Introductions

The drainage of the 6,000 ha Hula lake and swamps, in the north of Israel, during the late 1950’s resulted in the loss of a very diverse and rare ecosystem. It was one of the very few large habitats for freshwater flora in the Near East as well an important phytogeographic meeting zone for holoartic and paleotropic species (Zohary and Orshansky, 1947). It was an important feeding station for migrating birds such as *Pelecanus onocrotalus*, a wintering area for *Porphyrio porphyrio*, *Phalacrocorax carbo*, *Phalacrocorax pygmeus*, *Anhinga melanogaster*, *Ardea goliath*, *Anser albifrons*, *Grus grus*, the last three of which were known to winter in the region only in the Hula. It was also a breeding ground for *Ardea cinerea*, *Platalea leucorodia*, *Haliaeetus albicilla*, *Aquila clanga*, *Circus aeruginosus*, and also a habitat for sixteen fish species and some hundreds of invertebrata species (Paz, 1975; Dimentman et al., 1992). The rich flora described by Zohary and Orshansky (1947), Jones (1940) and others consisted of nine vascular plants associations:

- *Myriophyllum spicatum*, *Myriophyllum spicatum* and *Potamogeton lucens*,
- *Nuphar lutea*, *Ranunculus aquatilis*, *Vallisneria spiralis* and *Najas marina*,
- *Potamogeton pectinatus*, *Potamogeton nodosus*, *Ceratophyllum demersum*,
- *Potamogeton crispus* and *Potamogeton perfoliatus*.

An establishment of the 320 ha Hula Reserve in 1958, and its declaration as the first nature reserve of Israel in 1963 did help partial rehabilitation of the original habitats, but not the ecosystem as a whole, nor did it succeed in preventing the extinction of species (i.e. *Nymphaea alba*) some of them being endemic, e.g., *Discoglossus nigriventer* (Paz, 1975).

The aim of the Hula swamp draining to reclaim a large fertile, area for cultivation was found to be only partially successful. Oxidation of the organic peat soil
resulted in soil subsidence, while heavy autumn winds have eroded the dry peat, in some cases up to 1 cm of soil in a single storm. In addition, there have been occasional occurrences of underground fires. Moreover, the fields tended to produce vegetative growth rather than reproductive, due to nitrate surplus, restricting farmers mainly to hay production. In 1994, predictions that the sinking will continue and that more areas will go out of production led the authorities to re-flood the valley, creating a 100 ha Lake Agmon and ca 400 ha of grasslands and meadows. The aim was to rehabilitate the diverse wetland ecology and create an area attractive to ecotourism, as well as to create a clearwater body, which would contribute to the purification of the water flow to the Lake of Galilee, Israel's largest freshwater reservoir (Shacham ,1994; Livne, 1994; Dimentman et al., 1992)

The goal of the present study is to assess ecodiversity changes due to the major landscape and landuse alterations. The landscape richness and diversity and the flora and avifauna richness across 58 years prior to drainage, during the agricultural period and after the reflooding, have been investigated.

Methods

Vegetation reestablishment studies were carried out in the Agamon wetland and the surrounding arable land after the reflooding (Kaplan et al., 1998; Kaplan, 1999). These data were analyzed with flora and avifauna data collected by Oron (1998) in the Hula reserve, by Zohary and Orshansky (1947), Jones (1940) and others (Dimentman et al., 1992) in the Hula wetlands prior to drainage, and avifauna observations carried out by Vaadia (1998) in the Agamon wetlands.

Landscape diversity was GIS (ArcInfo Geographic Information System) analyzed, comparing 1940, 1992 and 1998 maps by measuring abundance and cover of landscape types along 14 km transect across the Hula Valley (see red line in Fig. 1,2,3). Classification of landscape elements to landscape fragmentation elements, such as, roads and built areas, and to other landscape elements such as lakes, swamps, vegetated canals, grasslands, planted trees, arable land and orchards, was carried out on the various landscape features derived from the GIS analysis. The number of elements and their length along the transect was GIS counted and measured.

Species richness was calculated as the number of species per 1 square kilometer. Landscape richness was calculated as the number of species in 1 kilometer along the transect, Shannon index by using the relative length of each landscape type in the transect and landscape fragmentation as the number of fragmentation elements along the transect.

Results

Analysis of changes show a decrease in floral richness from the original wetlands to the agricultural period, and an increase in the rehabilitation period, represented by the Hula reserve and the Agamon wetland (26.3, 10.7, 78.1 species/km², respectively). The same trend is shown in avifauna richness (56.3, 16.3, 72.2 species/km², respectively; Fig. 4).
Fig 1. Before drainage (1942).
Fig 2. After drainage (1958).
Fig 3. After reflooding (1997) with background of lake and swamps prior the drainage (1932).
Fig. 4: BIODIVERSITY IN HULA VALLEY 1942, 1958, 1997.

- **Species/Km sq**
  - **original wetland**
  - **agriculture**
  - **rehabilitated wetland**

- **floral richness (species/km sq)**
- **avifauna richness (species/km sq)**

Fig. 5: LANDSCAPE DIVERSITY IN HULA VALLEY 1942, 1958, 1997

- **landscape richness (types/km)**
- **landscape diversity (Shannon index)**
Map analysis of landscape richness and Shannon index diversity demonstrate similar trends (0.42, 0.42, 0.48 types/km, and 1.25, 1.02, 1.34 Shannon index values, respectively; Fig. 5), negatively correlated to the fragmentation analysis (see Fig. 6).

It is concluded that the agricultural period represents a change in the landscape function towards a more fragmented and monocultural landscape, resulting in ecodiversity decrease, and that the wetland rehabilitation shows a success from the ecological-functional aspect. This study shows also the possibility to use these indices as landscape rehabilitation success criteria.

References


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