrians, ATVs, and 4x4 vehicles, and the fourth subchapter deals with the treatment of invasive plant species.

**Epilog**

Sum and conclusions of the book author regarding the future of the coastal dunes in Israel and in the entire Mediterranean basin as well

**Bibliography**

**The bibliography includes a list of about 400 citations on studies conducted in Israel and worldwide.**

1. **Market Consideration**

This book is written for scholars. graduate students, advanced undergraduates, and policy decision-makers interested in ecology and conservation and management of coastal dunes.

One-tenth of the Earth's land surface is covered with dunes and sand plains concentrated mainly in deserts and along coasts. Therefore, it is unsurprising that many researchers are engaged in dune studies. I am exposed to various ecological work in the field that has been done worldwide, whether out of personal interest in the subject or because I am often invited to review manuscripts dealing with diverse ecological aspects of coastal dunes.

The book, recently published in Hebrew on a relatively limited scale, is currently distributed mainly by the Israeli Nature and National Parks Authority. Researchers, graduate students, nature lovers, and rangers of sand reserves in Israel approached me with a request to purchase the book. The reactions of the people and the local press were exciting, which motivated me to write a more detailed text in English for a broad target audience.

The book can also serve as a base book for advanced courses in ecology, especially on topics related to the geo-ecology of coastal dunes. The book contains many figures and color pictures, among other things, of unique and exciting plants and animals inhabiting coastal dunes in Israel and the Levant

1. **Comparable and Competing Books**

Most of the books focus on dunes on a global scale or temperate and tropics regions. Some books are devoted to geomorphic phenomena and processes, such as the book of Pye, K., & Tsoar, H. (2008) *Aeolian Sand and Sand Dunes*. Springer Science & Business Media. Another part relates to the biology /ecology of coastal dunes, emphasizing vegetation, such as the book by Maun, M. A. (2009). *The Biology of Coastal Sand Dunes*. Oxford University Press. Some books contain chapters from various researchers on different topics related to coastal dunes, such as Martínez, M. L., & Psuty, N. P. (Eds.) (2004). *Coastal Dunes*. Ecology and Conservation Berlin: Springer Verlag and Martínez, L. M., Gallego-Fernández, J. B., & Hesp, P. A. (Eds.). (2013). *Restoration of Coastal Dunes*.

Doody wrote a few books that included a general review of the habitat and its conservation and management and summary descriptions of the status of the sand dunes in most of the countries in Europe' such as:

Doody, J. P. (Ed.). (1991). *Sand Dune Inventory of Europe*. JNCC/EUCC.

Doody, J. P. (2001).*Coastal Conservation and Management: An Ecological Perspective* (Vol. 13). Springer Science & Business Media.

Doody, J. P. (2012). *Sand Dune Conservation, Management and Restoration* (Vol. 4). Springer Science & Business Media.

No books have focused on the geo-ecology of coastal dunes in the Mediterranean Basin, especially not for the southern and eastern regions. The proposed book entitled "Geoecology of Coastal Dunes" concentrates only on the habitats of the coastal dunes in Israel. The book includes knowledge based on consecutive studies conducted over 15 years and on specific topics even more. The studies included aspects of dune geomorphology and soils, vegetation, and animals (arthropods, reptiles, and rodents). The book refers to the spatial distribution of plants and animals, their interactions, and their stability over time. In addition, two chapters focus on human influence on this crucial and sensitive ecosystem and suggestions for managing and conserving the dunes in light of the far-reaching changes that have existed over the past 70 years. In practice, the book records what there is today in the eastern part of the Mediterranean basin, and it is not sure whether it will exist in the future.

1. **Apparatus / Illustrative Materials**

It is estimated that the book will contain: About 200 photos, 95% of which are colorful, and the rest are black and white (archival photos). A significant portion of the pictures will be concentrated on boards, such as boards of plant and animal species. About 40 figures and 21 tables

1. **Status of the Work**

The book in Hebrew was published in December 2022. Since then, additional new information has been added to that appears in the Hebrew version. In addition, in the proposed book, the introduction will include a broad literature review of the state of the coastal dunes and the geo-ecological knowledge that exists for the coastal dunes in the Levant region except for Israel (from Morocco in the west to Lebanon in the northeast). The book will be translated into English and undergo academic editing as required. The book manuscript is expected to be ready within a year and a half, at the latest, two years since the contract will be signed between all the parties concerned.

1. **Possible Reviewers**

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