

## Ecological aspects of vegetation removal from the coastal sand dunes of Israel

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### Abstract

Coastal sand dunes are known to be (i) free of vegetation and active (ii) partly vegetated and active (iii) fully vegetated and fixed. Some of the dunes are vegetated naturally while others were artificially stabilised for the purpose of controlling sand movement or because of biological invasion of alien species. The vegetation that covers two parabolic coastal sand dunes south of Ashdod, Israel, was removed as part of a study of dunes management. This inventive and not so well known method of management was used despite the common idea that active sand dunes are an undesirable nuisance which are a threat to arable land and infrastructure elements. The aims of the research are (i) to study the geomorphological and dynamic responses of the dunes to removal of vegetation (ii) to monitor the rate of vegetation recovery, its pattern and effect on dune morphology and dynamics. Coastal dunes provide us with examples of dynamic natural processes and the nature of the ecosystems that they support depends on this dynamism. Re-mobility of stabilised dunes is an important technique of ecological restoration. The parabolic dunes of the research area were formed during the last 30 years and are characterised by phytogenic mounds, known as nebkhas, composed of windborne sand that was trapped within or around shrub canopies. The nebkhas were formed mostly on the crest of the dunes because the crest is the area of no erosion and no deposition.

Two methods of vegetation removal were employed. First, removal by hand with no disturbance to the dune shape. By this method the nebkha mounds were sticking out at the dune crest. These exposed nebkhas turned the dune into a bluff body (a non-streamlined shape) that produces considerable resistance to the wind. The wind acts on the projecting mounds as an eroding force. After one year the nebkhas were not eroded. Artificial sand mounds near the nebkhas were eroded quickly after a couple of storms. The resistance of the nebkhas to the wind is due to the weave of the roots. In the second method, the nebkhas were flattened by a tractor shovel that reinstated the form of active transverse dunes. In both methods the roots of the shrubs started to sprout and grow, particularly in the dune that was exposed by the first method.

Keywords: Coastal sand dunes; Vegetation; Aeolian processes; Mobilisation.

## Introduction

The coastal sand dunes of Israel occupy about 460 km<sup>2</sup>, most of them south of Tel Aviv. All these dunes were formed within the last 1000 years (Tsoar, 1990) and during most or part of this period human agricultural and pastoral activities resulted in extermination of natural vegetation. The area south of Ashdod is preserved as Sand Park.

According to aerial photographs from 1944, the dunes were of transverse/barchan type with no vegetation cover. The stable interdune areas were used for agriculture. As a result of relocation of the population of the area in 1949, agricultural land-use stopped and grazing was drastically reduced. Vegetation recovered first in the interdune areas (the agricultural plots) during the 1950s and on the dune crests during the 1960s. Vegetation sprang up rapidly during the 1980s and even more so in the early 1990s and 2000s, covering the slip-faces and changing the transverse dunes into parabolic forms (Tsoar and Blumberg, 2002).

GIS analyses of the aerial photography show an increase in vegetation cover from 4.3% in 1944 (most of it in the agricultural plots in the interdunes areas) to 8.4% in 1974 and 17% in 1995 (most of it on the crest and lee sides of the dunes). All of the increase in vegetation, which is clearly discerned from the aerial photographs, is a result of the abatement of human impact. The quick change from mobile sand to vegetated sand required management interference in order to keep the free mobility of sand. We have tried two ways to remove vegetation from the dunes and to change the stabilizing sand dunes landscape back to active dunes landscape as it was in the past. We question whether we can form a sub-environment that will have ecological values together with recreation values. We assumed from the very beginning that vegetation may recover once our interference is curtailed. All sand dunes in Israel, including those that are in the extremely arid climate, are vegetated. The reason for that is the low wind strength in Israel compared to the high wind strength in NW Europe (Tsoar, 2001).

The removal of vegetation and subsequent monitoring may answer some of these management questions:

1. Can we turn parts of the Park into mobile sand systems?
2. What are the processes that would act on the system after the removal of vegetation?
3. How can we manage and preserve a system of active free sand in the Sand Park?

## Should we be afraid of shifting sand?

For many years, dune sand was erroneously considered as a substance with no economic or ecological value except for mining. Sand is easily blown by wind and as such is a threat to arable land and infrastructure elements. Because sand retains little moisture for plants, it is useless for agriculture. Many planners consider the coastal dunes as an undesirable nuisance and consequently, they designate the dune sand for quarrying or for building and industry. In the last twenty years, it has become abundantly clear that man is a greater threat to sand dunes than sand dunes are a nuisance to man. Coastal dunes provide us with examples of dynamic natural processes and the nature of the ecosystems that they support. Like many other landforms, coastal sand dunes and their ecosystems

have an intrinsic value. Their unique changing form and the specialized plants, animals and other organisms, which inhabit them, increase our understanding of the diversity that exists in this environment (Nordstrom and Lotstein, 1989; Van Zoest, 1992; Heslenfeld *et al.*, 2004; Martinez *et al.*, 2004).

Based on the above, there is an increasing awareness among scientists and managers in recent years of the importance of sand dunes as an active system. There were some attempts to remove vegetation and soil from the coastal sand dunes of Western Europe which had been artificially stabilised in the past mostly by planting trees (for stabilisation and wood production) and Marram grass (Arens *et al.*, 2004). Many ecologists and managers claim that dune stabilisation is not necessary because it changes the dunes' dynamics and the aeolian processes, with an impact downwind. Stabilisation is responsible for a less diverse landscape and a decrease in biodiversity. Mobile sand is considered as part of the natural successional landscape while stabilisation prevents normal function of the system (Heslenfeld *et al.*, 2004; Martinez *et al.*, 2004).

## Removal of vegetation

The coastal sand dunes of the Ashdod – Nizzanim Sand Park are covered mostly by *Artemisia monosperma* and some other shrub species (Fig. 1). Because of the sparseness of the vegetation (15%–17%), most of these shrubs trap sand to form phytogenic mounds known as nebkhas which are an important patch on the dunes. The nebkha has its own dynamics and its size and amount of trapped sand depends on the location of the shrub on the dune. Shrubs that are formed close to the crest where the maximum sand transport occurs are the biggest. Shrubs at the lower windward side of the dunes are subjected to erosion and degeneration (Fig. 2).

The removal of vegetation was first done by hand on one parabolic dune. In that case the nebkha mounds were left intact containing the roots of the plants (Fig. 3). Our assumption that these mounds of sand would be eroded very quickly after a couple of sand storms was refuted. The nebkha's mounds had not eroded after a year. Artificial mounds of sand of identical size were built near the exposed nebkhas and the rate of erosion was measured by erosion pins. Fig. 4 shows the results of the rate of erosion from the artificial mounds, the nebkhas without vegetation and the nebkhas with vegetation. The artificial nebkhas were eroded very quickly and disappeared after two storms. The rate of erosion of the artificial mounds was on average 7 times higher than the rate of erosion of the exposed nebkhas. The intact nebkhas continued to trap sand and slowly increased in height.

The removal of vegetation by hand did not eradicate the plants. The removal was done in November 2001. Sprouts of *Artemisia monosperma* gave off shoots by February 2002 and most of the plants recovered. In autumn 2002 we decided to remove the vegetation from another parabolic dune with a tractor shovel which levelled the nebkhas. After a short time of adjustment the dune restored the slip face on the lee side in winter 2002/03 and the dune advanced about 4 metres per year. A similar rate of advance took place in the following winter of 2003/04. Very few sprouts appeared from the roots but the sand

erosion had exposed the roots of the *Artemisia monosperma* and that formed some resistance to the wind erosion. The monitoring of this active dune is continuing.

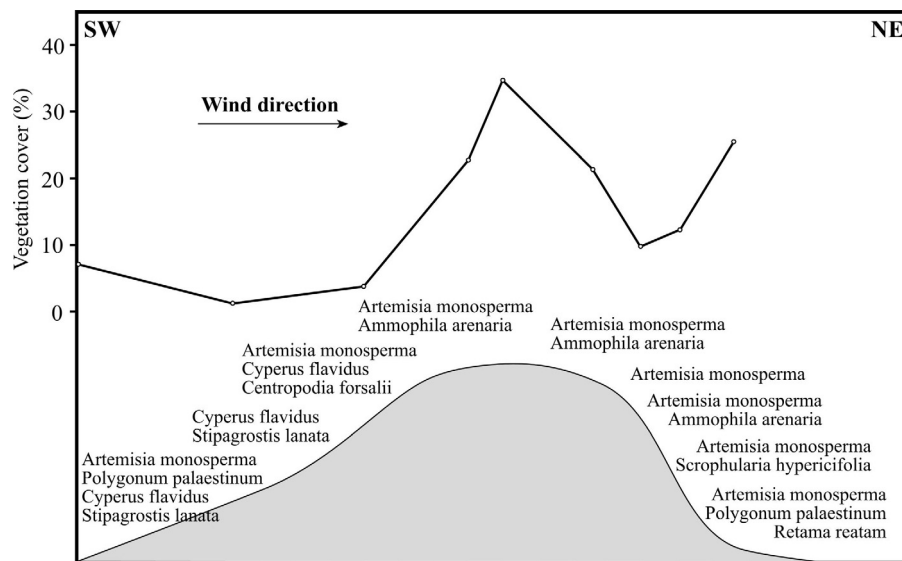


Fig. 1. Perennial vegetation cover on parabolic dunes in the Ashdod – Nizzanim Sand Park. The percentage of vegetation cover increases from zero at the mid-windward slope to 34 at the crest.



Fig. 2. The eroded windward side of a nebkha that exposes the roots of *Artemisia monosperma*.



Fig. 3. The exposed nebkhas on the crest of the parabolic dune.

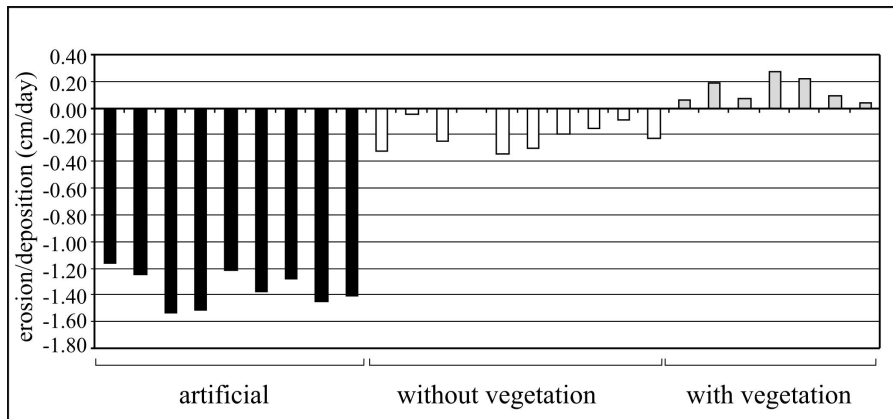


Fig. 4. The rate of erosion/deposition of the nebkhas (artificial, without vegetation with vegetation) during the storms of winter 2002/03.

## The increase in sand flux after the removal of vegetation

The sand flux was measured at each of the treated dunes by comparing it with the sand flux in a nearby dune (control dune). The flux was measured with a 'Sensit', which is a sensor composed of a ring-shaped piezoelectric crystal mounted on a 2.5cm diameter post (Stockton and Gillette, 1990). This ring reacts to impacting particles and registers every impact in a data-logger. The flux was measured in the treated dunes (research dunes) and the nearby control dune, on the lower windward slope and near the crest during four storms that occurred in winter 2002/03. Results are shown in Table I.

Table I. The average sand flux ratio between the treated dunes (research) and the nearby untreated dune (control) during four storms that occurred during winter 2002/03. The vegetation was removed from dune 1 by hand in November 2001 and from dune 2 in October 2002 by tractor shovel

Dune	Sand flux ratio (research/control) at the lower windward slope	Sand flux ratio (research/control) near the crest
1	130/1	1.5/1
2	573/1	77/1

It is obvious that dune 2 is more active than dune 1 because of the flattening out of the nebkhas. However, the nebkhas near the crest are bigger and more developed. For that reason the ratio of the sand flux near the crest is much lower than that at the lower windward slope particularly on dune 1 where the nebkha mounds persist. The wind magnitude increases towards the crest. For that reason there were cases in which the wind speed at the lower windward slope of the controlled dune was below the threshold velocity needed to move sand. That brought about a higher ratio of sand flux at the lower windward slope.

It was also found that during rain there was a drastic decrease in the sand flux of the research dune while the control dune showed very little decrease. We assume that this is because of the process of precipitation landing on the leaves of the shrubs being intercepted and held in temporary storage (interception).

## Conclusions

1. Removal of vegetation from a coastal sand dune for the purpose of formation of a dynamic dune landscape is much more effective when a tractor shovel is used to take off the shrubs and their roots and to level the nebkha mounds.
2. The nebkha mounds are resistant to wind erosion after removal of the vegetation. This is probably due to the roots of the shrubs which can make the sand more cohesive. According to the rate of exposed nebkha mound's erosion we assume that it would take a nebkha mound 6 to 7 years to become completely level.
3. The vegetation on an exposed nebkha recovers quickly during the rainy season. Taking into account the low rate of erosion, the exposed nebkha mound will turn from erosional mode into accumulation mode within a year or two.

4. The sand flux of a vegetated dune is less affected by the rain because of the processes of interception. For that reason the ratio of the sand flux between research and the control dunes is reduced during a sand storm that is accompanied by rainfall.

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