**Dune Complexes of the Israeli Coastal Plain**

Israel's coastal plain has four main dune complexes: the Caesarea, Palmachim, Nitzanim, and Netiv HaAsara dunes (Figures 4-7). The sand sources and climatic conditions are similar in all four complexes but vary in soil composition and plant and animal communities. The main differences are found between the Caesarea dunes, located in the coastal plain north of the Yarkon River, and the two southern complexes, Palmachim and Nitzanim, situated south of the Yarkon River. Our research took place in these three areas and is the book's focus.

The Caesarea Sand Dunes

The Caesarea dune complex extends from the Taninim Stream in the north to the Hadera Stream in the south, and from the Mediterranean Sea in the west to the Tel Aviv-Haifa railway line in the east. It is an area of 32 square kilometers (Figure 4) and is characterized by three geomorphological units: dunes and sand plains, red loam soil (Hamra soil), and eolianite ridges. The latter two are covered with younger dunes of various thicknesses.



Figure 4: The Caesarea dune complex shows a decrease in shifting dunes in favor of fixed dunes and other land uses between 1880 and 2021. The figures are based on a topographic map by the Palestine Exploration Fund (PEF) from 1880, a 2018 survey of vegetation cover and built-up area by the National Program for the Assessment of the State of Nature in Israel, and satellite images from the Landsat program for the years 1984 and 2021 (courtesy of Noam Levin).



Image 13: Coastal open forest with common carob (*Ceratonia siliqua*) trees and mastic (*Pistacia lentiscus*) shrubs in the Caesarea dunes (Photo: Pua Bar).

The Caesarea dune complex consists of some shifting dunes but mainly semi-fixed and fixed dunes. The dunes cover the area up to approximately 6.5 kilometers east of the coast. In most dune areas, the layer of sand covering the red loam soil (Hamra) and eolianite ridges is 0.5 to 10 meters thick. Most shifting dunes are east of Highway 4; lower shifting dunes are west of the highway. The area is intersected by Highway 4 and the Coastal Highway (Highway 2) from north to south, by the crossroads of Highways 65 and 651, and by settlements in the area—Caesarea, Or Akiva, and the Caesarea industrial zone.

This dune area is distinguished by the perennial vegetation community in the fixed dunes, dominated by *Helianthemum stipulatum* (Samson's shrub), and the common carob (*Ceratonia siliqua*) trees and mastic shrub (*Pistacia lentiscus*) community in the coastal open forest, dominating the sandy plains (in contrast to typical carob and mastic open forest communities that typically appear in the higher lowlands). The coastal open forest is unique within Israel's coastal plain and even within the Mediterranean Basin (Kutiel et al. 1980, Photo 13).

Moreover, in this dune complex, there are plant species that are almost unfound in the southern dune complexes; for example, *Ballota philistaea*— a perennial herb characteristic of fixed dunes, which is endemic to the coastal plain and a small area in the Adom Mountains in Jordan—is defined in Israel as an endangered species. There are also unique annual plant species in the area, such as *Aegilops sharonensis*, an endemic species with a distribution limited to the coasts of Israel and Lebanon; *Medicago italica*, a species endemic to the Mediterranean Basin; and *Lobularia libyca*, a cruciferous plant with a desert (Saharo-Arabian) distribution, which is rare and endangered in Israel.

The dune complex in this region has significantly decreased over the years (Figure 7), mainly due to the expansion of developed urbanized areas and other infrastructure, such as roads and railways (Kutiel & Sharon 1996). Only recently was the coastal dune vegetation in the southern part of the Caesarea dune complex cleared for further urban expansion.

Palmachim-Yavne Dunes

This dune complex, which encompasses Kibbutz Palmachim and the city of Yavne, extends from the Sorek River in the north to the Lachish River in the south and from Highway 4 (connecting Tel Aviv and Ashdod) in the east to the Mediterranean Sea in the west. The total area of this dune complex used to be 64 square kilometers. Currently, only 12 square kilometers remain in a relatively natural state; half of the area (621 ha) has been declared a nature reserve and is within a military area in the western part of the dune complex (Figure 5).

Most of the dunes in this area are semi-fixed. The northern section, below the Sorek River, is relatively well-preserved, while the rest of the area has been disturbed by invasive species such as *Acacia saligna* and *Heterotheca subaxillaris*, in addition to other disturbances (Cohen et al. 2007; Ben-Shachar 2010; Cohen et al. 2018; 2019a, Figure 7 and Photo 14).



Photo 14: Invasive species in the Palmachim dunes: In the foreground is *Heterotheca subaxillaris*, and in the background is the Sorek River with a thicket of common reed (*Phragmites australis*) growing in its channel, *Acacia saligna* trees along its banks, and planted eucalyptus trees (Photo: Pua Bar).



Figure 5: From 1880 to 2021, there was a reduction in the area of shifting dunes in the Palmachim-Yavne dunes in favor of fixed dunes and other land uses. The figures are based on the topographic map of the PEF from 1880, a survey of vegetation cover and built-up area by the National Program for the Assessment of the State of Nature in Israel from 2018, and satellite images from the Landsat program for the years 1984 and 2021 (courtesy of Noam Levin).

In the Palmachim dunes, there are no distinctive species of animals or plants, but the area is highly valued both scenically and zoologically. In a survey conducted in 2008 by Gal and colleagues, 126 plant species with a high affinity for sand were found, 60 of which were defined as "red species"— species at risk of extinction. The Palmachim dunes are the southernmost distribution range of *Silene modesta*, a rare plant on the verge of extinction, and the northernmost distribution range of the following reptiles: the false smooth snake (*Macroprotodon cucullatus*), Simon worm snake (*Rhinotyphlops simoni*), and the Roth's dwarf racer (*Eirenis rothii*) (Achiron-Frumkin and colleagues 2003; Gal et al. 2008).

Nitzanim Sand Dune Nature Reserve

The Nitzanim Sand Dune Nature Reserve is the largest dune reserve complex in the coastal plain. It is located in the southern part of the coastal plain, between the cities of Ashdod and Ashkelon, with the Mediterranean Sea bordering it to the west. A marine reserve was declared in 2008, covering the first two kilometers from the coast into the sea.. To the east of the dune reserve are the community settlements of Be'er Ganim and Nitzan. The reserve area is 20 square kilometers, comprised of approximately 70% semi-fixed dunes, 20% shifting dunes, and 10% fixed dunes (Photo 15). The height of the shifting dunes can reach up to 12 meters above the underlying paleosol layer, and the height of the semi-fixed and fixed dunes reaches about 5 meters above the paleosol layer.



Photo 15: Nitzanim Sand Dune Nature Reserve, aerial photograph (Photo: Pua Bar).

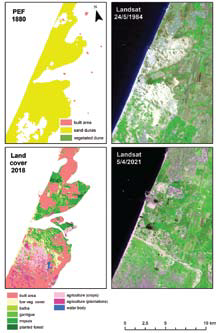


Figure 6: From 1880 to 2021, there was a reduction in the shifting dunes area in the Nitzanim dunes (A) and Netiv HaAsara dunes (B) in favor of fixed dunes and other land uses. The figures are based on the topographic map of the PEF from 1880, a survey of vegetation cover and built-up area by the National Program for the Assessment of the State of Nature in Israel from 2018, and satellite images from the Landsat program for the years 1984 and 2021 (courtesy of Noam Levin).

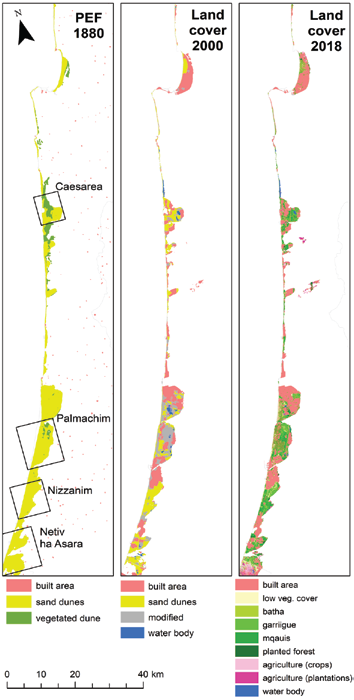


Figure 7: Changes in land use that occurred between 1880 and 2018 in the dune complex of the coastal plain. The figures are based on the PEF map from 1880, a 2000 dune survey by the Society for the Protection of Nature in Israel, and a survey of vegetation cover and built-up areas by the National Program for the Assessment of the State of Nature in Israel (Nature Status Report 2018) (courtesy of Noam Levin).

The Nitzanim Reserve, like all of the dune complexes along the coastal plain, has changed over time. These changes are mainly due to the fixation process of the dunes, the effects of the cities and small settlements near the reserve, as well as the activities of the Israel Defence Forces and the off-road vehicles it utilizes (Figure 6).

The Avtach Stream flows through the reserve from east to west. The area to the south of it is designated as a fire zone and was declared a nature reserve in 2005, while the northern part was declared in 2008. The reserve also contains, besides the native vegetation, cultivated plants such as grape vines and olive, pomegranate, and sycamore trees, primarily concentrated in the interdunal depressions, remnants from the Arab (Mawasi) agriculture that existed in the area until the establishment of the state of Israel (Levin & Ben-Dor 2004).

The Nitzanim dune complex is the southernmost distribution range of species such as *Maresia nana* (annual), *Anthemis phlistea* (annual), *Cyperus sharonensis* (a perennial herb endemic to Israel), and *Ballota philistaea* (a perennial, common in the coastal plain and Adom Mountains in Jordan, characteristic of fixed dunes). It is also the only reserve in the coastal plain that houses the lesser Egyptian jerboa (*Jaculus jaculus*) and other desert animals. Despite its importance, the reserve has been threatened by construction pressures and expansion from surrounding human settlements, including Nitzan, Be'er Ganim, Ashkelon, and especially Ashdod, over the last 15 years. Furthermore, invasive species such as *Acacia saligna*, *Heterotheca subaxillaris*, and the common sunflower (*Helianthus annuus*, in the Avtach Stream), as well as invasive animal species such as the golden jackal (*Canis aureus*), dogs, and cats, threaten the unique characteristics and wildlife of the reserve.

In 2004, a research team from Ben-Gurion University of the Negev launched a project that aimed to survey all plant species as well as arthropods, reptiles, and small mammals in the Nitzanim nature reserve. The project sought to monitor the changes occurring in these populations and communities over several consecutive years, and to trach their affinity for different types of dunes (shifting or fixed). These data and observations would then inform an examination of possible methods for landscape conservation, taking into account the diversity of plant and animal species, particularly those with a high affinity for shifting sand, endemic species, and red species. The project lasted 15 consecutive years, during which extensive data was collected and research was conducted.