



## Ecological Effects of Afforestation in the Northern Negev

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**Guy Rotem, Prof. Amos Bouskila, Alon Rothschild**

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**The Society for the Protection of Nature in Israel (SPNI)** is Israel's largest and most veteran environmental NGO. SPNI was founded in 1953 and today enjoys the support of over 40,000 members. SPNI is an IUCN member and *Birdlife International* affiliate. SPNI advocates for the conservation of Israel's ecosystems using education, land use planning, research, legal activity, policy design and public campaigns.

**Guy Rotem** is an independent ecological consultant. He is Owner of "Guy Rotem Ecological and Environmental consulting", a doctoral candidate in the Department of Life Sciences at Ben-Gurion University and Postdoctoral fellow at the Spatial Ecology Lab. He is currently leading the Northern Negev Survey for the Open Landscape Institute.

**Prof. Amos Bouskila** is a faculty member at the Department of Life Sciences, Ben-Gurion University of the Negev (BGU). His research interests include behavioral ecology, and in particular behaviors related to predation (in both prey and predators), conservation of reptile species and habitats, and mathematical models as a tool in the study of the behavior of animals.

**Alon Rothschild** is SPNI's Biodiversity Policy Coordinator. He has a M.Sc. degree in Ecology from Tel Aviv University and has been a lecturer in the Department for Natural Sciences at the Open University of Israel since 2006. As Coordinator of Biodiversity Policy he leads a variety of issues including invasive alien species policy, fisheries management, ecosystem services, endangered ecosystems conservation, etc. Alon is a member of the Supervising committee of NOP 22 (National Outline Plan for Forestry), and the Advising committee to the minister of agriculture regarding the Forest Ordinance.

**Contact:**

Environmental Protection Division, Society for the Protection of Nature in Israel, Phone: +972 (0)3 6388744

[alon@spni.org.il](mailto:alon@spni.org.il), [www.teva.org.il/migvan](http://www.teva.org.il/migvan) <http://natureisrael.org/>

## Executive Summary

This document analyzes the ecological implications of afforestation in the northern Negev in light of the large-scale afforestation activities in this area in recent years, and aims to facilitate an open public debate concerning the environmental aspects of these activities.

A draft of the document was distributed to relevant agencies (Keren Kayemet LeIsrael -KKL, Ministry of the Environment, Nature and Parks Authority, Ministry of Interior - Southern District Zoning (planning) Committee, the Israel Lands Administration, etc.) and meetings were held with some of these organizations. The draft was also distributed to a select group of scientists. Comments from these reviews have been incorporated into this final version.

**Loess plains and steppe shrublands** are two of the rarest and most threatened habitats in Israel. They are underrepresented in nature reserves and national parks (only 4% are protected), and yet support unique biodiversity including threatened Red List species (e.g. Coleman Garlic, *Allium kollmannianum*), and endemic species (e.g. Beersheba Fringe-fingered Lizard, *Acanthodactylus beershebensis* and Dark - Brown Iris, *Iris atrofusca*).

A feature common to both of these habitat types is the absence of trees except in some drainage tributaries, which is characteristic of arid environments. The absence of trees is a key element to the ecology of these natural habitats that support ecological communities adapted to these landscapes such as ground-nesting birds, several lizard species, etc.

The northern Negev and southern Hebron Hills are located within a transition zone between the Mediterranean and desert climates, creating an Ecotone – i.e., an area where an ecological community with a unique genetic diversity may exist (for example, the most southern population of "wild wheat" that is common within the Yatir area). The transition zone of the northern Negev is particularly sensitive to climate change and does not naturally support extensive forests because of limited rainfall and high evaporation rates.

Historically, trees were found mainly within tributaries, and the majority of the area was characterized by sloping terrain supporting grasslands and shrubs. The few trees that grew here were typical native species to the northern Negev such as Twisted Acacia (*Acacia raddiana*) and Jujube (*Ziziphus spina-christi*), and did not include Mediterranean species like Jerusalem Pine (and certainly not nonnative species like Eucalyptus, Victoria Acacia, etc.).

Agriculture has occurred in this region for the past few thousand years, however, this agriculture was limited to within tributaries, and trees could not be planted on the dry slopes, which comprises the majority of the area. Furthermore, archaeological, ecological and historical evidence from maps and aerial photographs clearly shows the arid character of the area, and the historic lack of forests. Conversely, evidence suggests that the area was grazed extensively for thousands of years.

Anthropogenic pressures impacting the natural habitats in these areas include agriculture, infrastructure, settlement (including illegal Bedouin settlements) and forestry. This document focuses on afforestation activities and their impacts.

In recent years afforestation activities have intensified within the area of the northern Negev and southern Hebron Hills, resulting in significant impacts on the natural habitats of the loess plains and steppe shrublands. According to KKL reports, approximately 70% of afforestation activity in recent years has been carried out in the southern regions. For example, forestry operations (including land preparation before afforestation) covered approximately 1,600 hectares in 2010. Some forestry activities included road construction and extensive earthworks, whereby creating high dirt embankments, blocking tributaries and clearing the natural vegetation with heavy mechanical equipment.

The forestry impacts on biodiversity in this region were examined for a limited set of taxonomic groups; however, these studies clearly indicate the far-reaching negative effects on the composition of the ecological community, and the significant harmful impacts on the natural biodiversity of the area. Changes have been documented in reptiles, birds and mammals both in forests and natural habitats such that species that occur naturally in steppe shrublands and loess (e.g., lizards, desert and ground-nesting birds) were replaced in the forested areas by Mediterranean and eruptive species. In addition, species richness of natural vegetation in afforested areas was lower compared to natural areas.

Afforestation activities and planting have resulted in large-scale changes in the landscape ecology of the northern Negev on a number of levels:

- Landscape level – change from flat, steppe landscape to a landscape with vertical structures (embankments, trees).

- Patch level – accelerated fragmentation of natural habitats and edge effects of the forest on natural habitat patches.
- Local level – direct disruption of natural habitats, including damage to soil surface composition (soil crust) and the runoff regime.
- Spatially, nonnative tree species were introduced into the region. In addition, Mediterranean species have colonized these introduced forests at the expense of local natural species.

Two key features of these forestry activities have the greatest negative impact on the natural ecosystem:

- Use of heavy machinery and destruction of surface soil composition in conjunction with alteration of the terrain into uneven mounds and embankments.
- Introduction of trees into an ecosystem where trees are scarce, resulting in significant impacts, especially in regards to predation patterns.

Afforestation activities are key factors threatening the extinction of species within the ecosystem, including flag species such as Dark – Brown Iris and the Beersheba Fringe-fingered Lizard.

It is important to note that many of these species are defined as protected natural values (under the National Parks and Nature Reserves Law – Declaration of Protected Natural Values) and protected wildlife (under the Protection of Wildlife Act). At present, enforcement of these laws by the Israel Nature and Parks Authority is very limited in regards to KKL activity that damages these natural values.

There is a significant question as to the sustainability of afforestation in the Negev: planted forests in this region do not reproduce naturally and currently the trees are suffering significant water stress following the past years of droughts. This trend of drought-stressed trees is expected to worsen with predicted climate changes in the region, and in particular, impact semi-arid desert margins. This question is more acute given that in the first years after planting KKL must irrigate the trees with costly and limited water, yet their long-term survival and regenerative capacity is questionable.

Various claims, arising at times from the proponents of Negev afforestation, attempt to justify these actions on the basis of "ecosystem services"

approach. This document also discusses the implications of converting natural open habitat into forest in terms of ecosystem services.

In terms of leisure and recreation, there are many questions as to the suitability of sparsely planted Savannization areas for these purposes. Furthermore, in light of studies indicating that tourists prefer natural areas (especially in spring) that are not afforested, the question arises why not provide limited, localized patches of shade picnic groves and leave the majority of the area as an attractive natural spring flowering area?

In terms of mitigating climate change, a seminal research study of the Yatir Forest by Prof. Yakir indicates that there is a balance between the positive effect of the forests to limiting climate change through carbon sequestration, and the negative impact on climate change resulting from increased heat dissipation due to the dark color of the forest. Currently this balance is negative and is expected to become positive only in 80 years from the time of planting.

In terms of preventing erosion and flooding it is apparent that "mature" forests can moderate soil erosion and runoff, but this is also true for natural habitats with grass and shrub plant cover. However, the first years after afforestation (and sometimes more than eight years) are most problematic during which the loss of natural vegetation and soil compaction by the afforestation mechanical activities result in furrowing and accelerating erosion.

The apparently scientific justification for the Savannization operations is based on limited research studies conducted at Shaked\_Reconnaissance Park. It is important to emphasize that these experiments were conducted over a limited area and using light machinery to create low mounds of earth about 20 cm high. In contrast, the KKL afforestation activities in the Negev employ heavy machinery that destroys extensive areas, creates high mounds reaching to more than a meter high and tens of meters long, and uses herbicides to eradicate local vegetation. Therefore, the ecological impact is completely different from that of the experiment plots. Furthermore, these studies are limited and lack important data and analysis.

Given the lack of important ecological information and that these operations are performed on a large scale, it is appropriate to examine fundamental questions regarding afforestation policy in this region, their justification and measures employed to implement these activities:

- What is the impact of afforestation activities on the natural biodiversity, particularly in regards to sensitive desert species?
- Are ecological implications considered as part of the decision-making process, based on scientific data related to these unique aspects of nature conservation and potential tradeoffs in ecosystem services?
- What are the criteria that underlie the claim that the northern Negev is a "degraded" area, and are these criteria (if they exist) used in choosing each plot intended for planting? And whether afforestation is the right solution?
- Why implement afforestation in areas that are in good condition and not degraded?
- What is the cumulative damage to the region for the first 10-15 years in terms of soil erosion, runoff and biodiversity; and do the benefits, if any, of the mature forest justify these impacts?

In summary, this document clearly shows that the afforestation activities in the northern Negev constitute a significant threat to the unique biodiversity of the loess plains and steppe shrublands, while the alleged "environmental" justifications, such as enhancing ecosystem services, are problematic and raise serious doubts.

Thus, a re-examination of the current operational activities and management issues by all stakeholders is an important step forward to optimally protect this unique natural area, which we are committed to preserving for future generations.

## Introduction

The loess plains and steppe shrubland habitats are an integral part of the Israeli landscape. These habitats are severely underrepresented within the existing nature reserves and national parks.

Large-scale forestry operations are implemented over vast expanses of the northern Negev and southern Hebron Hills, with significant impact on the natural loess plains and steppe shrublands. These activities include extensive earthworks using heavy mechanical equipment, creation of embankments and mounds, destruction and blockage of tributary dry gullies (*wadi*) and clearing natural vegetation.

The extent of afforestation in the area is significant and is dramatically impacting land use in the northern Negev. According to the Keren Kayemet Lelsrael (KKL; Jewish National Fund), approximately 70% of afforestation in recent years has been carried out in the south of the country. In 2010, for example, forestry operations and land preparations for afforestation (clearing natural vegetation) amounted to approximately 1,600 hectares.

These areas remain "open space" in that they are "undeveloped", however habitat quality and ecological functioning changes dramatically after afforestation operations that introduce forests into an area that has not been forested in over 2000 years, and probably never with this configuration of tree species and density.

Given that these operations are performed on a large scale, it is appropriate to examine fundamental questions regarding afforestation policy in this region and measures employed to implement these activities:

- What is the ecological impact of afforestation activities within this region?
- Are ecological implications considered as part of the decision-making process, based on scientific data related to these unique aspects of nature conservation and potential tradeoffs in ecosystem services?
- How compatible are these afforestation and ground preparation activities in terms of Israel's commitment to national and international biodiversity conservation of the unique shrublands and loess plains?
- What is the sustainability of converting an arid area characterized by few trees to a forested area, especially during an era of climate change?

- What are the criteria that underlie the claim that the northern Negev is a "degraded" area, and are these criteria (if they exist) used in choosing each plot intended for planting?

This document examines the impact of afforestation on the unique biodiversity of the northern Negev and south Hebron Hills and changes in their ecosystem services.



Afforestation works in the northern Negev, February 2014. Note the complete destruction of natural vegetation and soil crust on the places where heavy machinery was employed, versus the untouched natural patches. Photo: Alon Rothschild.

# 1. Loess plains and steppe shrublands – Rare habitats found within a unique bio-geographical area

The area encompassing the northern Negev and south Hebron Hills, between the Gaza strip border to the west, Shikma River to the north, Arad Valley to the east and Beersheba in the south is characterized by two rare habitat types that support a unique biodiversity representing an important character of the land of Israel: loess plains and steppe shrublands. Both of these habitats are characterized by low vegetation and sparse tree cover.

## A. Loess plains of the northern Negev

Loess soil is composed of sand and clay and is only partially permeable to water. Typically loess landscapes in arid regions are flat with few trees, and therefore characterized as "two-dimensional". Vegetation is composed of a combination of herbaceous grasses and low shrubs, with sparsely scattered trees, mostly within tributaries.

The loess plains of the northern Negev support several endemic species (unique to the region) that are adapted to loess soils in open landscapes. Several endemic or nearly endemic species are noteworthy: Beersheba Fringe-fingered Lizard (*Acanthodactylus beershebensis*) (Critically Endangered) <sup>[28]</sup>, and plant species such as Coleman Garlic (*Allium kollmannianum*) and Dark - Brown Iris (*Iris atrofusca Baker*) categorized as "Red Species" (Threatened) <sup>[29]</sup>. Several species of birds are unique to this open loess habitat, such as McQueen's Bustard (*Chlamydotis macqueenii*) and Cream-colored Courser (*Cursorius cursor*) both of which are Threatened Species <sup>[25]</sup>. The small rodent Greater Egyptian Jerboa (*Jaculus orientalis*) was once common in the Arad Valley. Loess plains are extremely underrepresented within nature reserves and protected areas in Israel.



Coleman Garlic (Photo: Yuval Sapir)



Loess Plains near Beersheba Stream (Photo: Mimi Ron)

## B. Steppe Shrublands

Steppe shrublands (Batha) are composed of Mediterranean vegetation characterized by low shrubs and plants with maximum height of about 50 cm and interspersed with herbaceous grassland vegetation.

Steppe shrublands are found in semi-arid desert (a region located between the Negev and Judean deserts and the Mediterranean region), creating a unique meeting point between the Mediterranean and desert flora, along with plants unique to the steppes, such as Jerusalem Sage *Phlomis brachyodon*. The dominant shrubs and bushes are Mitnan *Thymelaea hirsuta*, Jerusalem Spurge *Euphorbia hierosolymitana*, Thyme *Coridothymus capitatus*, and Thorny Burnet *Sarcopoterium spinosum*, all of which originate from several different bioregions. Characteristic plant species include Prickly Alkanet (*Anchusa strigosa*), Dominican Sage (*Salvia dominica*), Common Ballota (*Ballota undulata*).

As a result of the two-dimensional physical structure (absence of trees), the steppe shrublands support a variety of unique wildlife such as Spectacled Warbler (Near Threatened species) and Long-billed Pipit (Endangered species)<sup>[25]</sup>. These shrublands team with ground-nesting birds, specially adapted reptiles and large birds of prey that are adapted to hunting in the open landscapes.

In Israel only 2.5% of the steppe shrublands is found in nature reserves, a much lower percentage than the IUCN recommendation of protecting at least 10% of.



Steppe shrublands in the Yatir region. Note the open landscape with low shrubs and no trees (photo: Open Landscape Institute (OLI) Site)



Characteristic birds of the steppe shrublands:

Long-billed Pipit. Photo: Asaf Mayrose | Mourning Wheatear. Photo: Yoav Perlman

### C. Biogeographic aspects of regional nature conservation

The northern parts of this region form a biogeographic "transition zone" between the northern Mediterranean belt and the southern desert region. Areas of transition between ecosystems and different climatic zones are known as *Ecotones* that support ecological communities with a rich genetic diversity making them a critically important component in conservation biology [10, 13, 12]. An example of this is Israel's most southern population of wild wheat ("mother wheat") found within the steppe shrublands of the Yatir belt. The importance of preserving this population as a genetic reserve for commercial wheat crops in terms of resistance to changing conditions of drought and heat is unquestionable, especially in an era of global climate change. The southern parts of this region are characterized by completely desert features.



Steppe shrublands in the Yatir region. Photo: Alon Rothschild

## 2. Afforestation – development pressure on the natural habitats of loess plains and steppe shrublands

The loess plains and steppe shrubland habitats have been severely impacted by development such as agriculture, infrastructure, settlements (including resettlement of Bedouins in permanent and temporary settlements) and forestry operations. These development pressures are continually impacting land use of natural areas.

This document focuses on the development pressures of forestry activities and their full scope and impact on the ecosystem. However, the document does not assess the relative impacts of each of the above development pressures on loess and shrubland habitats.



Examples of development pressures in the Yatir region:  
From left: Bedouin settlements. From right: Agriculture and Afforestation. Photos: Alon Rothschild

### A. History of forestry activities in the northern Negev

Already back in the 1950s, the KKL began experimenting with planting forests in desert areas south of Beersheba. During the 1960s with years of low precipitation, large sections of these planted forests died out. Consequently, thereafter KKL has focused on planting in areas where rainfall averages at least 200 mm per year. An exception to this policy was the creation of small, reinforced local water catchment basins (referred to in Hebrew as: *liman*) in the 1960s used for planting trees, such as eucalyptus, acacia and pine, in areas that received less than 100 mm of rain annually.

Within semi-deserts, regions with 200–300 mm of rain per year, large-scale afforestation efforts were carried out beginning in the 1960s, comprised primarily of coniferous trees including Yatir Forest of some three thousand hectares, including many stream wadis (Map 2).

Furthermore, beginning in the 1980s, trees were planted as "green belts" around communities in the Negev.

In 1986, the KKL began its 'Savannization' and 'advanced water runoff harvesting' activities. Within this framework, land is severely altered through the use of heavy equipment, and trees are planted at a density of a hundred trees per hectare in order to create the savannah-like landscape.

## B. Characteristics of forestry activities

### Runoff-harvesting forests ("Savannization")

The Savannization project focuses on planting trees over broad areas. Because the region is characterized by a minimal precipitation and is unable to support trees, operations are carried out to collect water runoff and increase local resources. Dirt embankments (locally called '*shichim*') are established along the contour lines of the slopes, using heavy engineering equipment that pushes the dirt and piles it up into an embankment, while digging into the ground along the embankment. The embankments are meant to stop the runoff and prevent water draining down the slope, thus allowing the establishment of trees that are planted in the hollow created before the embankment. Typically, creation of the embankments is accompanied by clearing the ground and sometimes spraying herbicides. Savannization has been implemented over thousands of hectares in the Negev.



Savannization. Photo: Uri Ramon and Ethan Romam

## Coniferous Forests

Since the early 1960s, KKL has implemented tree planting projects within large areas of these steppe shrublands that occur along the semi-arid edge of the desert. For example, in the Yatir Forest, since planting began in 1964, more than four million trees have been planted (the largest planted forest in Israel). Additional forests include Meitar Forest (300 ha), Kramim Forest (700 ha), Lahav Forest (1,100 ha), and Devira Forest (400 ha).

The trees were planted densely, usually without intensive soil preparation, yet were accompanied in most cases by the removal of natural vegetation through chemical and mechanical means. Currently, the forests cover large areas, including islands of natural shrublands, especially around historical sites of antiquities. These forests are mostly coniferous, especially the older plots. Since the early 1980s, more forest plots were planted with different broad-leaved tree species, but they still constitute a small part of the overall forest.



Pine forest landscape in the Yatir Forest. Photo: Alon Rothschild

### Limans (planted local water catchment basins)

In the 1960s, the Jewish National Fund began planting small areas (up to 0.6 ha) that were irrigated by dammed runoff within a tributary wadi. These *limans* are usually located along the edge of roads.

Over 500 *limans* are spread throughout the Negev, most of which are located along Highway 40 (the section between Beersheba- Mitzpe Ramon), Route 25 (Dimona – Beersheba – Netivot) and Route 31 (Arad – Shoket – Lahavim) <sup>[31]</sup>.

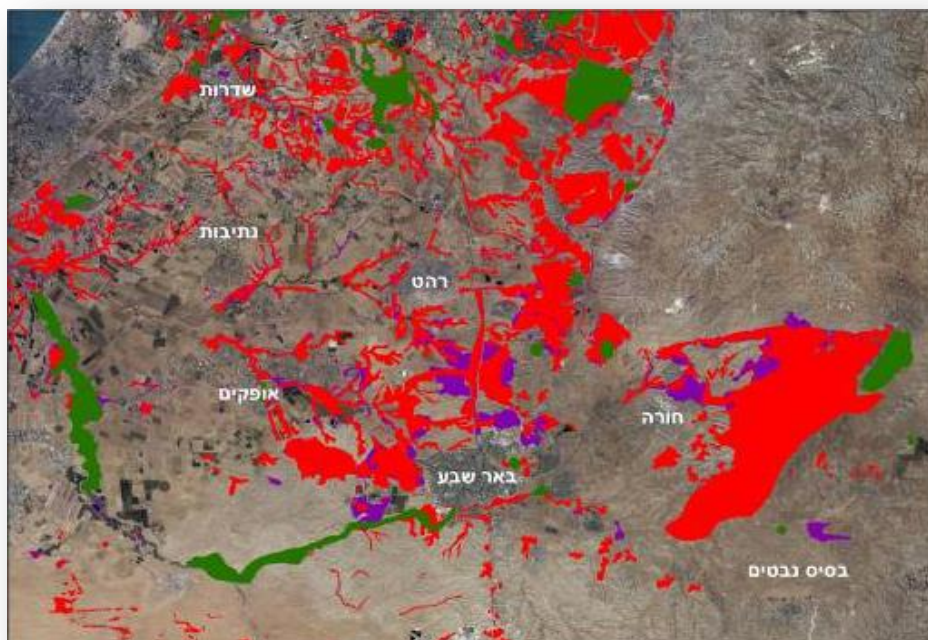
### Forests Surrounding Settlements

Forests have been planted around many settlements in the region such as Meitar. Forest plots are irrigated using 'harvest runoff' and therefore required intensive alteration of the ground including roads, leveling and raising embankments.

## **C. Distribution and extent of regional afforestation – the present situation**

Large sections of the northern Negev and the southern Hebron Hills have been afforested over the years, whether within the National Outline Plan (NOP) 22 (National Outline Plan for Forests and Afforestation) zones or outside the NOP 22 zones that are allocated for other purposes.

Map 1 shows the widespread distribution of the NOP 22 zones (red) and the extent of forest stands outside the NOP 22 (purple), compared with the limited areas designated for nature conservation: nature reserves and national parks in NOP 8 (National Park and Nature Reserve Outline plan) zones (green). In other words, most of the area is under the management of the KKL, and most of it is afforested or intended to be forested (except for "Protected Natural Forest" that are defined as areas without planting, Map 3). The limited areas that are managed by the Israel Nature and Parks Authority are not adequate to preserve the unique biodiversity of the region's natural landscape.



Map 1. Distribution of areas managed by KKL and INPA within the region: NOP 22 areas (red) and the extent of forest stands outside the NOP 22 (purple) managed by KKL. Nature reserves and national parks in NMP 8 zones (green) managed by INPA.

Map 2 illustrates the distribution of land management. The dominance of the areas managed by KKL is readily apparent in the following table (based on Map 2) totaling about 50,000 ha under KKL, compared with only 12,600 ha under INPA management (the Loess Park Project is currently being promoted jointly by KKL and INPA):

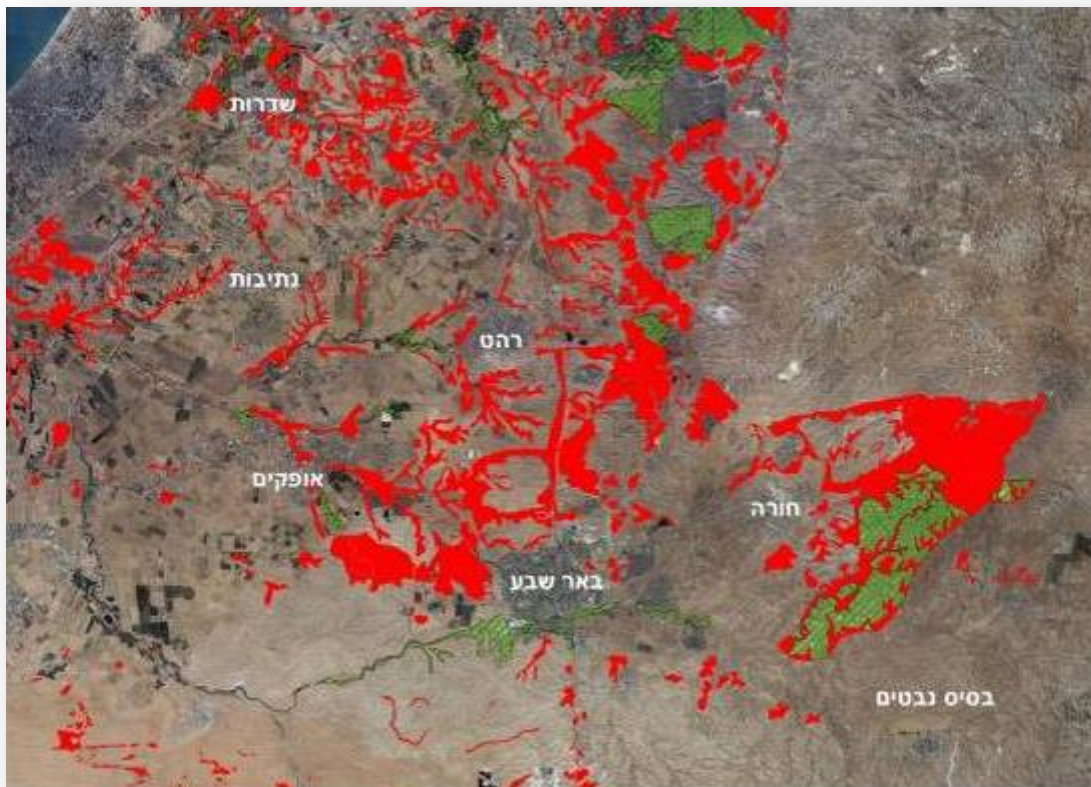
| Areas according to Map 2                  | Area (in Hectares) |
|-------------------------------------------|--------------------|
| NOP 22                                    | 41,732             |
| Actual Forest                             | 22,880             |
| Existing Forests within NOP 22            | 15,975             |
| Existing Forests outside NOP 22           | 6,905              |
| <b>Total Existing Forests and NOP 22</b>  | <b>48,638</b>      |
| Nature Reserves                           | 16,986             |
| Loess Park                                | 4,369              |
| <b>Nature Reserves without Loess Park</b> | <b>12,617</b>      |

In recent years, the Southern Region of the KKL has been the most active area for afforestation land preparation and planting. According to the Central Bureau of Statistics (CBS), 69% of the plantings in 2010 and 73% in 2011 were carried out in the Southern Region<sup>[47]</sup>. According to the annual report of the Israel Lands Administration (ILA) in 2010, the allocation of funds for afforestation work on ILA property rose from one million dollars in 2008 to 6 million dollars in 2009, and 8.5 million dollars in 2010<sup>[41]</sup>.

The 2010's summary report of the KKL's Southern Region <sup>[46]</sup> specifies forestry activities and land preparation areas on 1,600 hectares, of which about 800 hectares are afforested [including replanting (92 ha), NOP 22 (164 ha) and planting on state land for soil preservation (521 ha)], and further activities of about 800 ha of surface preparation prior to planting in 2011 [including replanting (234 ha), NOP 22 (143 ha) and planting on state land for soil preservation (396 ha)].



Map 2. Distribution of afforested areas, NOP 22 and nature reserves in the northern Negev and south Hebron Hills region (Israel Nature and Parks Authority).



Map 3. Most of the NOP 22 zoned areas are slated for some type of afforestation (red), except for the "Protected Natural Forests" (green hatched) that are to be preserved in their natural state.

### 3. Afforestation as a Substantial change in landscape characteristics of the Negev region

Forests have not been a part of the natural landscape in the northern Negev and the south Hebron Hills for at least two thousand years if not more. Humans have lived in the northern Negev for thousands of years. Permanent settlement in the area began around the fifth millennium BC, but did not maintain a continuous presence. One manifestation of this, is that the main settlement sites varied over time <sup>[38]</sup>.

Agriculture existed in the region for thousands of years and included crops and grazing, such that the characteristic landscape pattern is the result of ecological communities that developed over years of human influence, mainly through grazing and traditional agriculture <sup>[43]</sup>. In phytogeographic terms, the region dealt with herein is not characterized by the presence of forests but rather shrublands and grasslands (Prof. Avinoam Danin, pers. comm.). The few trees, such as Twisted Acacia, were scattered sparsely along tributaries and pockets of land that could support them. These trees were characteristic along semi-desert areas and did not include Mediterranean species, such as Jerusalem Pine that was found naturally, before afforestation, in the Judean Mountains, Carmel and Western Galilee <sup>[39]</sup>.

It is probable that more than two thousand years ago, some of the region was characterized by open park-like forest with native trees such as the Atlantic Pistachio (*Pistacia atlantica*), Jujube and other species. However, the intensive settlement and agriculture that characterized the region from the Roman-Byzantine era had by this time already logged much of this open forest to make way for agricultural areas (Dr. Motti Haiman, pers. comm.). Thus it appears that for at least the past two thousand years the region has been characterized by an open landscape with a sparse scattering of individual trees (Dr. Orna Reisman-Berman, pers. comm.).

Agriculture in the region was based on farming within stream wadis in which runoff water could be collected in the wadi and from the slopes. Open slopes were probably not utilized. Among other things, one of the difficulties with farming the loess plains was increased salinity due to high evaporation. Therefore, even agricultural trees were not grown in most of the region, but were restricted to the wadi tributaries (Dr. Motti Haiman, pers. comm.). This landscape structure is responsible for the existing biological community <sup>[8]</sup>.

Maps from the end of the 19th century and the middle of the 20<sup>th</sup> provide further evidence for the described landscape structure above: Maps from the Palestine Exploration Fund (PEF) from 1880 (Map 4) show no evidence of forested areas. Analysis of aerial photographs from the mid 20<sup>th</sup> century shows short natural vegetation of shrublands with little tree cover (Map 5). There is no basis to the common claim that forests in this area were cut down to provide the necessary coal for Ottoman Army steam trains; rather the fuel came from trees logged in northern part of the country [45].



Map 5: Aerial photograph of Lahav Reserve from 1945. As can be seen from this photo, the valleys and slopes of the hills are farmed and the tops of the hills appear to be steppe shrublands. The aerial photo is from the Doctorial Thesis of Orna Reisman-Berman, compliments of Survey of Israel.



Map 4: The Beersheba Valley in a British map from 1880. This map, created before World War I, shows the region as not forested[9]

#### 4. Effects of afforestation on the natural ecosystem

The loess plains and steppe shrubland habitats in general, and in the northern Negev and south Hebron Hills in particular, have not been researched in depth. Furthermore, no systematic ecological studies were conducted before and after afforestation activities, and therefore, we lack these valuable data that could have been used as a basis for policy decisions.

Although the effects of afforestation on regional biodiversity were examined in a limited number of taxonomic groups, these studies clearly indicate the far-reaching negative effects on the composition of the ecological communities:



The above two photos were taken from the same point south of Meitar in spring 2012. The right view shows a Eucalyptus plot planted using the 'harvest runoff' method. In the left view, a grazing area can be seen that characterizes parts of the loess plains. Comparing the two photos highlights the tree-less loess area with a rich diversity of herbaceous vegetation, contrasting with the planted plots that have sparse natural vegetation and typically large expanses of bare ground (Photo: Alon Rothschild).

## A. Reptiles

### Savannization

Studies that examined the impact of savannization type afforestation on reptiles in the northern Negev showed a change in community structure and species composition between natural and planted plots, although the overall species richness did not change. That is, the number of species remained similar, but the identity and relative abundance of the occurring species (i.e., diversity) changed to Mediterranean type species at the expense of local desert species that are critical to nature conservation in the region <sup>[36]</sup>. Thus, it appears that altering the natural habitat patchiness reduces habitat heterogeneity, and provides an advantage to 'generalist' species of Mediterranean origin. Moreover, two desert species: Pale Agama Lizard (*Trapelus pallidus*) and Beersheba Fringe-fingered Lizard (*Acanthodactylus beershebensis*) completely disappeared in the planted areas.

A possible explanation for this phenomenon is that reptiles living on the loess plains are greatly impacted by the creation of the planting embankments. Creating the embankments entails digging up the top soil that buries rocks and destroys the upper soil crust that is used for digging burrows, thereby reducing the options for hiding. Another explanation, tested and supported by studies conducted in the northern Negev (see in greater detail below) relates to increased predation pressure from birds that use trees as effective foraging perches.

### Coniferous Forest

Hevlana <sup>[36]</sup> found a decrease in the frequency and abundance of each species of reptiles in the Lahav Forest compared to shrublands. Some species, such as Günther's Cylindrical Skink (*Chalcides guentheri*) (Vulnerable Species <sup>[28]</sup>) and Schneider's Skink (*Eumeces schneiderii pavimentatus*) were found infrequently and in low abundance in natural plots, and were absent altogether in forested plots. In other words, in the pine forest all lizard species were found in low abundance except for the Rüppell's snake-eyed Skink (*Ablepharus rueppellii*) (Redlist species not at risk), a common Mediterranean species found only in the planted plots.

## B. Birds

The creation of large patches of forest in the northern Negev has resulted in many changes in the bird diversity of breeders <sup>[19]</sup>, migrants <sup>[16]</sup>, and wintering species <sup>[17]</sup> in the area. In general, species that specialize in arid and open landscapes were replaced with Mediterranean or generalist species.

### Savannization

Species such as Macqueen's Bustard (*Chlamydotis macqueenii*), Pin-tailed Sandgrouse (*Pterocles alchata*), Black-bellied Sandgrouse (*Pterocles orientalis*), Cream-coloured Courser (*Cursorius cursor*), Long-billed Pipit (*Anthus similis*) and small larks (*Alaudidae*) disappeared or stopped nesting in savannization areas. The creation of a park forest configuration in most of the remaining natural open areas in the northern Negev may cause severe impacts to populations of these specialized species (Black-bellied Sandgrouse, Cream-coloured Courser, Macqueen's Bustard, etc.) and in some cases lead to their extirpation in Israel.

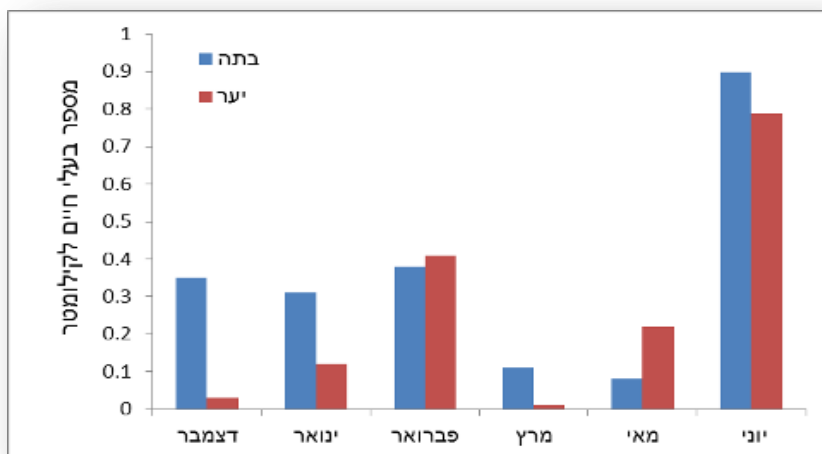
Savannization of loess plains represents a radical change in habitat for large, ground-nesting birds, not only because of the planting, but also due to the creation of embankments. Sandgrouse species, Cream-coloured Coursers and Macqueen's Bustards disappear completely in these areas <sup>[25, 26]</sup>. Recent annual surveys of Macqueen's Bustards conducted by the Israel Nature and Parks Authority found only around 200 individuals, most of which are found on the Hatzarim Air Force Base where much of the area is preserved in its natural state.

### Coniferous Forest

In areas where the average annual rainfall is higher than 200 mm, the diversity of wintering seed-eating bird species is lower in pine forests than in natural shrublands. Similar results have also been found for more arid areas. Afforestation has caused the disappearance of shrubland specialists, such as Spectacled Warbler (*Sylvia conspicillata*) and Long-billed Pipit (*Anthus similis*) and their replacement by forest species. The new forests have also allowed for the range expansion of Mediterranean species, like the aggressive Eurasian Jay that significantly affects local species, including outside the boundaries of the forest <sup>[20]</sup>.

## C. Mammals

A survey conducted in 2000–2001 [ 33 ] in the Lahav Forest found that the frequency of mammal observations was double in open spaces (shrublands) than in forest areas. The survey indicates that the diversity and abundance of mammals was larger in natural open and agricultural areas compared to mature pine forests. These results suggest that single-species forests are of low quality habitat (relative to natural areas) for a variety of animal species and, hence, fewer individuals and species are found therein.



Mammal activity level in the Lahav area. Quantitative comparison between shrublands and forest based on observations per kilometer. Y axis of Graph: **Number of animals per kilometer**, X-axis: **months December–June**. Blue= Shrublands, Red=Forest [35]



Greater Egyptian Jerboa. Photo: Roi Talbi, Israel Nature and Parks Authority.

## D. Vegetation

A study that was conducted in the Yatir Forest found that the biomass of herbaceous plants and shrubs was significantly higher in non-forested, natural areas compared to forested areas. In addition, they found a significantly higher density of shrubs in non-forested, compared to forested areas. Although there was no significant effect of forested areas on herbaceous plant density, the average number of plants found per square meter was 278 in the non-forested areas compared to 224 in forested areas. Species richness was also significantly higher in non-forested compared to forested areas <sup>[2]</sup> – 95 species in non-forested versus 79 species in forest areas <sup>[15]</sup>. Furthermore, it was found that 43 plant species typical of the natural area were absent from the forested area, in contrast to 27 species of plants that were found in the forested area and were absent from the natural area. Fifty-two plant species were found in both the natural and forest areas <sup>[15]</sup>. These data reinforce the idea that species richness in natural areas is larger than the richness in the forest areas, and that the natural plant species composition of the region does not survive in the forested areas. Moreover, it is likely that with the decrease in plant diversity within the forest, and decreased biomass of herbaceous plants and shrubs, there may be a corresponding reduction in arthropod diversity in forested areas compared to natural areas, particularly for shrubland and loess specializing species.



Desert Tulip (*Tulipa systole*), Eshtamoa Stream. Photo: Alon Rothschild, March 2012.

## 5. Negative impacts of afforestation on biodiversity

Afforestation and planting activities have resulted in large-scale changes in the landscape ecology of the northern Negev on a number of levels:

- Landscape level – change from a flat, steppe landscape to one with vertical elements such as embankments and trees.
- Patch level – increased fragmentation of natural habitats and the negative edge effects of forest margins on natural habitat patches.
- Local level – damage to natural habitats including destroying the soil crust and runoff regime (at least in the early years), and introduction of nonnative tree species. In addition, immigration of Mediterranean species that thrive under these altered conditions at the expense of local natural species.

Although the afforestation plots differ in character from each other, such as tree density, dominant tree species, etc., there are two key features of afforestation activities in the region that are most harmful to the natural ecosystem:

- Use of heavy machinery and compaction of the natural soil structure while altering the terrain from flat to rough mounds.
- Introduction of trees into an ecosystem where trees were scarce, consequently leading to additional direct and indirect negative ecological outcomes <sup>[2]</sup>.

This chapter examines the ecological effects of tree planting on the natural biodiversity, focusing on two main types of tree-planting formation in the region: 'savannization' and 'forest'. Factors in which impacts differ significantly according to the type of afforestation activities will be examined separately.

### A. Destruction of soil structure and plants in natural habitats

One of the ultimate goals of conservation is to preserve the diversity of species and natural habitats while maintaining the ecological and evolutionary processes within the different habitat types. It is generally assumed that in most terrestrial habitats the plant community structure (as primary producers) forms the foundation for the entire ecosystem. Thus changing the composition and structure of the plant community also changes the ecosystem.

### Direct impact to the natural vegetation

Forestry activities damage the natural vegetation (by trampling and removal of plants with the use of heavy machinery, herbicides, etc.) in steppe or loess areas, resulting in loss of natural habitats and their unique species. For example, the Snake-eyed Lizard (*Ophisops elegans*) is common in the Mediterranean region of Israel while also inhabiting marginal areas in the northern Negev Desert. In these desert margins there is a high correlation between the presence of this species and the steppe shrublands-dominated Thorny Burnet (*Sarcopoterium spinosum*). Thus, damage to and destruction of the steppe shrublands results in habitat loss for this species and threatens its survival in the region (Prof. Amos Bouskila and Dr. Boaz Shaham, pers. comm.).



Snake-eyed Lizard (*Ophisops elegans*)- found in the northern Negev semi-arid desert, this species is highly correlated with the presence of Thorny Burnet shrubs. Photo: Boaz Shaham

### Indirect impact to the natural vegetation

Certain species of trees planted by the KKL, such as eucalyptus species, are distinguished by germination inhibitors for herbaceous plants (Allelopathy). In addition, the trees shade and impede the growth of some plant species that are adapted to open, sunny habitats [29]. Competition for water, a limiting factor in this desert region, may also be a factor.



Impact of trees on herbaceous plants: accumulation of pine needles and lack of herbaceous plants (right), and allelopathic impact of eucalyptus trees (left) at the Vatikim Forest north of Goral Junction, March 2012. Photo: Alon Rothschild.

### Compacting topsoil, destroying soil crust and impact to functionality

Afforestation activities, especially in the savannization project, involve driving heavy equipment over the area and sometimes spraying herbicides against the natural vegetation. The heavy, earth-moving vehicles compact the topsoil, and thus, decrease germination of herbaceous plants, at least in the first years after the work. There is evidence of initial rehabilitation of herbaceous germination in old embankment troughs (approximately 15 years old), and even higher biomass of herbaceous plants in the troughs compared to the slopes (Tarin Paz-Kagan, 2012, pers. comm.). However, species composition was not yet explored -- Are unique species lost to the area? How long does it take to rehabilitate the area for herbaceous germination? What damage is caused to the ecosystem prior to recovery? In addition, the soil crust in desert regions is permeated with microphytes – cyanobacteria, bacteria, algae and lichens. Driving heavy machinery over the ground breaks the soil crust and may damage its functionality, such as its importance as a food resource to other organisms and its use (stability) for animal burrows<sup>[23]</sup>.



Savannization Area at the Yatir region. Germination of herbaceous plants observed only between the embankments, or within the troughs, apparently due to damage to the soil crust and the seed bank. Photo: Alon Rothschild, March 2012.



Savannization area following soil compaction from heavy mechanical equipment. In the right photo, an extreme difference can be seen in vegetation cover between the savannization plots (right side of photo) and the loess area in which no ground works were conducted (left side of photo). In the left photo, a planting trough without any herbaceous plants and tire tracks from the heavy equipment still visible after several years. Photographed from south of Meitar, March 2012. Photo: Alon Rothschild.



The Desert Woodlouse (*Hemilepistus reaumuri*) on loess soil crust. A key species, important to the ecology of the soil crust. Photographed north of Meitar, February 2013. Photo: Alon Rothschild.

## **B. Changes in vegetation and terrain configuration alter predation pressure patterns**

As described in Chapter 1, the natural landscape that characterizes the loess plains and steppe shrublands is of a low-growing plant community with no tall, vertical elements. This landscape is basically a two-dimensional habitat supporting organisms that are not adapted to the types of predation pressures existing in a three-dimensional structured habitat. Any change in this two-dimensional structure results in a change in predation pressure. Therefore, the addition of a pole or tree, which are part of the physical structure of a forest, provides a tall observation perch in the flat loess plains for predators, such as the Common Kestrel (*Falco tinnunculus*) or Great Grey Shrike (*Lanius excubitor*) [8]. An example of this effect can be found in the increased predation rate of Beersheba Fringe-fingered Lizard (*Acanthodactylus Beersheba*), an endemic, globally endangered species [28], in experimental plots compared to natural plots. Researchers found that this species is under heavy predation pressure in planted and adjacent natural areas, disappearing completely in some places. The mechanism causing increased predation pressure is related to the introduction of high, vertical elements in the area, as was demonstrated experimentally by placing artificial tree-like iron poles in some plots and comparing reptile species with control plots in adjacent natural plots. Among the findings, a phenomenon of an "ecological trap" was identified – the reptiles "perceived" the planted areas as suitable habitat (e.g., having

rich insect food source), yet in actuality they experienced a high predation pressure (that they are not adapted to), which resulted in poor physical condition [8].



The flowering loess plains east of Meitar. Photo: Alon Rothschild

Another example can be found in increased predation on artificial nests of ground-nesting birds in areas with high, vertical elements as was found in a study located at the loess plains near Hatzetim (Dr. Assaf Tzoar, INPA, 2012, pers. comm.). Additional preliminary evidence from the Hatzetim Army Base indicated that altering the ground by raising embankments for the savannization project created new opportunities for generalist predators, such as foxes, that dig their burrows in the embankments, thus exerting additional predation pressure in the area (Asaf Mayrose, 2012, pers. comm.). Systematic research is required to fully examine these observations.

Observations of birds that specialize in walking on the ground (like Macqueen's Bustard and Cream-coloured Coursers) point to the preference of these species to open areas, in part because they allow observation of potential predators. The very construction of embankments in the savannization project, that can reach a height of over a meter, creates a "closed" landscape in terms of a ground dwelling bird and may be a factor in deterring them from the area, even without the presence of trees (Meyrose and Perlman, 2012, pers. comm.).



Beersheba Fringe-fingered Lizard (*Acanthodactylus Beersheba*). Photo: Boaz Shaham

## C. Ecological fragmentation

Forestation in the Negev is a foreign element in the natural system and creates fragmentation between the natural habitats. In extreme cases, natural habitats are reduced in size and become isolated patches ("islands") that are unable to support viable populations of some organisms unique to the area. An example of this can be found in Map 6 that illustrates fragmentation from afforestation between the natural areas on Mount Amasa, Hiran and Lahav.

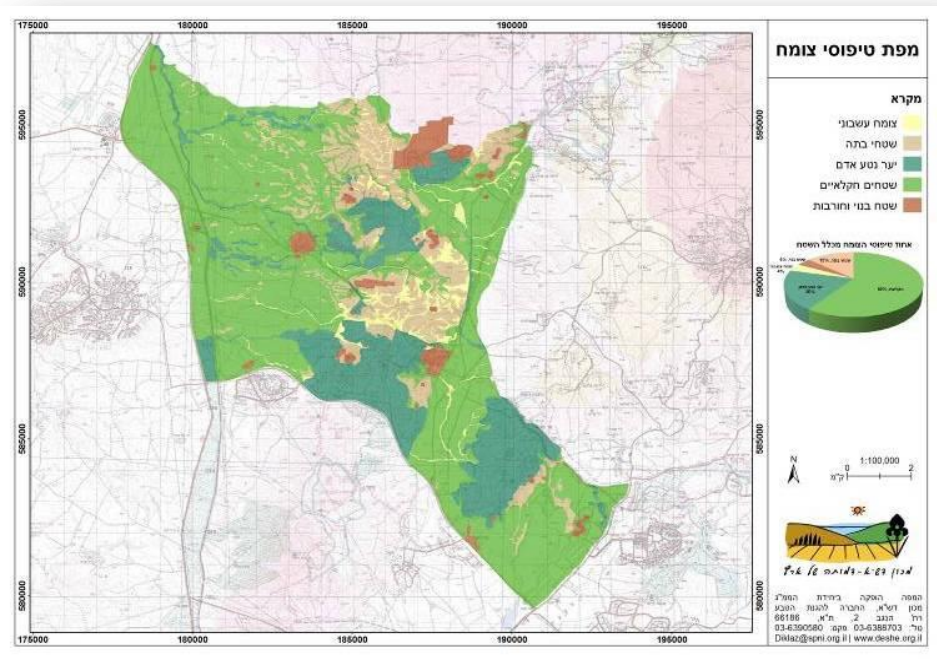
Fragmentation is the phenomenon of separating populations in isolated natural habitats, which may cause wildlife loss and seed dispersal limitation. Fragmentation leads to negative impacts on genetic diversity and demographic processes because of reduced ability of individuals from different populations to breed, as well as increased effects of marginal areas on the natural habitats, leading to compromised genetic resilience of the population to cope with environmental stresses <sup>[5]</sup>.

In addition, fragmentation reduces the mobility of the population and their ability to cope with natural or human disturbances and stress (uneven distribution of food resources, fires, development activities, hunting, disease, etc.

Fragmentation has a negative impact on various aspects of ecological communities such as abundance (number of individuals per unit area), species richness (number of species per unit area) and species diversity (combined index of the number of individuals and species richness) <sup>[1, 4, 21, 26]</sup>. Extreme fragmentation leads to a reduction in habitat size available to the population, and therefore decreases the number of individuals <sup>[1]</sup>.

In a study conducted on a bird community north of Beersheba <sup>[19]</sup>, in an area where large-scale afforestation has been carried out, a correlation was found between species richness and the size of the area. Small natural areas supported fewer bird species compared to larger natural areas. Long-billed pipits, for example, were completely absent from the shrubland patches smaller than 50 hectares.

A plant community study conducted at the south Judean Plains found a negative effect of patch size on natural plant species richness <sup>[6]</sup>.



Map 6. Example of fragmentation in shrublands and grasslands (yellow and light brown) resulting from afforestation and agriculture that penetrates into the natural habitats and forms isolated patches of shrublands. Source: Lahav Surveu. OLI.

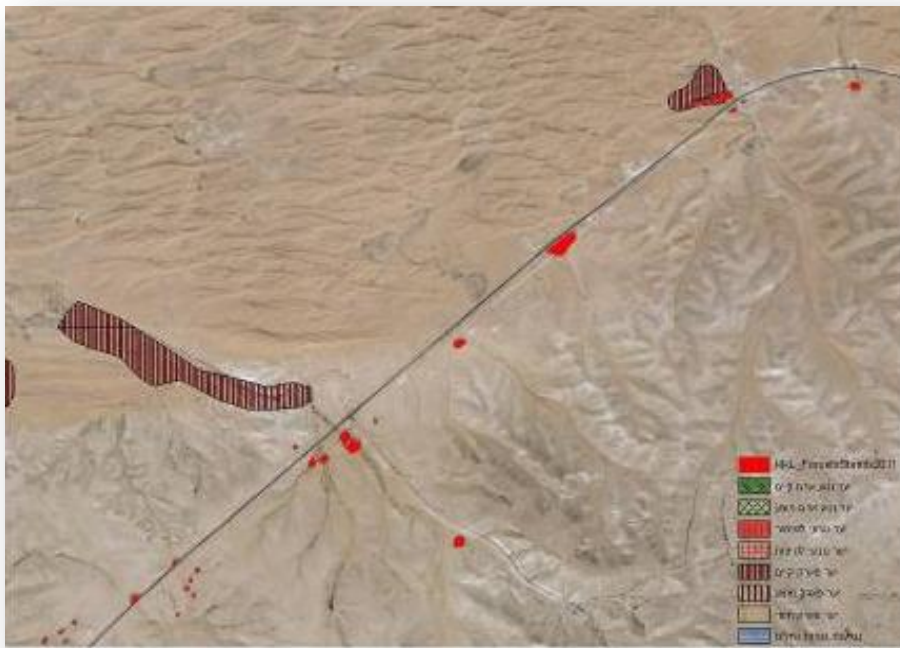
## D. Ecological change causes immigration of Mediterranean species into desert regions

Extensive tree planting allows Mediterranean species such as tits, jays and crows to expand their distribution into the desert expanse. These species utilize the forested areas as "stepping stones" that allow them to increase their range into new habitats while pushing out local species. Some of these species, such as the Hooded Crow, are considered anthropogenic, eruptive species that can have negative impacts on local biodiversity. Crows nest on tall trees and, thus, the forests help spread their population. This phenomenon is particularly evident in the case of the limans, where these small planted areas can be used as stepping stones for Mediterranean and invasive species to penetrate into the heart of the desert, greatly impacting broad expanses of the surrounding desert region <sup>[31]</sup>.

In addition, some aggressive Mediterranean species, such as jays, were found to stray from the forest. These birds are able to locate and destroy bird nests in shrublands up to two kilometers from the forest <sup>[20]</sup>. This is an example of the 'edge effect' of forested areas on natural areas – an impact that far exceeds the size of the planted area, affecting the ecological functioning of natural areas adjacent to the forest.

It is important to note that other human activities such as agriculture, infrastructure and settlements are also attracting Mediterranean and invasive species. Although the absence of afforestation in the northern Negev may not

have prevented immigration of these species into the region, afforestation limits the size of local species' populations and increases the edge effect of the forest on the core natural areas, thereby impairing the resilience of natural ecosystems to invasive species.



Distribution of limans at Shivta Junction. The limans (red) contain small patches of trees that are foreign to the ecology of the desert. Areas zoned NOP 22 (hatched) can be seen in the background. Note that the limans are not within zoned areas.

## E. Planting invasive alien species

The extensive planting of exotic species such as non-native acacia and mesquite species increase the risk of invasion into natural areas. An invasive plant (or species) is: "a species that is both alien to the environment and detrimental to the environment and local organisms" [34]. Of the species planted over the years, several species are considered invasive, such as Mexican Thorn or Mesquite (*Prosopis juliflora*) and Victoria Acacia or Gundabluie (*Acacia victoriae*) [27] (Dror Havlana, pers. comm.). These species have recently been categorized as species not recommended for use in Israel by a team of experts led by the Ministry of the Environment [35]. In many places, for example at Goral Junction, exotic acacia species can be found, most of which have spread from adjacent afforestation areas.



Distribution of limans at Shivta Junction. The limans (red) contain small patches of trees that are foreign to the ecology of the desert. Areas zoned NOP 22 (hatched) can be seen in the background. Note that the limans are not within zoned areas.



Planted Sallow Wattle (*Acacia longifolia*) south of Meitar. Photo: Alon Rothschild

## 6. Direct impact to protected natural resources during afforestation activities: Dark – Brown Iris test case



Dark – Brown Iris (*atrofusca Baker*) near a tractor preparing the ground for tree planting, Goral Hills, Spring 2013 (Photo: Avner Rinot).

Afforestation activities include the use of heavy vehicles, herbicide spray against native vegetation and significant alteration of the habitat. These actions have both direct and indirect impact to protected natural assets.

The law of National Parks, Nature Reserves, National Sites and Memorial Sites (1998) stipulates that: *"No person shall damage a protected natural resource without a general or special permit from the director"* (Director of the Israel Nature and Parks Authority).

Damage to a natural asset is defined as *"including extermination, destruction, breakage, injury, extraction, plucking and uprooting, taking, poisoning, alteration of appearance or of the natural position of a natural asset or interference in the process of its natural development, its reproduction or its preservation"*.

Some of the unique natural values of the steppe shrublands and loess plains are defined as protected natural assets by Proclamation 2005 (Declaration of "Protected Natural Assets"), including various species of reptiles and birds, and the endemic flower Dark – Brown Iris.

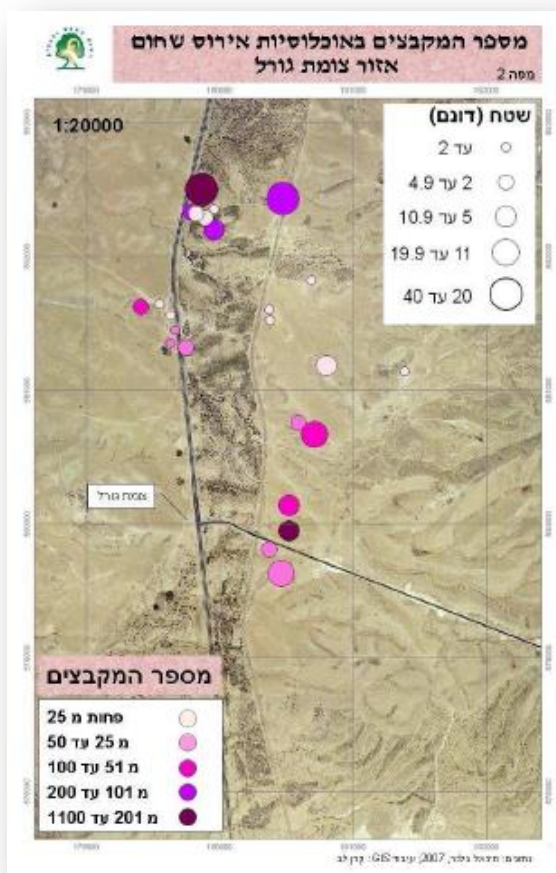
It should be emphasized that afforestation (including land preparation, shade tree plantings, invasive non-native trees) was identified by Blecher (2007) as one of the major threats to the survival of Dark – Brown Iris in Israel <sup>[29]</sup>. A number of cases of impact on the Gilead Iris have been documented during KKL forestry operations, including a report in 2004 by Dr. Yuval Sapir. Despite extensive documentation of Dark – Brown Iris stands in the region, in at least one afforestation operation, work was conducted on flowering site (Goral Junction), after the publishing of an INPA map report.

Another case, which was widely reported in the media, involved damage to the protected species Autumn Crocus (*Sternbergia clusiana*) during KKL operations in Yatir Forest on 11/08/2004 at the site known as the "Trail of the Autumn Crocuses" (Ynet , 09/11/2004).

The Israel Nature and Parks Authority generally refrain from enforcing the law in cases where KKL damages vulnerable natural assets, despite the fact that the KKL did not have a general permit or a special permit for damaging natural assets from INPA director. Leniency in compliance with the law for KKL is not granted within the framework of KKL-INPA agreements, which do not deal at all with this issue, and thus, INPA does not have the authority to dismiss KKL compliance with the law.



Israel Nature and Parks Authority vehicle near Dark - Brown Irises that were damaged by KKL's savannization project, north of Goral Junction, 2004. Photo: Yuval Sapir.



From right: Dark-Brown Iris near afforestation land preparation, Goral Junction, spring 2012 (Photo: Alon Rothschild).

From left: Map from an INPA document – Dark-Brown Iris patches at Goral Junction [30]

## 7. Impacts of afforestation activities on ecosystem services

Ecosystems provide a variety of services to humans. These services, known as ecosystem services, are defined as benefits people receive from ecosystems, and classified into different categories within the Millennium Ecosystem Assessment (MEA, 2005). MEA defined land-use change as the most damaging to global biodiversity.

Change in land use from natural areas into forest in the semi-arid region of the northern Negev and the south Hebron Hills affects a variety of ecosystem services that people benefit from in the area. It is worthwhile exploring the trade-offs in the set of services received as a result of the transformation from natural to forested areas. Here we look at three key system services.

### A. Recreation and leisure service

Pine forests and eucalyptus trees planted along the edge of the desert attract tourists and vacationers that use the forest for nature recreation and picnicking, mainly owing to the shade provided by the densely planted trees.

Shrublands and loess areas have a different quality as open landscapes with minimal shade and natural flowering of annual herbaceous plants, geophytes, herbaceous perennials and shrubs. Shrublands offer visitors wide-open panoramic views where you can see far and wide, with the sense of open space and an opportunity to see unique animals like Gazelle out in the open.

A study of visitor preferences in the north found that tourists prefer open landscapes with a view over planted forests and dense woodlands. However, for picnicking preferences were similar between open landscapes and planted forest, and lower for dense woodland <sup>[ 1 ]</sup> . The shrublands are particularly attractive in the winter and spring, and we can assume that during these seasons preference results would be similar to those of visitors to the northern Negev region.

It should also be noted that in the summer, forests in semi-arid areas (like Yatir Forest) have minimal photosynthetic activity, and therefore the rate of transpiration (evaporation of water through stomatal openings in the leaves) is reduced. Thus, the ability of the forest to create a cooler microclimate is significantly reduced in summer (Prof. Gabi Schiller, Conference on KKL Land Development Administration, Bet Dagan 5 September 2012) thus, reducing the attractiveness for visitors.

Recreation and picnic services by planted forests can be provided in a way that reduces damage to the natural ecosystem: Firstly, native trees can be planted instead of non-native species to provide shade. Secondly, groves can be limited in number and adjacent to developed areas, while leaving most of the region open for delivering tourism services.

It would be worthwhile to examine how many hectares of the 3,000 hectares of Yatir Forest is indeed utilized for picnicking compared to the area utilized for hiking, and to check the preferences of visitors and potential users in order to determine how much forest is needed for providing leisure and recreation compared to the extent of natural areas. Unfortunately, such information does not exist, in spite of the size of that forest and the many years it has existed.

Compared with dense forest, savanna planting in a park-forest configuration occupies comparatively larger areas and provides less shade, and therefore its ability to provide leisure and recreation services as a shaded picnic site out in nature is relatively low.



A young hiker on the flowering loess plains north of Meitar. Photo: Alon Rothschild.

## B. Climate regulation service

Global terrestrial vegetation absorbs about 25% of the carbon dioxide (hereinafter CO<sub>2</sub>) that is emitted into the atmosphere. This service is called global climate control because it moderates the rate of increase in the concentration of CO<sub>2</sub> in the atmosphere, thereby moderating the pace of global climate change.

A 9-year study carried out in the Yatir Forest found that the forest absorbed CO<sub>2</sub> at the rate close to the global average for forests, an interesting statistics considering its location in the semi-arid region. However, the authors weighed the positive influence of the CO<sub>2</sub> fixing forest against the negative impact of increased heat absorption. The forest is a darker shade from the surrounding natural area (light colored steppe shrublands) which causes a decrease in reflective heat radiation (Albedo or reflection coefficient – an expression of the degree of reflectivity of a body or surface, and is the ratio between the amount of electromagnetic radiation reflected from a surface to the amount of radiation that hits it. Radiation absorbed by the surface becomes body or surface heat) of the forested area in relation to its natural surroundings. Thus, while the absorption of the CO<sub>2</sub> has a cooling effect at the global level, the decline in the albedo value results in increased heating values. It can take decades before the cooling effect will be greater than the heating effect in forests in semi-arid regions <sup>[14]</sup>, and up to 80 years in the case of Yatir Forest (Prof. Dan Yakir, HaMAARAG Conference- Israel's National Ecosystem Assessment Program, 2012). Hence, afforestation in this semi-arid desert could harm Israel's efforts to reduce its climate change footprint since the forests in the northern Negev and south Hebron Hills are still balanced toward global climate warming. The study also suggests that desertification worldwide increases the amount of exposed surfaces without woody vegetation (bright and reflective) and helps moderate global warming because of the low absorption of radiation heat in semi-arid regions <sup>[14]</sup>. Although these data require critical, scientific examination of the afforestation activities within this semi-arid zone, they may imply a correlation between the benefits of natural areas in providing climate control services, and to the benefit of natural areas in protecting unique steppe species and the conservation of this semi-arid desert region.

## C. Soil erosion prevention service

Ground cover vegetation (including Microphytes) provides an essential service of protecting topsoil from erosion and weathering. Intensive activities that remove vegetation, especially in semi-desert areas, can lead to exposure of the soil to wind, Aeolian processes (erosion by wind) and erosion by runoff, and further desertification <sup>[24]</sup>.

One of the arguments underlying the Negev afforestation in general and the Savannization project in particular, is that forestry operations are stabilizing the sediment balance in the ecosystem, thereby preventing desertification processes. Considerable ongoing research shows that mature runoff harvesting systems (about 15 years old) prevent erosion, and thereby increases the eco-service function of conserving soil. However, ground preparation operations for the construction of runoff harvesting systems include the use of heavy machinery, herbicide spraying, deep ploughing of the soil, soil compaction and embankment construction. These actions are causing Aeolian weathering and soil erosion.

The Soil Erosion Research Station found that the impact of herbicide spraying on increased runoff and erosion is evident even after 15 years. In contrast, the aftereffect of mechanically clearing vegetation on slopes with no spraying is much shorter: slope clearing using a snowplow increases runoff in the first few years and then declines after only four years. After eight years there is no difference in runoff from land-clearing compared to control plots (Shmulik Arbel, Soil Erosion Research Station, 14 May 2012, email, pers. comm.).

Increased furrows and erosion are a known phenomenon that results from land clearing during the first few years following preparation for afforestation, and continues until an eventual natural "rehabilitation" occurs. However, areas covered by natural shrubland vegetation are stable ecosystems, with vegetation cover and soil crusts, and therefore provides an erosion prevention service.

To our knowledge, no extensive, long-term investigation has been conducted that examines the balance of soil erosion interactions in areas developed for afforestation. This examination should include the period during which the land has not yet recovered, and the "mature" period with full system functioning. Without significant, in-depth research that would show the balance of erosion for the entire life cycle of the runoff harvesting system, from the land preparation period up to stabilization that occurs only after more than a

decade, it will be impossible to point out the positive or negative balance of the erosion prevention services.



Furrowing and soil erosion in areas prepared for planting where natural vegetation has been removed - Goral Junction. from the left - Lahav area. Spring 2012. Photo: Alon Rothschild.



The forested area is characterized by minimal plant cover, most of which is exposed and vulnerable to soil erosion. Above is a shrubland slope characterized by herbaceous vegetation cover and shrubs with almost 100% coverage making it resistant to soil erosion. North of Lahav Forest, August 2013. Photo: Alon Rothschild

## 8. Sustainability of planted forests in an arid region

A significant factor in examining the cost-benefits to the public of the afforestation project in the semi-arid desert is the long-term sustainability of the forest in light of climate change that is expected to result in reduced precipitation and water shortages.

A historical example of this involved the planting of forests south of Beersheba in the 1950s (suspended during the 1960s), that was left dried out and dying for years, and subsequently KKL stopped planting forests below the 200 mm precipitation line <sup>[40]</sup>.

The region discussed in this document is characterized by a climate gradient from north to south. In the north the average rainfall reaches to 300 mm while in the south the average rainfall reaches to only 100 mm. At the Yatir Forest, the average rainfall available to be exploited by trees (effective rainfall), after factoring in foliage and soil evaporation, is only about 150 mm (Prof. Gabi Schiller, The KKL Land Development Authority Conference, Beit Dagan, 5 September 2012). Climatic conditions of these desert and semi-desert areas are not sufficient for natural forests to develop <sup>[42]</sup>, and at the Yatir Forest no natural regeneration of pine has occurred (Prof. Gabi Schiller, The KKL Land Development Authority Conference, Beit Dagan, 5 September 2012).

Climate change derived from anthropogenic activities is undoubtedly worsening in recent decades. According to climate change forecasts for the Mediterranean and Israeli water basins, desertification may increase even if rainfall remains stable due to: (1) increased evaporation arising from an increase in average temperatures; and, (2) a change in the frequency of precipitation and its spatial distribution.

It is important to note that the increase in climate variability in space and time will exacerbate the hydrologic regime <sup>[51]</sup>. Heat stress will increase the risk of crop damage from impacts of weather, pollution (especially ozone) and pests. For example, in recent years, hundreds of pines in planted forests in the northern Negev have died <sup>[50, 32]</sup>. Various models forecast that the main impact of these processes in Israel will be on the semi-arid desert <sup>[44]</sup>, and therefore, long-term survival of the forests is questionable.

It is noteworthy that KKL planted areas in the northern Negev require irrigation during the first few years after planting. Likewise, we know that even older planted areas (such as limans along Route 40 <sup>(49)</sup>) are irrigated through KKL initiative. This puts the sustainability of planted areas, irrigated

artificially, into question regarding the suitability of the desert region to afforestation, especially given the reality of national water conservation needs.



A water tanker that finished irrigating a liman on Route 40 south of Negev Junction, winter 2011.  
Photo: Guy Rotem



Pines dying from lack of water at the Lahav Forest, March 2012

## 9. Gaps in scientific knowledge of the Negev runoff harvesting project

*"Over the years, the KKL has invested much resources in preventing the spread of the desert and rehabilitated areas undergoing processes of desertification ... as such, forests prevent desertification processes at the edge of arid regions ... "*/ KKL website [22]

The Savannization project that began in 1986 [40] relies on limited background research, and as such it is important to look at the accumulated data, the difference between the research program and how the project is implemented, and the gaps in existing knowledge.

On the local scale, the desert ecosystem consists of two types of patches: Shrub Patch and Crust Patch, that act together as a Source–Sink system [3, 18]. Research has shown that crust patches contribute water, soil and nutrients to shrub patches, thus maintaining their existence.

The main argument underlying the Savannization project is that human activity such as grazing and cutting woody shrubs for fuel has reduced the shrub patch areas and changed the relationship between the source–sink patches. The result of this process, according to the savannization proponents is the loss of nutrients, soil and water from the system and further depletion of biomass. Their proposed solution to this problem was to artificially destroy the soil crust and create niches that allow germination of plant seeds that will act as sink patches and stop the drain of resources from the system.

The first experiments were conducted in the Shakked Reconnaissance Park and included the creation of small, artificial pits (length 1 m, width 30 cm, depth 20 cm), along with low mounds. These preliminary studies found that herbaceous plant species richness and biomass were higher in the pits and mounds compared to the area covered by the soil crust.

However, it is important to note the gaps in knowledge and implementation between the research project and the widespread implementation:

- The study was conducted using small, low pits and mounds, whereas, the implementation involves large embankments of 10s of meters long, over one meter in height, and that are created using heavy machinery that tramples the soil crust and compresses the topsoil.

- The species composition that contributed to biomass was not investigated: which plant species disappeared and which additional plant species occurred following the experimental interventions?
- How many resources (erosion, seeds, soil and nutrients) are lost from the system in the early years of preparing the land after clearing the natural vegetation?

Various studies have shown that artificially planting trees in semi-arid deserts improves the soil nutrient condition and reduces the amount of surface runoff and soil erosion <sup>[15]</sup> (Tarin Paz-Kagan, pers. comm.). It was also found that plant biomass measured in mature embankments (*Shichim*) of 10–15 years old was higher than the biomass in the natural control plots (Tarin Paz-Kagan, pers. comm.).

Contrary to the claims presented as the basis for Savannization, particularly the description that the degraded state of the desert ecosystem was beyond restoration, some researchers have put forward the possibility that the phenomenon of desertification in the northern Negev is the result of climatic cycles and likely that the system, at least in most sites, can rehabilitate naturally (Prof. Haim Kigel, 29 April 2012, email, pers. comm.). It is further argued that even if some areas are deteriorating such as in Shaked Reconnaissance Park (mortality of Thorny Saltwort *Noaea mucronata* and Mitnan *Thymelaea hirsuta*), other areas such as Lahav and Goral Hills support certain species that show relative resistance to drought (Thorny Saltwort and Thyme) or drought resilience (Prickly Burnet on north-facing slopes). Recent research suggests that some species are resistant to drought but not grazing (Thorny Saltwort) compared with other species that are resistant to grazing but not drought (Mitnan) <sup>[48]</sup>.

The natural desert ecosystem has undergone years of evolution that has resulted in a community biodiversity that is resistant to various types of stress. The argument that this ecosystem has degraded beyond a restorable threshold is highly debatable and unproven. Furthermore, no clear criteria have been set for defining what constitutes a "degraded" ecosystem. Also the connection between grazing and soil erosion, and degradation of the ecosystem, often cited as the reason for afforestation work, is unclear. Some argue that in Israel, a region that has been under heavy grazing pressure for thousands of years, excessive grazing is not an issue <sup>[15]</sup>.

Therefore, if the problem of desertification is intensified by grazing, the best solution would be an appropriate grazing management for preventing soil erosion, and not a complete change in the natural ecosystem.

At present there are still large gaps in knowledge between the limited research that is based on experimental plots of Savannization that was conducted in a limited area and manner, and between the extensive and intensive implementation in the region. It is important to note that insights gained from this ecological research conducted at the Shaked Reconnaissance Park (mentioned above) have pointed to the problems of planting activities in the loess plains areas of the park [8]. The information was then transferred to the KKL, which helped modify some planting programs, including a decision to advance the Loess Park Plan, in which most of the planned area would be preserved without planting. However, implementation of these ecological insights in terms of afforestation in the Negev region is far from adequate. Open issues that require answers prior to the continued implementation of intensive and extensive afforestation operations in the northern Negev include:

### **A. Macro-level questions**

- What are the criteria for identifying a degraded ecosystem that justifies intervention?
- Why perform operations in areas where the ecosystem is in good condition and not degraded?
- What are the cumulative impacts to the system for the first 10–15 years in terms of soil erosion, runoff and biodiversity (assuming that the "mature" forest system reaches an improved condition)?
- What is the impact on biodiversity with emphasis on sensitive desert species?

### **B. Micro-level questions**

- Why plant trees instead of native shrubs?
- Why plant non-native/invasive species instead of local species?
- Is it possible to create lower embankments that are farther apart in order to reduce the three-dimensional character of the landscape?



From left: Natural area in the Mount Hiran area. From right: Tractor implementing afforestation activities.  
Photos: Alon Rothschild

What are the criteria for determining ecosystem degradation that requires intervention?

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## Appendix 1 : Scientists letter

08/22/13

### Re: Ecological consequences of forestry operations in the northern Negev

(Translated from the original Hebrew by Zev Labinger – April 2014)

We, the undersigned, wish to express our concern, as ecologists involved in nature conservation in Israel, regarding the extensive afforestation operations that are implemented across the northern Negev region, causing significant damage to rare habitats.

Afforestation activities that are carried out over large expanses of more than 1,500 hectares per year, dramatically impact the natural landscape of steppe shrublands and loess plains, habitats that are threatened at a national level, and mostly not included in protected nature reserves.

These ecosystems have been impacted by forestry activities that include clearing and terrain alteration, invasion of alien and Mediterranean species, and a landscape change from low, desert vegetation to an alien forest landscape.

In an era of climate change, it is doubtful whether it makes sense to plant non-native trees in an area that requires huge investments of earthworks and irrigation for the first years after planting saplings.

These issues are described in detail in the document "*Ecological Effects of Afforestation in the northern Negev*" (August, 2013).

Our responsibility for conserving the unique biodiversity of this region is part of our commitment to maintaining the character of the land that we inherited from our ancestors, including the semi-arid desert region. This region bestows the area with a unique landscape that we should be proud of and should support with varied management tools (e.g. nature reserves, pasture lands, natural forest conservation, etc.), while also educating the local community about the natural treasures of this region.

We call on the planning and land management agencies and organizations to condition continued afforestation activities upon an examination of the ecological implications of these activities, in conjunction with the Israel Nature and Parks Authority and academia, in the form of a "strategic assessment of the northern Negev region". As part of this process, areas that deserve preserving in their present situation should be identified, criteria should be determined for "restorative" forestry operations, and general policies should be set based on the precautionary principle.

**Signed:**

Dr. Uri Shanas, University of Haifa - Oranim  
Prof. Gidi Ne'eman, University of Haifa - Oranim  
Dr. Yuval Sapir, Tel Aviv University  
Dr. Dror Hevlana, Hebrew University of Jerusalem  
Prof. Yoram Yom Tov, Tel Aviv University  
Dr. Shai Meiri, Tel Aviv University  
Dr. Boaz Shacham, Hebrew University of Jerusalem  
Prof. Eli Gefen, Tel Aviv University  
Prof. Marcelo Sternberg, Tel Aviv University  
Prof. Uzi Motro, Hebrew University of Jerusalem  
Prof. Ran Nathan, Hebrew University of Jerusalem  
Prof. Amotz Dafni, University of Haifa

Dr. Daniel Simon, Tel Aviv University  
Prof. Moshe Inbar, University of Haifa  
Prof. Moshe Kol, Hebrew University, Rehovot  
Prof. Ido Izhaki, University of Haifa  
Prof. Yehuda Warner, Hebrew University of Jerusalem  
Prof. Dan Izikowitz, Tel Aviv University  
Prof. Simcha Lev-Yadun, University of Haifa - Oranim  
Dr. Achik Dorchin, Cornell University, USA  
Dr. Rafi Kent, University of Cambridge, England  
Prof. Noga Kronfeld-Schor, Tel Aviv University  
Prof. Avigdor abelson, Tel Aviv University

## **Ecological Effects of Afforestation in the Northern Negev: Policy Recommendations**

**Alon Rothschild, Noa Yayon, SPNI**

**August 2013**

### **Background**

In light of the large-scale afforestation activities in the northern Negev and south Hebron Hills in recent years, an examination of the ecological consequences of afforestation on the region was carried out with the aim of encouraging an open public debate concerning the environmental aspects of these operations (Based on the report "**Ecological Effects of Afforestation in the Northern Negev**, August 2013).

This paper presents the rationale for integrating ecological considerations into regional management and into the decision making processes related to afforestation in the northern Negev, and offers a set of policy recommendations based on the findings of the ecological report.

### **Need for integrating ecological considerations into regional management**

The analysis indicates that the **northern Negev forestry activities negatively affect the natural ecosystem in the region**, and impact plants and animals characteristic of the area's natural habitats, including reptiles, birds, mammals and plants. Furthermore, afforestation causes direct and indirect damage to natural assets that are protected by law. Environmental benefits of afforestation activities are, at the very least, controversial (including evidence of negative impacts on ecosystem services such as soil erosion prevention, climate regulation, etc.).

The Savannization project, which is the main driving force of afforestation in the north Negev, is based on limited, small-scale research that incurred minor impacts to the soil. And yet, the project has been transformed into large-scale afforestation operations that are carried out much more intensively and include significant alteration of the natural topography using heavy equipment, and thereby changing large expanses beyond recognition.

**Hence, clear evidence for negative impacts on local biodiversity, alongside gaps in scientific knowledge supporting afforestation, require a re-examination of forestry policy in the region.**

### **Regional decision-making processes**

The main organization dealing with forestry activities in the region is Keren Kayemet LeIsrael (KKL). KKL is an afforestation and development organization, which has no legal authority for managing open spaces, and lacks legal authority for protection of natural values (except mature trees), managing visitors, preventing intrusions, etc.

KKL's lack of legal tools for land management, is particularly striking in comparison to the law that underlies the activities of a parallel land management agency – the Israel Nature and Parks Authority (INPA), which is granted wide-reaching authority to manage land under its control as open space that emphasizes the preservation of the area's natural assets within a specific legal framework (National Parks and Nature Reserves Act, 1998).

Moreover, KKL is a private entity that functions as a National Forest Agency, and yet, is not subject to oversight by the State Comptroller, is not responsible to a government office, and its forestry and land development policy is not determined by a public council (KKL Land Development Administration), even though it was decided that such a council should be established under the State – KKL Convention (1961). In contrast, the INPA has authority under a full, public

plenary law, representation by a wide range of government and public agencies, a professional scientific committee, chief scientist, and is subject to full oversight by the State Comptroller.

Afforestation of the Negev is currently implemented under two decision-making tracks. First, the statutory track required by NOP 22 areas (National Outline Plan for Forestry). The second track bypasses planning Law and implements afforestation under the guise of "agricultural planting". It was initiated by the Israel Lands Administration for strengthening the prevention of intrusions, with KKL as the implanting contractor.

#### **1. Planned Forestry under the Planning and Building Law (NOP 22)**

In NOP 22 areas, KKL is required to submit detailed plans. Since the approval of the NOP in 1995, planning authorities have not conducted a broad review of the impacts of afforestation on biodiversity in the northern Negev as part of an environmental impact statement, and have not set updated, general policies on this issue.

Up until the approval of the detailed plans, KKL requires regulatory approval from the Monitoring and Control Committee of NOP for planting, within the framework of submitting work plans, and semi-annual and annual reports. The Monitoring and Control Committee has enforced environmental regulation only in specific cases and has not examined the ecological issues for evaluating impacts of afforestation in the northern Negev region.

#### **2. Planting (afforestation) on State land at the initiative of the Israel Land Administration (Authority)**

Forestry and planting operations initiated by the Israel Lands Administration are conducted primarily outside the NOP 22 areas, on state land and with KKL as the implementing contractor. The purpose of the planting is "taking

possession” and preventing intrusion that relate to the complex enforcement issues in the Negev. Locating areas for planting is mostly performed by the ”Green Patrol” unit.

According to Resolution 1045 of the Israel Lands Council, allocating land to KKL will be made for the purposes of nature and landscape preservation. To the best of our knowledge, no ecological assessment has been conducted by the Administration to examine whether afforestation activities in the northern Negev actually support this condition.

The Israel Lands Administration Decision (107), which implements the Council Resolution (1045), defines the transfer of land to KKL for reasons of ”taking possession of the land for the nation” – a goal that is not found in the Council’s decision, but under which it is derived. Planting activities are promoted as ”agricultural activities”, whose stated goal is ”restoration of ancient agriculture” and ”support of sustainable agriculture” (by supporting grazing, planting orchards, land reclamation, collecting runoff and preventing erosion). By referring to ”agricultural activity” and not afforestation, the Israel Land Authority and Keren Kayemet LelIsrael are not required to submit detailed plans or apply for building permits.

Our position is that, for all intents and purposes, these are all forestry operations that have a significant impact on the land, the environment and the public, and therefore should be subject to a full planning process, as decided by the High Court on the 288/00 appeal.

### **Recommendations**

The following is a suggested list of tools designed for land management and conservation of the area’s natural assets.

- **Stop afforestation activities in sensitive natural habitats.**
- **Implementing the principles of ”the theory of afforestation” in management of the Negev** – The KKL Board of Directors recently approved

the new *Forest management Policy* document ("Torat Hayiur"), emphasizing the importance of land management based on natural processes while preserving biodiversity. The principles of this theory should be applied to the management area in the northern Negev, while at the same time taking into account the area's natural arid characteristics and unique biodiversity.

- **Afforestation only in compliance with Planning Law** - All forestry activities (or "planting") should comply with the detailed statutory planning in accordance with the High Court of Justice (HCJ) 288/00, and according to the Israel Lands Council Decision concerning the allocation of land for the purposes of "conservation of nature and landscape".

- **Update master plans** - The Monitoring and Control Committee for NOP 22 that operates under the council's decision according to the HCJ 288/00 must institute a broad examination of the afforestation issue in the region, with adjustments if necessary, for various land uses allowed for NOP 22 areas and for the suitability of different forest types in terms of ecological sensitivity.

- **Integrating ecological considerations in Green Patrol operations** - The General Director of the INPA, who oversees the Green Patrol activities, should determine an internal procedure for prioritizing appropriate enforcement tools, while balancing between the threat of intrusion and the ecological assets of the threatened area, and creating a mechanism for consultation with the district ecologist. Within this framework, it is important to examine alternative solutions for maintaining state land in which its ecological functioning has not been irreversibly harmed, including creation of nature reserves, grazing lands and other solutions.

- **Enforcement of protected natural assets** - The INPA must implement full enforcement against impacts to protected natural assets. We propose a mechanism of KKL submitting an annual work plan of forestry activities for approval by INPA, similar to the mechanism that a Forest Officer employs with the Ministry of Agriculture regarding trees.

- **Forest Authority and Forest Law** – It is proposed to promote a Forest Law, which would establish a government authority to manage areas of NOP 22, defining clear goals, enforcement powers, together with determining an appropriate organizational structure (including a public committee with broad representation, professional scientific committee, chief scientist), and assigning a government minister (Preferably minister of environment) responsible for the authority and with proper oversight mechanisms.
- **Research and surveys that support planning** – A survey is currently being conducted by SPNI for determining sensitive natural loess areas in the northern Negev. It is important to increase research concerning the ecological effects of afforestation in the region and to incorporate the knowledge and insights from research and surveys into land planning and enforcement processes.
- **Education and community** – It is proposed to develop educational and community programs among the local population (Jewish and Bedouin alike) to encourage conservation and familiarity with the natural habitat.