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TERRESTRIAL BIOMES:

Global Biome Conservation and Global Warming Impacts on Ecology and Biodiversity

Chapter 2

Northern Great Rift Valley: Deserts and other biomes

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1 Introduction

Biologists have always been fascinated by the very rich diversity in the areas known as the Great Rift Valley (GRV), which is the largest such structure in the world stretching around 6800km from Mozambique to Syria. To understand the geological and climatic history of the GRV, we must examine its faunal and floral distributions. The southern part of the GRV has separated into a wide area, creating mountains and savannas in East Africa with rich faunal diversity, attractive today for tourist safaris. Here, we focus on the narrower Northern Rift Valley (NRV) because we find, within a very small area, fauna and flora involving several phytogeographical zones. For example, going from Jerusalem to Jericho, a distance of only 30km, one encounters Mediterranean, Irano-Truranian, Saharo-Arabian, and Sudanese-Aethiopian fauna and flora. Understanding the causes of this biodiversity requires studying the geographic distribution of fauna and flora and relating them to the geological history of this area.

Studies of the biodiversity in the areas of the NRV commenced in the 19th century with visiting scientists (Tristram, 1884; Hart, 1891). Many more studies were conducted in the 20th century on species of plants and animals in the area, including interesting attempts at reconstructing biogeographical history (e.g., Tchernov, 1968; Zohary, 1973; Shmida and Aronson, 1986; Holt et al., 2013). These studies were limited to attempts to relate species distribution to climatic and geological history. Recent advances in molecular biology allowed for a better understanding of biological diversification in relation to geography based on DNA sequence divergence (e.g., Pook et al., 2009; Carranza et al., 2002; Metallinou et al., 2012).

Here, we focus on the distribution of plants and reptiles and attempt to expand on earlier studies by using new studies (like molecular biology) to comeup with explanations for distributions and the history of expansion, especially of Sudanese-Aethipian and Saharo-Arabian elements in the NRV. Plants were chosen because they usually respond to climatic, elevational, and soil conditions and provide good phytogeographic markers. From animals, we chose reptiles because of their ubiquitous presence and that many species show very strict distribution along phyogeographic areas.

2 Geographic and geologic history

For millions of years, what is now the eastern Mediterranean area was covered by the Tethys Sea, which regressed during the late Eocene and exposed most of the land. The land of what is now the Eastern Mediterranean Region (including Sinai) was uplifted from the Tethys sea drained into the Mediterranean from 35 to 5 MYA (Bandel and Shinaq, 2003; Segev et al., 2017). This continuous landmass was critical for the evolution of animals and plants making the NRV more contiguous with what is now Persia/Iran and Africa. The formation of the GRV began in the south during the Oligocene and gradually spread north during the Miocene, with the bulk of what we now know as the GRV opening up around 20 MYA. It started with the splitting of the African plate into two plates when uplift due to tectonic plate movement resulted in the gradual uplift of mountains and opening up of the NRV (Marcus and Slager, 1985). That geological history is why the valley system, which stretches nearly 7000km from Syria to Mozambique, includes in its Southern part secondary rifts that created lake systems and wide savannas that are of critical importance to animal and human evolution (Fig. 2.1).

The GRF is narrower and peculiar in its shape, stretching from the Gulf of Aqaba through Wadi Arabah, the Dead Sea, and the Jordan Valley. The Red Sea area (including the Gulf of Aqaba) opened up as a result of a "paar," a depression caused by the movement and migration of Arabian and African tectonic plates. This depression was not connected to the Gulf of Eden or flooded until the Pliocene (Swartz and Arden, 1960). Furthermore, the last ice

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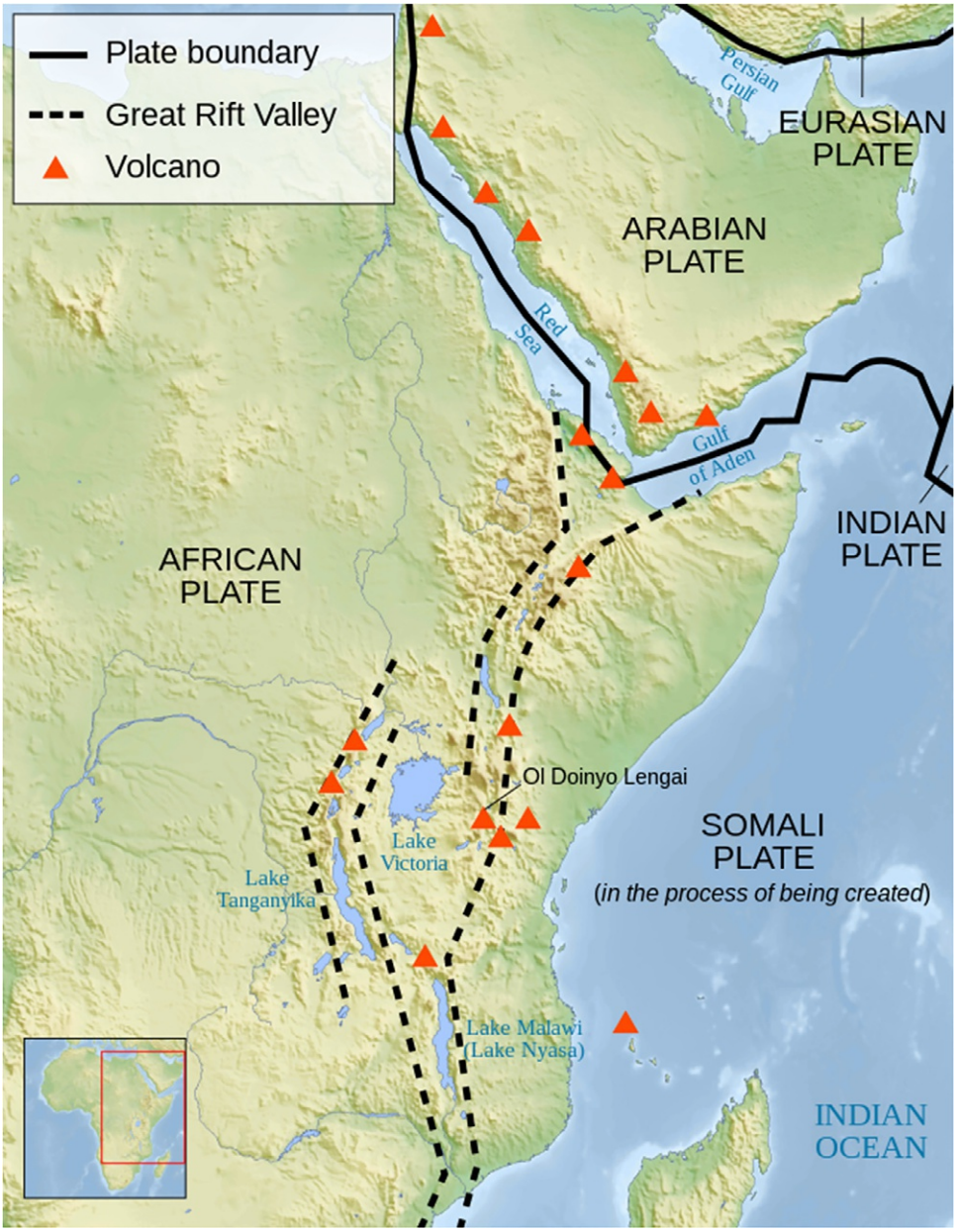

FIG. 2.1 The Great Rift Valley showing Eurasian, Arabian, African, and Somali tectonic plates. Map lines delineate study areas and do not necessarily depict accepted national boundaries. *(Credit: Wikemedia Commons.)*

age ensured that few temperate animals and plants were found in the northern parts of Palestine and Jordan. Qumsiyeh (1985) conducted an analysis of the distribution of mammals (including bats) in the Arab world and showed associations not related to geographic proximity, especially around Sinai, Palestine, and Jordan, which can only be attributed to geologic history.

In very recent times, desertification has been discussed (Edgell, 2006; Groucutt and Petraglia, 2012). Yet, it is important to understand what the concept of desert is and its relation to biodiversity and the unique adaptation of certain Sudanese-Aethiopian fauna and flora to "desert conditions." Most authors understand desert conditions in relation to aridity. For example, Grove (1977) classified deserts into hyper-arid (rainfall <25 mm), arid (25–200), and semiarid (200–500). Others have considered latitude and evaporative potential in forming arid conditions (Köppen, 1931; Belda et al., 2014). But clearly arid regions are expanding (desertification), especially in the era of climate change and this has ramifications for many areas including humans and biodiversity in our region (Soultan et al., 2019; Bayram and Öztürk, 2021).

There is significant evidence that the Arabian Desert, what now stretches to the NRV, had a moist subtropical climate during the Pleistocene, including an assemblage of what is now present in tropical and subtropical regions of Africa and Africa (Groucutt and Petraglia, 2012). The initial desertification due to climatic changes is estimated to have started no earlier than 8000 years ago (Bate, 1937; Avnimelech, 1937). Typical arid or semiarid land snails, for example, are noted from this period in Palestine and Jordan in the hills around the NRV but the desertification removed most semitropical elements of the large vertebrates leaving only small ones like *Procavia capensis* (see Picard, 1937).

3 Notes on Fauna and Flora

Vegetation zones along the NRV include mountains, steppe, desert, and wetlands/reeds. But each of those can have flora and fauna elements that are related to Sudanian, Irano-Turanian, or Saharo-Arabian elements. For example, if we take the Sudanian flora, we find species widespread in Wadi Araba, around the Dead Sea, and in the Jordan valley. Sometimes the penetration of Sudanian elements is surprising. For example, *Moringa peregrina* tree (Fig. 2.2) is found not only in Wadi Araba, Dead Sea, and Jordan valley but has also been recorded reaching the Yarmouk River valley system (Al-Himma Al-Ordoniyya area). Shmida and Aronson (1986) summarized two hypotheses presented by earlier authors about the origin of these elements of our flora: (1) relicts from the Miocene era (Tchernov, 1968; Zohary, 1973) and (2) recent Pleistocene migration (Tristram, 1884; Hart, 1891; Bodenheimer, 1935). Due to the lack of a high degree of endemism, adaptation to aridity, and vicariance, they supported the second hypothesis. However, this issue remained unresolved, and new molecular data suggest that the earlier spread hypothesis (Miocene) may be valid. The Red Sea rifting occurred geologically around 20–22 MYA (Zachos et al., 2001) and significant climatic changes began to happen over 8 MYA. These two dates explain the Saharo-Arabian distribution of some, but not all, Sudanese animals and plants.

FIG. 2.2 *Moringa peregrina. (Credit: PIBS.)*

The split of the area that is now the Red Sea that began around 24 million years ago had a profound impact on speciation. Molecular data/clocks show this split into African and Arabian populations around 20 million years ago, for example, in the genera *Echis* (Pook et al., 2009) and *Stenodactylus* (Metallinou et al., 2012). In some reptile genera like *Uromastyx*, the split seemed to have happened later around 11–15 MYA (Amer and Kumazawa, 2005). The data on molecular relationships of reptile species are clearly concordant with geological shifts creating vicariant populations, allowing speciation to proceed rapidly afterward (Metallinou et al., 2012). But one could also cite early Miocene divergence in other species like scorpions (Cain et al., 2021a, b). Soultan et al. (2020) based on vertebrate distributions believed that those animals previously described as Saharo-Arabian (Holt et al., 2013) should not be grouped together and that there is indeed an Arabian and Saharan distinct fauna. The molecular data cited above confirm that the Miocene vicariant split by the formation of the Red Sear does indeed lend credence to this designation. Indeed, there is evidence of the absence of post-Miocene land bridges over the Red Sea area, with the North Sinai land bridge being available only after the glacial periods of 40,000 YA (Fernandes et al., 2006).

In terms of historical species presence, since the Pleistocene in the upper Jordan Valley, there has been a remarkable persistence of species of Sudanese origin (Biton et al., 2019). Examples of reptiles include the ornate mastigure, *Uromastyx ornata*, the Palestine Mole Viper, *Atractaspis engaddensis*, Mueller's two-headed snake, *Micrelaps muelleri*, and species of the genus *Tropiocolotes* (Fig. 2.3). Mammals of African origin that spread through the Middle East are exemplified by the Rock Hyrax, *P. capensis*, the extinct Cheetah, *Acinonyx jubatus*, the Egyptian Fruit Bat, *Rousettus aegyptiacus*, and the Hyrax *P. capensis* (Fig. 2.4). The distribution of *Paraechinus aethiopicus* (Ethiopian hedgehog) along the NRV area is another interesting example (Qumsiyeh, 1996).

Another driver of evolution in our region is paleoclimatic shifts. Based on molecular phylogenetic data, Tamar et al. (2016) concluded that diversification of the genus *Pseudotrapelus* likely started in Western Arabia during the mid to late Miocene around 8.1 MYA and that species spread into other areas of what is now the Arab world, including the northern part of the GRV. This was driven by the climatic changes (expansion of arid areas) that affected the region starting mid-Miocene (Flower and Kennett, 1994; Griffin, 2002; Edgell, 2006;

FIG. 2.3 Interesting reptiles of the NRV: (A) the Palestine Mole Viper, *Atractaspis engaddensis*. (B) Mueller's two-headed snake, *Micrelaps muelleri*. (C). *Tropiocolotes nattereri*. (D) Ornate mastigure, *Uromastyx ornata*. *(Credit: Prof. Zuhair Amr.)*

FIG. 2.4 Interesting Ethiopian-Sudanese mammals of the NRV: (A) Hyrax *Procavia capensis*. (B) Fruit Bat *Rousettus aegyptiacus*. *(Credit: Authors.)*

Steinthorsdottir et al., 2021). This was another critical period for creating the shape of the fauna and flora of the NRV.

The NRV hosts a number of endemic species related to the recent expansion of arid regions including land snails (i.e., *Buliminus diminutus*, *Buliminus therinus*, and *Euchondrus pseudovularis*) (Amr et al., 2018) and scorpions (*Buthacus arava*, *Buthacus amitaii*, and *Buthacus levyi*) that were recently described from Al Naqab desert (Cain et al., 2021a, b). Finally, we note that studies in Fainan (South Jordan) using bird bones found in Neolithic community deposits showed that the area was far more biologically diverse due to the presence of water bodies and woodlands that subsequently disappeared (Mithen et al., 2022). There is evidence of increased habitat changes affecting the distribution of flora in our region, concomitant

with human development since the beginning of the Netufian agricultural period (Soto-Berelov et al., 2015). Only a few remnant freshwater wetlands remain in the NRV like Ein Gedi, Ain Al-Fashkha, Wadi Al-Mujib, and the marshlands in Mallaha. These changes were dramatic and are linked to human activities (Schaffer and Levin, 2014) and have accelerated in the past 200 years.

4 Human activities and their impacts

The rich biodiversity related to geology and paleoclimatic events now contends with major global threats (i.e., climate change, habitat destruction, pollution, invasive species, and overexploitation) as well as local threats like colonization, wars, and sociopolitical instability (Qumsiyeh and Abusarhan, 2021). Climate change, for example, has been modeled to have negative but variable regional effects on endemic species (Soultan et al., 2019). Desert-adapted species are also vulnerable to climate change (Vale and Brito, 2015; Kechnebbou et al., 2021). There need to be tailored responses (action plans, activities, targets) to the regional, national, and local community situations which also link directly to global/international strategies, agendas, and policies adopted by international conventions. Here, we need to address some specific threats to the NRV not discussed enough in the literature and then propose how we may address the challenges.

5 Dead Sea and Jordan Valley area

Before 1967, Israel diverted and used most of the water resources of the Jordan River basin for irrigation farming through the so-called "Israel national water carrier/canal" (Elmusa, 1998). From 1250 million cubic meters (mcm) per year in the 1940s, the river's flow declined to 20 mcm (Chen and Weisbrod, 2016). Israel uses 68.5% of the Jordan River basin and the rest is divided among Jordan, Syria, and Lebanon and none is used by Palestinians in the West Bank (Isaac and Hilal, 2011). Palestinians used 140 pumping units along the Jordan River before 1967 and all were destroyed or confiscated by the occupying authorities. The US-sponsored Johnston Plan 1950s was adopted to address shared water resources, but Israel refused to accept this arrangement (see Alatout, 2011; https://history.state.gov/historicaldocuments/frus1961-63v17/d8). According to the plan, Palestinians were to share 250 million cubic meters annually. According to Johnson's plan, the mountain aquifer in the West Bank provides approximately 850 million cubic meters annually, while the coastal reservoir in the Gaza Strip provides 150 million cubic meters, which indicates that there was an abundance of water that was more than the population's needs. But since then more resources also become available. Significant depletion of the Jordan River basin water was occurred because of megaprojects like the draining of the Hula Wetlands and the diversion of significant amounts of water from upstream (Lake Tiberias) (Messerschmid and Selby, 2015; Phillips et al., 2005). The Dead Sea is a unique natural phenomenon being the lowest point on the Earth. The economic, historical, sociocultural, and touristic importance of the basin region of this inland salt lake cannot be overstated. The area has essentially a tropical climate (but with little rain) making it a winter destination for the people of our region for thousands of years (e.g., the Roman Edomite vassal King Herod had a winter palace in Jericho area near the basin and a summer palace in Tequa area—Herodion). The muddy shores with high concentrations of salts and rare elements have therapeutic uses for both locals and internationals. It is also fed by the Jordan River and springs like Ain Al-Fashkha (a protected area). The part of the Dead Sea that is supposed to be part of the State of Palestine is under Israeli occupation (the whole state is under occupation). Contrary to the Fourth Geneva Convention, its resources are being utilized by the State of Israel (Al-Haq, 2012).

This diversion of the water via the Israeli National Water Carrier from Lake Tiberias, and the draw that Israel makes further downstream, has resulted in a significant decline in the level of water in the Dead Sea (Salameh and El-Naser, 2008; Figs. 2.5 and 2.6). The current rate of decline in the level of the Dead Sea is estimated at about 80–100 cm annually. As a result, the water level has declined from −397 (in 1968) to about −434 in 2018 over the past 50 years. This has also resulted in a decline in the surface area from 950 to 637 km^2. In the event that the situation continues as it is, the level of the Dead Sea surface is expected to drop by about 46 m by 2070, and is accompanied by a decline in the surface area of the Dead Sea.

The first military order given by the state of Israel at the conclusion of the so-called Six-Day War was military order number 92 on June 7, 1967, regarding the issue of water in the occupied territories, giving exclusive authority over all water sources and even controlled rainwater harvesting. This was followed by order 158 on November 19, 1967, ensuring control of "installations of water infrastructure" and on December 19, 1968, Israeli authorities declared all previous water dispute settlements invalid and all water resources in WB to be state-owned (military order 291). On March 23, 1971, military order 418 centralized decision-making under a High Planning Council and in the 1980s, the council declared that the upper limit of Palestinian consumption of West Bank water resources shall be limited to 125 mcm of the Mountain Aquifer (DIHLC, 2013). Water was stolen and Palestinians were made to buy more than 50% their own water from Israel (Rouyer, 2000). In parallel, Israeli authorities and settlers devastated the system of springs that existed in the WB before 1967 (Braverman, 2019). Israel destroyed all the

FIG. 2.5 The current "shrunk" dead sea. Map lines delineate study areas and do not necessarily depict accepted national boundaries. *(Credit: Google Earth.)*

pumping stations on the Jordan River. It prevented the Palestinians in the West Bank from using the Jordan River while simultaneously drawing 600 million cubic meters annually from Lake Tiberias at the head of the Jordan River. The Mekorot Water Company Ltd. (Mekorot) was founded in 1937 as a joint Zionist venture by the Jewish Agency for Israel, the Jewish National Fund, and others. In 1949, Mekorot became a government company. According to Al-Haq (2022) "in 1982 the West Bank water infrastructure controlled by the Israeli Occupying Forces (IOF) was sold to Mekorot for the symbolic amount of 1 NIS. Since then, Mekorot has been the largest single water supplier for Palestinians and has taken over the entire water supply in the West Bank, in violation of the Palestinian inalienable rights of self-determination and permanent sovereignty over their natural resources."

The Oslo Agreement was supposed to end the occupation, but instead it simply entrenched it, further strengthening Israeli control over the natural resources including water. International treaties and laws pertaining to water have been ignored in favor of "might makes right" approach. Regardless of political outcomes, there is simply a very small geographic territory (historic Palestine) with one hydrological system (Elmusa, 1998; Daibes and Daibes-Murad, 2003). A democratic state ensuring distribution of water to its citizens based on international guidelines is actually the most logical.

6 There is also pillage of resources of the Dead Sea

The Israeli settlements in the northern part of the Dead Sea explicitly and actively utilize the natural resources of the area (Al-Haq, 2012). For example, within two decades of its launch in 1988, the annual global sales of Ahava, an Israeli cosmetics company that uses minerals from the Dead Sea, reached almost $150 million. The company has been the target of boycott campaigns. Meanwhile, Palestinians

FIG. 2.6 Overlook area over the Dead Sea, showing shrunk areas that now have sinkholes, whose impact on biodiversity is still not well understood. *(Credit: PIBS.)*

are prevented from using the Dead Sea area for tourism (Abu-Baker and Farah, 2020; Al-Haq, 2012). According to ARIJ (2016) "Access to the Dead Sea is completely sealed off for Palestinians as far as economic activities are concerned." For the Palestinian economy, this represents a loss proportional to the potential economic value from the exploitation of these resources. Accordingly, if Palestinians had free access to their share of the Dead Sea and were allowed to invest in and develop their mining industries, their production value could range between $917.70 million and $2366.40 million, or equivalent to 7.2%–18.6% of 2014 Palestinian GDP. The average potential production would equal $1642.05 million, or 12.9% of GDP. Access to Dead Sea salts and minerals will also allow Palestinians to invest in the cosmetic industry with the potential to generate even more revenue.

From the Knesset Dead Sea Concession law 1962 "[the Israeli government gave to Dead Sea Works Company] the exclusive right to extract by way of evaporation (solar or artificial), cooling, mining, quarrying, or in any other way, mineral salts and minerals and chemicals, whether in solution or in solid form, which are in and beneath the Dead Sea… the exclusive right to make, expand, modify, maintain and demolish, in and beneath the Dead Sea…including—but without derogating from the generality of the aforesaid—embankments, evaporation ponds, culverts, water barriers, pumping stations, canals, pipes, electricity lines and electricity cables, roads, anti-flood installations, wells and bores, and other installations." (Hasson, 2022).

The Dead Sea Works basically transformed the southern half of the original salt lake into an evaporation pond. However, since it is now completely dry, to extract the minerals water is pumped from the northern half (which is legally Jordanian and Palestinian territory) to the southern half by the Dead Sea Works (the Israeli company). As a result, the northern half is shrinking very fast (due to the diversion of Jordan River and pumping by Israel). In 2021, a huge new pumping station called P-9 started operating, pumping 450 mcm/year from north to south (Hasson, 2022).

Jericho is a town that has been continuously inhabited since the dawn of the agricultural era, about 11,500 years ago. As one of the oldest (if not the oldest) town/village, it has amazing features including the archeological site of Tel Al-Sultan. There were two refugee camps in Jericho, stemming from the Nakba (Ain As Sultan and Aqbat Jaber) but most residents fled to Jordan in 1967. Wadi Al-Qelt brought water from three springs (Fara, Fawwar, Qelt) for thousands of years (Fig. 2.7). Together with local springs like Tel-AlSutan, Ain Al-Auja and others, Jericho had ample agriculture including in the old days sugar cane. There is a notable sugarcane press and other archeological sites (Tela Abu Al-Alayiq, Herod's Winter Palace, the Sycamore tree mentioned in the Bible in association with Jesus, the Baptismal site, etc.). There is also Deir Hijleh Monastery (one of the oldest historically 455 AD by St Gerasimus) and Deir Qarantel (Monastery on the so-called Mount of Temptation). Qumran caves are also the caves where the Essenes kept bible scrolls that were initially housed in the Palestine Museum (aka Rockefeller Museum) in Jerusalem but were illegally taken to the Israel Museum in West Jerusalem.

According to B'Tselem, 2011 "East of Route 90, along the Jordan River, are 64 sections of land—16,973 dunams, constituting 1.1 percent of the Jordan Valley and northern Dead Sea—in which Israel buried hundreds of thousands of mines, most of them antipersonnel. Even following the Israeli-Jordanian Peace Treaty, in 1994, Israel did not remove the minefields. On the East Bank, the Jordanians cleared some 100,000 mines, enabling the land to be used once again as farmland…In 1995, Israel signed the

FIG. 2.7 Ein Al-Qelt. *(Credit: January 2023 by PIBS.)*

Convention on Prohibitions or Restrictions on Certain Conventional Weapons, and in 2000, joined Protocol II of the Convention, which restricts the use of mines that are liable to be excessively injurious. In November 2006, Israel reported to the Convention's committee that the army had removed 40 minefields against tanks in the northern Jordan Valley, at a cost of five million shekels.60 Israel has not signed the Mine Ban Treaty, which took effect in 1999. The treaty completely bans the use of mines and requires their removal." However, we also note that Israeli occupation forces set up both "nature reserves" and, most of the time, overlapping military zones in the Jordan Valley (Fig. 2.8). All of this impacts both the environment and the human well-being in the area.

The Red Sea-Dead Sea Canal project is a prime environmental problem and should not be implemented as it could damage the environment in the whole region (see Salem, 2009; Rosenberg, 2011; Georges et al., 2021; Qumsiyeh and Amr, data available/unpublished). Its impact in SP will be most acutely felt in the unnatural "replenishment" of the Dead Sea, leaving the Jordan Valley essentially dry and with continued environmental deterioration. Some work has been done on this, but much more research needs to be done and a summary of these works is beyond the scope of this report.

7 Conservation

The area is notable for its rare/endangered birds (both resident and migratory) such as the bearded vulture *Gypaetus barbatus*, Dead Sea sparrow *Passer moabiticus* (LC), and the lesser kestrel *Falco naumanni* (LC). Several species have a conservation status, including *Aquila heliaca* (VU), *Circus macrourus* (NT), *Neophron percnopterus* (EN), *Streptopelia turtur* (VU), *Falco concolor* (VU), and *Lanius senator* (NT). In addition, 24 key (notable) species of mammals belonging to 11 families are known to occur in this PA. This includes eight species of bats, three felines, two canids, and three bovids. Several of these species have conservation status, including *Gazella dorcas* (VU), *Gazella gazella* (NT), and *Hyaena hyaena* (NT). The local status of the Arabian leopard, *Panthera pardus*, requires confirmation. Furthermore, the area is known for its rare and endangered plants (Al-Sheikh and Qumsiyeh, 2022).

In collaboration with IUCN ROWA (International Union for Conservation of Nature and Natural Resources Regional Office for West Asia), Palestine (OIBS & EQA with support from the Ministry of Agriculture and Ministry of Local Economy) worked on a new Protected Area Network (PAN) for the West Bank. The work on the new PAN was completed in December 2022. However, neither the PAN nor the new NBSAP has been published yet. The PAN designates protected areas according to IUCN criteria. The protected landmass increased from 9% to 11% and the

FIG. 2.8 Firing range and Nature reserves. Map lines delineate study areas and do not necessarily depict accepted national boundaries. *(Credit: B'Tselem, 2011. Dispossession and Exploitation Israel's Policy in the Jordan Valley and Northern Dead Sea. https://www.btselem.org/sites/default/files/sites/default/files2/201105_dispossession_and_exploitation_eng.pdf.)*

27 protected areas (PAs) represent all Palestinian vegetation types and phytogeographical zones. The PAN protects key biodiversity hotspots and ecoregions, but so far, only five of the PAs have management plans, and intensive surveys of the remaining areas are necessary to ensure effective protection (Qumsiyeh and Al-Sheikh, 2023). The Dead Sea Protected Area (for outlines of the PA see Fig. 2.9) is the largest PA in the West Bank and designated based on IUCN criteria as category Ia Strict Nature

FIG. 2.9 Redrawn protected area network portions around the Dead Sea. Old areas in black, new in Red. Map lines delineate study areas and do not necessarily depict accepted national boundaries. *(Credit: PIBS.)*

Reserve. That means, it is a "strictly protected area set aside to protect biodiversity and also possibly geological/geomorphological features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values" (Dudley, 2008).

Plant biomes and altitudinal effects are also conservation priorities in the NRV (Aynekulu et al., 2012). That this area includes the lowest point on Earth and that it has a mixture of fauna and flora related to African, Asian, and Saharan elements make it of particular conservation status. We recommend the following action for management:

(1) Significant new data to aid conservation efforts need to be collected on the state of the Palestinian environment (UNEP, 2020).

(2) Establish a Geopark and combine it with the protected areas on both sides of the Rift Valley to create the "Northern Rift Valley Global Protected area." The Dead Sea PA encompasses the lowest point on Earth and has interesting geological and geomorphological features. According to Gordon (2019), "the integration of geo-conservation across the full range of IUCN protected area management categories (…) should help to enhance their management and to deliver more effective nature conservation, with consequent benefits for geo-heritage, biodiversity, and people." The lowest point on Earth can be classified as a cultural ecosystem service, as it provides a *sense of place* (for a definition see Ryfield et al., 2019). Therefore, an analysis of the feasibility to incorporate a geopark in the Dead Sea PA will be an integral part of the developing recommendations for an ecosystem services-based management plan.

(3) This area should be also listed on IUCN's list of Red Ecosystems (Keith et al., 2015) because of its unique fauna and flora and the many endemic forms occurring around the lowest point on land globally.

(4) Transboundary and regional issues should be taken into consideration in strategic actions (Mason et al., 2020; Perrings and Halkos, 2012). In fact, there could be transboundary protected areas that increase cooperation (Sandwith et al., 2001). There is also increased desertification and a risk of fires (Turco et al., 2017). The main threat to the effective management of the new PAN is the lack of sovereignty, followed by the need for capacity building and a better Palestinian management structure.

(5) Tackling the threats facing the valley including Israeli projects that damage the environment. The best remedy for the shrinking Dead Sea and its sink holes (Arkin and Gilat, 2000; Ezersky et al., 2013; Salem, 2020) is to restore the flow of the Jordan River. Furthermore, we must address the power imbalance (Qumsiyeh and Albaradeiya, 2022(. While the state of Palestine needs to develop better plans for managing the resources, a big impediment to implementing many existing plans (e.g., for water resources) or complying with signed International treaties is that the State essentially has no control over most of its natural resources (due to the Israeli occupation).

(6) The most important aspect of success in conserving the area is to ensure local participation and empowerment (Rowe, 2006; Orenstein and Groner, 2015; Al-Assaf et al., 2022).

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