J Agric Environ Ethics (2009) 22:401–422
DOI 10.1007/s10806-009-9162-9

ARTICLES

Herd no More: Livestock Husbandry Policies and the Environment in Israel

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Accepted: 10 March 2009 / Published online: 29 March 2009

Abstract Livestock production in both industrial systems, where livestock are packed tightly together, and in highly traditional systems, where a shepherd follows her herd in dispersed rangelands, are cited as key contributors in some of the most acute environmental problems around the globe. Israel is one of the few countries where both of these systems exist, with surprisingly little contact between them. The environmental impact of the sectors were examined along with Israel's public policies in the field. While historically, much attention has been placed on the contribution of the Bedouin pastoralists to desertification and erosion, this may be linked to historic misapprehension about actual impacts of goats on local rangelands as well as political motivations and concerns about losing national sovereignty over large areas of rangelands. The true environmental effects appear to be minor. A far more critical concern is water pollution caused by the industrial sector of livestock production—an issue that recently has attracted considerable government attention and investment in a successful dairy infrastructure initiative. The divisions between governmental supports for the Jewish and Arab sectors of livestock management are inconsistent with efficient environmental management. Policies should be designed to encourage Bedouin to find ways to sustainably continue their traditional livestock husbandry practises, which today are largely associated with ecological benefits and constitute a unique cultural asset for Israel and the world.

Keywords Grazing · Pastoralism · Livestock · Israel · Bedouin · Agriculture · Environmental science · Middle eastern studies

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Introduction

> "The livestock sector emerges as one of the top two or three most significant contributors to the most serious environmental problems, at every scale from local to global."
> —Livestock's Long Shadow-The Food and Agriculture Organization of the United Nations.

Globally, livestock production accounts for 40% of agriculture's GDP (Steinfeld et al. 2007). More and more of meat and dairy products are produced in large, industrial style farms, whose polluting potential is well-documented. The main benefit of the industrial system of food production is that better nutrition can become available to a wide array of people. This may also have a beneficial effect on the environment since poverty and the environment are closely related (Millennium Ecosystem Assessment 2005).

There are both potential benefits and harm to the environment from livestock husbandry. Livestock farming can cause land degradation and desertification, the reduction and pollution of water resources, greenhouse gas emissions, and a loss of biodiversity. But with appropriate management practises, livestock husbandry can also improve soil quality, increase biodiversity, and enable the creation of alternative energy sources such as biogas.

Israel provides a unique setting in which to examine the differing environmental impacts of contrasting practices for raising livestock. Local milk production alone accounts for 10% of agriculture's GDP (Hojman and Malul 2005). Meat consumption per capita is rising, as it is among the world population. With its highly diverse climatic zones, Israel is home to several differing ethnic groups, and is one of the few places in the world where ultra-modern, zero-grazing techniques of livestock management coexist alongside transhumant grazing (Kressel 2003). Its small size facilitates observation, and its 60-year history of consistent regulation in the field of grazing and animal husbandry offers a strong location for a case study about the environmental effects of raising livestock. Evaluation of the various practices and policies of livestock production in Israel, with an eye to characterizing their environmental impacts, offers insights and tools for policymakers and farmers seeking a more sustainable agricultural orientation.

While much has been written on the impacts of grazing in Israel on biodiversity (Perevolotsky and Seligman 1998), there is little research tying Israel's intensive livestock production to its broader environmental effects. Studies have not attempted to link the two types of livestock production and consider their relative environmental impacts. And very little has been written about the policy mechanisms affecting livestock production and the environment, particularly since the major Dairy Farm Reform (1999–2006).

This article attempts to offer a response to several related questions:

1. What is Israel's current policy toward livestock husbandry and grazing?
2. What are the environmental impacts of this policy?
3. What changes should be made to ensure that animal husbandry in Israel remains environmentally sustainable?

This article considers only the production systems in the modern day boundaries of Israel (see Fig. 1) and does not evaluate practises in the Palestinian territories. The focus is on the production of sheep, goats, and cattle, rather than other types of livestock. While organic agriculture may be an important factor in the sustainable agriculture in the world, it is not a major force in the Israeli market, and is not considered in the present research. Finally, the study considers the livestock production industry on the farm (or the field)

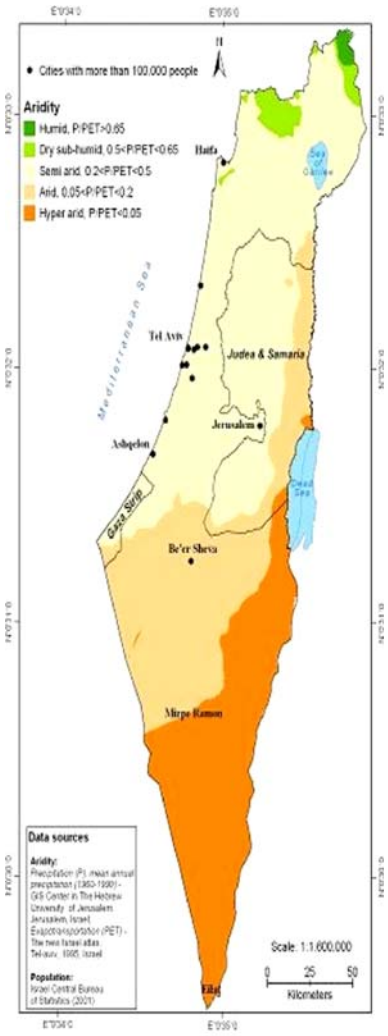

Fig. 1 Map of Israel showing divisions into climatic zones (from Tal 2007)

rather than the environmental effects of the processing and transport stages, or the rest of the lifecycle of the animal products.

The Evolution of the Jewish Livestock Economy

Jews in Israel, with some exceptions, always sought to emulate European agricultural practises (Tal 2002). For early Jewish settlers, agriculture was both an ideological ruralistic axiom (De Shalit 1995) and part of the open strategy to establish a Jewish homeland (Kellerman 1993). Agriculture was crucial to establishing ownership of large tracts of land, because land under Ottoman rule had to be continuously cultivated or it reverted to state control. Initially, livestock production was a component of mixed farming systems in Jewish agricultural efforts. By the period of the British Mandate, small ruminant production

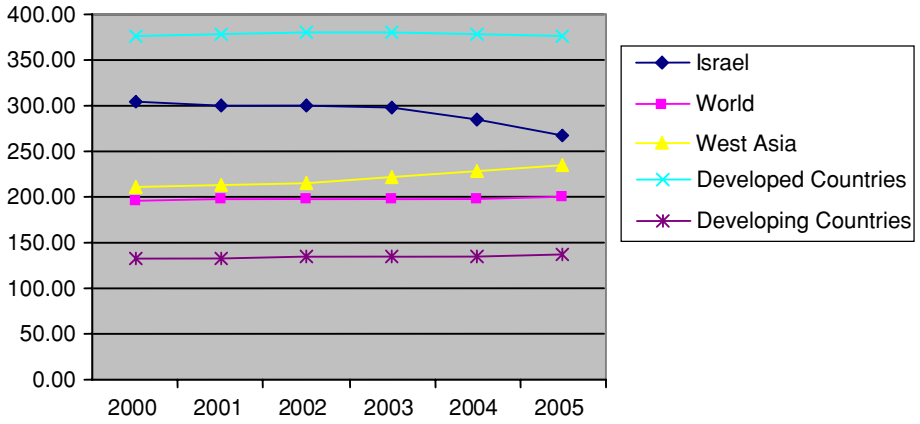

Fig. 2 Milk consumption comparison 2000–2005. Data from FAO statistical database

as well as dairy farming had begun to be important branches of agriculture in their own right.

Rummel et al. (2003) and Hirsch (1933) detail the history of Jewish involvement with sheep and goat husbandry; despite early enthusiasm it remained marginal in Jewish agricultural production. Instead, Jewish livestock production increasingly became associated with dairy cattle. Volcani's studies of the dairy industry published in the late 1920s provide a good resource detailing the early growth of the cattle sector and how it began to expand (Volcani 1930). Israel's successful dairy industry can surely trace its antecedents to the Jewish pioneers' extension program in pre-state period in Palestine.

The Jewish Livestock Sector Today

After more than half a century of dairy production, Israeli cows, 83% of which are located on large Jewish family (*moshavim*) and communal (*kibbutzim*) centralized dairy operations, now have the highest milk and milk solids production in the world (Hojman and Malul 2006). Israel is self-sufficient in its production of milk and dairy products and is home to approximately 350,000 cattle. The dairy industry uses more than 111,000 or one-third, of this herd. Israelis consume double the world average of milk and milk products (see Fig. 2), although rates would surely be higher without Jewish dietary laws and traditions that prohibit milk when meat is eaten. (They fall below the trend line for developed countries, but above that of their neighboring West Asian states—although this gap has narrowed in recent years see—Fig. 3). The remaining cattle population is made up of the Israeli beef herd and feeder calves imported from Hungary and Australia. Israel imports around 60% of the beef consumed annually, and produces some 40% of local fresh beef supply (Hojman and Malul 2006; Negev Foundation 2004).

Israeli dairy farmers today rely on a high technology, zero grazing approach. Since Israel is a dryland country where land is scarce, but the price of grains on the world market has historically been low, a zero grazing method makes sense in order to maximize production. Tnuva, an agricultural cooperative, is the largest dairy producer in Israel. In 2005 it processed 75.6% of Israel's milk. Tara (recently acquired by Coca Cola) and Strauss are the next two largest producers.

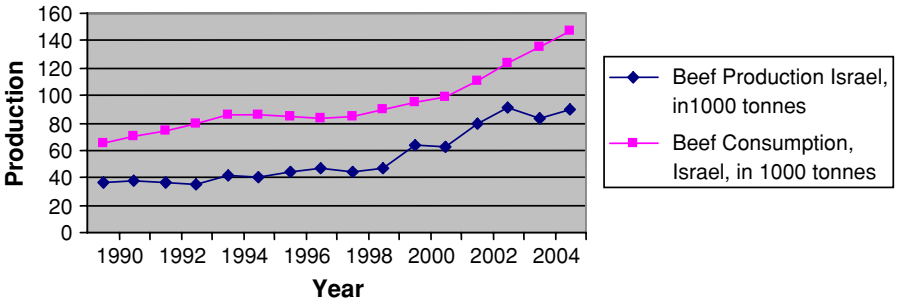

Fig. 3 Beef production and consumption in Israel, 1990–2004. Data from FAO statistical database

In the typical Israeli dairy, computerized sensors track even the number of paces taken by each cow, as well as its historic milk production. The touch of a button can instantly call up any of this data, and display relevant trends. The workers can also track likely illnesses in the herd via computer (site visit, August 2006). Records of 90% of Israeli dairy cattle are maintained in the Israeli Herdbook, a management tool that stores official information on milk production with breeding and veterinary data. The information in the herdbook is publicly available and can be used by farmers to analyze trends and records and make changes in practice. Dairy cattle are almost all Israeli-Holstein.

Cattle made up 14% of the value of Israel's Agricultural output in 2004. Sheep and goats are included in the "other" category, which makes up only 10% of Israel's agricultural output of over 4 billion dollars (Koskas 2005). In 2004 the value of Israel's total cattle output was 2,580 million NIS (1,918 million from milk, 407.1 from dairy cattle used for meat, and 254.6 million in cattle raised for meat). The value of sheep and goats was a mere 510.7 million NIS.

Israeli beef production has more than doubled since 1990. The sharp increase in domestic beef production is due to a liberalization of trade policies that allowed Israel to import "feeder calves" beginning in 1996 (Negev Foundation 2004). In 2002, a case of Bovine Spongiform Encephalopathy (BSE) was discovered in Poland, which had been the primary source for Israel's feeder calves, which prompted Israel to suspend the imports. Hungary and Australia are now the chief sources of Israel's feeder calves. Hungary exports Holstein dairy calves, similar to the Holstein cows from Israel's own dairy industry. Australia exports high quality beef cattle, including Black Angus. In terms of domestic production, the Israeli beef industry is essentially a byproduct of its dairy industry (Negev Foundation 2004). Male calves born on dairy farms are sold to be fattened for consumption as beef, as are some heifers from dairy herds. The calves and heifers from the dairy herd make up 40% of Israel's fresh beef supply. The domestic beef herd continues to enjoy a grazing subsidy (Negev Foundation 2004). There are over seven hundred feedlots and seventeen slaughterhouses in the country (Table 1).

While the milk production of sheep and goats is marginal to the dairy industry, representing less than 1% of total production, some believe it is an area with a high growth potential. The production of goat milk has almost tripled since 1994, and sheep milk has also risen substantially (Hojman and Malul 2006).

Despite its remarkable achievements, the future prosperity of Israel's livestock industry faces substantial uncertainties. Modern husbandry practices expose the animals to high health risks. Both Foot and Mouth Disease (FMD) and Bovine Spongiform Encephalopathy (BSE), also known as Mad Cow Disease, have been present in Israel. In the Middle

Table 1 Dairy and beef cattle in Israel

Veterinary office	Beef				Dairy				Grand total
	Farms	Minority	Kibbutz	Total	Farms	Minority	Kibbutz	Total	
Beersheva	16,733	5,950	1,490	24,173	9,032	254	16,864	26,150	50,323
Hadera	3,060	3,835	133	7,028	12,783	12	17,497	30,292	37,320
Teberia/K-Shmona	21,464	14,245	23,130	58,839	15,110	2	17,980	33,092	91,931
Kanot	4,643	974	6,558	12,175	35,493	35	20,610	56,138	68,313
Acco	5,274	10,927	2,545	18,746	5,321	8	12,603	17,932	36,678
Afula	2,228	2,369	7,310	11,907	27,823	0	22,059	49,882	61,789
Ztotal	53,402	38,300	41,166	132,868	105,562	311	107,613	213,486	346,354

Data from Israel Veterinary Services, Ministry of Agriculture and Rural Development (2004)

East region, foot and mouth disease is endemic, and the pathogens travel by air. Even with strict controls, it is difficult to prevent it from entering Israel's borders when it is endemic in neighboring countries. Israel's first and only case of BSE was discovered in 2002 (FAO 2002).

Intensive systems of livestock production rely on a low cost supply of grain. Noy Meir and Seligman (1979) described the relationship of grain prices to livestock production in Israel. In August 2007, the milk price was raised 3.8% due to a substantial increase in grain prices worldwide. The Israeli Dairy Board cited an increase in demand for grains in China, increased prices for transport, and a lack of grain surplus (partially due to an increased demand for grains for the production of biofuels) as reasons for the higher grain and milk prices. If the price of grain continues to increase, feeding livestock on concentrate may become less economically viable in Israel.

The Arab Sector before the State of Israel

By the end of the Ottoman Empire, the Arab inhabitants of Palestine fell mostly into two groups as far as livestock husbandry is concerned: the fellah, or Arab peasant, who relied mainly on cultivation and whose major type of livestock was the goat, and the Bedouin, whose livelihood was chiefly derived from pastoralism and whose major type of livestock was the Awassi sheep.

Already during British rule, transhumance, the system of wandering with flocks of sheep around a defined home base, was replacing nomadism (Rummel et al. 2003). Hirsch's *Sheep and Goats in Palestine* (1933) provides a thorough overview of Arab and Bedouin systems of livestock husbandry at the time. Rummel et al. (2003) demonstrate the evolution of grazing systems among the Bedouin during the twentieth century. Tal and Cohen (2007) detail the various ordinances passed to regulate grazing during the pre-state period. Marx (2000) and Abu-Rabia (1994) detail changes in Bedouin lifestyle and husbandry after the declaration of the State of Israel.

The tally of sheep in the Bedouin sector increased greatly during the twentieth century. However, the amount of grazing taking place is harder to track. It was estimated that in 1997, 35,000 Bedouin were still engaged in pastoralism. Some 10,000–18,000 of them reported shepherding as a full time occupation (Ginguld et al. 1997) while no updated official figures exist, the head of Israel's Grazing Authority estimates that by 2008 the

number was as high as 20,000 full-time Bedouin herders (Friedman 2008). At the end of the twentieth century there were 1,395 flocks registered with the Ministry of Agriculture (Stavi et al. 2006). The number has risen since then, and the Ministry of Agriculture shows upwards of 1,800 flocks of sheep in the minority sector in Beer Sheva for 2004 (Israel Veterinary Services and Animal Health 2004). Bedouin frequently continue to hold livestock as they move to towns (Degen 2007), and the weak employment prospects in the Bedouin sector prevent pastoralists who live outside of towns from giving up their flocks.

Sheep in the Bedouin sector kept principally for meat and are generally are only milked for home consumption; some are not milked at all (Rummel et al. 2003; Ginguld et al. 1997). When they are milked, it is done by hand. Degen suggests that at least in Bedouin towns, a cottage industry of fresh milk may be able to emerge from female livestock holders milking sheep and goat on a small scale and producing dairy products (Degen 2003). Whereas under an extensive system yogurt, cheese, and other dairy products were produced, marketing these products requires sanitary standards mandated by the Israeli Ministry of Health that would be difficult for Bedouin to obtain.

The health of the herds throughout Israel has improved over time. It is mandatory, for example, in Israel that sheep be vaccinated against the following illnesses: brucellosis, foot and mouth disease, and peste des petite ruminants (PPR) disease. The Bedouin also typically have access to and utilize veterinary care if other needs arise (Rummel et al. 2003). Sheep are tagged when they have their vaccinations, and must receive them by the time they are 2 months old. These veterinary practices have reduced the occasion of diseases among the sheep and goats, reducing herd mortality. The improved Awassi and crossbreeds grown now have a higher prolificacy (reproduction rate). Grain is now consumed as a feed supplement for most of the year, making the industry less dependent on weather while increasing the system's vulnerability to international market swings as the grain comes from outside of the community.

Many Bedouin welcome modern veterinary practices, and other technologies and medication that can enhance prosperity, and allow sheep to produce more than one lamb per year (Euda Abu Shiba, personal interview 2007). Bedouin herders complain that technical assistance that will allow them to have more prolific sheep is not disseminated quickly enough. The strict enforcement of animal transport laws and general bureaucracy associated with maintaining a pastoral lifestyle present further barriers. Many complain that in order to bring a sheep or goat as a wedding gift, they now need to go through a bureaucratic procedure and carry a permit (Mohamed Abed Abu Farija, personal interview 2007).

But while there are positive signs for the pastoral Bedouin community, there are also significant obstacles and challenges. Among the key challenges for pastoral Bedouin is gaining access to sufficient lands for their herds to graze. First the institutional maze can be confusing. Authorities involved range from the Bedouin Affairs Department of the Ministry of Agriculture, the Jewish National Fund (JNF), the Israeli Defense Forces (IDF), Green Patrol, Israel Lands Authority, and the Veterinary Office (Abu-Rabia 1994). Each authority has different requirements for granting grazing permission. The permission to graze is valid for one grazing season, and each location gives permission for several months of the grazing season. During the grazing season, the Bedouin are assigned rangelands by the Bedouin Department of the Ministry of Agriculture where they may graze their flocks. The license requires proof of vaccinations for their livestock as well as a symbolic fee for access to grazing land and for access to water sources (Roughly 200 dollars for a flock of 250 head) (Abu Farija, personal interview 2007). When Bedouin move their flock by truck they must receive special transport permits (Abu Farija, personal interview 2007).

But Bedouins correctly sense that the problem is not just negotiating yet another annoying aspect of Israel's government bureaucracy. Israel was established as a Jewish state and its land policies are designed to encourage Jewish settlement. The Bedouin feel the flip-side of this preferential treatment. For example, while the Ottoman Land Code remained in force in Israel until 1969, land policies in Israel from its inception have tended to favor the intensification of animal agriculture and the rural land rights of Jews over those of Arabs (typically due to reasons of national security reasons or special assistance to Jewish farmers) (Rouhana 1998; Yiftachel 1999).

The establishment of the Israel Lands Administration (ILA) in 1960 created an administrative body to oversee management of the state's land (Forman 2006). The Green Patrol, a 1977 interagency initiative, was established to prevent illegal encroachment and settlement on state lands (Tal 2002). Their rangers began a policy of aggressive efforts against both Jewish and Arab squatters, but soon gained a reputation for targeting enforcement interventions on the Bedouin pastoral sector. While tensions between the Negev Bedouin communities and the Green Patrol have diminished in recent years, the Green Patrol is still resented by the Bedouin.

While for the past 5 years, veterinary records show a fairly stable population of sheep among the Negev Bedouin, the future of this pastoral sector is in question. A recent survey of Bedouin herders grazing in semi-extensive systems showed that they all saw their future prospects in sheep production as negative (Rummel et al. 2003). As one such herder explained:

> Each year I see that I lose more and I don't stay on the same level as the year before. The feed is more expensive and the sheep go down in price. The feed is very expensive. This year the price is double (Abu Farija, personal interview 2007).

At the same time, as a sector, Bedouin pastoralists have recently become more organized and politically active to lobby for their economic interests.

Over the past 10 years, the JNF has begun to strongly encourage grazing in their forests. This is due to a growing recognition of the efficacy of grazing as a method of fire prevention. This grazing is primarily from sheep.

Research is underway to produce a more prolific genotype that will increase the profitability of shepherding (Elisha Gootwine, personal interview 2007). Nevertheless, for Bedouin who do engage in semi-intensive grazing, the profits from sheep grazing itself are usually secondary. Profits are chiefly made by renting machinery (Rummel et al. 2003). Flocks under semi intensive systems are larger than in extensive systems, and they live in permanent housing. Also, rather than pure Awassi sheep, crossbreeds of Awassi with Assaf or Merino are more common in semi-intensive systems.

The dairy industry associated with sheep and goats is expanding, although it is the dairy production from within the Jewish sector that is growing more rapidly. The lack of a dairy infrastructure in the Arab sector will make it difficult for them to play a part in this industry, and Bedouin political action groups are anxious to establish such infrastructure (Personal interview with Yeela Ra'anan, the Bedouin Sheep Growers Committee Coordinator, 2007). Moreover, Arab cattle farmers tend to have less access to natural pasture land than do Jewish beef cattle farmers (Eizhik Shafran, personal interview 2007).

But neither is the Arab minority's share of Israel's livestock trivial, and it indeed exceeds their relative size of the population. Israel's non-Bedouin Arab sector holds 161,331 sheep, roughly 24% of Israel's total sheep holdings, as of 2005. They also own 34,008 goats, or 29% of the national stock. Their total cattle holdings are 32,407, which is less than 10% of the total cattle population. Of this cattle, the vast majority is sold as beef.

The Veterinary Service reports that only 57 *dairy* cows can be found in the Arab non-Bedouin sector. However, the Arab sector holds roughly 24% of Israel's beef cattle (Animal Census Publication 2005).

The Druze, a non-Muslim, Arab minority group, make up a large portion of the Israeli minority beef cattle holders. Theft is prevalent (as is poisoning) in Israel's beef industry, and many Jewish cattle growers suspect Arabs (Hassin 2005). The Beef Cattle Growers Association (AMBAL) demonstrated in support of Shai Dromi by planting trees on his farm when he was arrested for killing a Bedouin would-be sheep thief in the Negev.

It would seem that today's Arab livestock farmers are in a position somewhere between the Jewish and Bedouin sectors. As recently as 6 years ago, only ten Arab farms were given a quota for sheep and goat milk in 2003 (Ahali Organization 2003). Their farm size tends to be smaller than Jewish farms and they lack much of the infrastructure that Jewish farms have; the shelters for the sheep and goats frequently are not sufficient.

The Environmental Effects of Livestock Husbandry in Israel

Globally, livestock husbandry has significant effects on many of the most important environmental problems today, such as desertification, climate change, species loss, and water shortage and pollution. The magnitude of these impacts in Israel is now considered with an eye towards establishing an Israeli environmental agenda and prioritizing regulatory resources towards its livestock sector.

Rethinking Perceived Land Degradation in Israel due to Livestock Overgrazing

Grazing affects ecosystems in many ways, one of which involves erosion. The associated land degradation can include several factors: a decrease in biodiversity, including ecosystem services, a change in the "structure" of the ecosystem, biomass productivity and usefulness to society (Perevolotsky and Seligman 1998). But land degradation must be assessed on a case by case basis. For some areas, an increase in primary productivity can be a sign of degradation. In addition, changes must be evaluated in terms of whether damage, when it occurs, is permanent. Scientists talk about whether the resilience of land is damaged. If grazing is considered a degrading factor, that should mean that after grazing stops, the land will take a long time to revert to its pre-grazing state. If instead, grazing stops, and within a few years, the land is back to its pre-grazing state, then true degradation did not take place.

This is the case in the border between Egypt and Israel in the Nizzana region. The geopolitical border is clearly visible in satellite images and research has shown that the line is due to a biogenic crust formed on the Israeli side because of grazing restrictions. (Otterman 1977; Karnieli and Tsoar 1995). But Israel's entry and exit into the Sinai showed that the landscape changes could be reversed in just a few years (Otterman and Tucker 1984).

The terms "overgrazing" and "undergrazing" are often applied without a precise measurement making it difficult to assess whether grazing has led to degradation of soils. Perevolotsky and Seligman (1998) assert that the heavy grazing typical to northern Mediterranean extensive grazing systems is popularly, but incorrectly, termed overgrazing. A recent study by Henkin et al. (2007) showed that people surveyed on grazing levels in a park in the North of Israel preferred a moderate form of grazing because of the aesthetic appeal of the combination of trees and brush found in moderately grazed land. Given the

economic interests, it is not surprising that livestock producers may prefer a more intensive stocking rate to this combination of trees and brush.

In addition to desertification, livestock grazing in Israel has been blamed historically for deforestation, replacement of palatable grass species with herbaceous vegetation, compaction of soil, decreasing water infiltration, decrease in organic matter, and water shortage. This was the common perception prevailing during the British Mandate. The position was summed up in a 1946 report to the British government:

> The practice of extensive grazing, a tolerable and even sound practice in temperate regions, is in the Palestine climate and conditions the greatest single bar to rural prosperity. In the time of Abraham a few pastoral nomads roamed through great areas of forests and scrub and found an easy livelihood. Since then the population has vastly increased, the area and volume of vegetation has correspondingly dwindled, and it is now an inescapable fact that the destruction of vegetation by the grazing of animals is severely damaging the economy of the plains and bringing ruin to the hill country… The remedy lies in the curtailment of the numbers of animals to be grazed and in radical change of the present regime, familiar to scores of past generations. The instinctive and traditional methods of a peasant population are not easily altered and persistent attempts to give practical instruction in this matter by precept, demonstration and persuasion must be continued for a considerable period (Shaw 1946, p 428–429).

Accordingly, the colonial government took an active role in managing the settlement of the land and in monitoring degradation. In 1928, Colonel E. R. Sawer, the then Director of Agriculture and Forests in the British Mandate Government, said the following in an address to the Palestine Economic Society:

> There remains the outstanding and distasteful problem of the goat—the alleged evil genius of the Mediterranean, against whom has been directed a larger body of legislation than has honored, or otherwise, any domestic animal.

Sawer mentioned that at the time there were half a million goats in Palestine, and they provided the country's principal milk supply. At that time there were efforts made to encourage goat owners to replace them with sheep. The British Mandate government instituted a policy of issuing grazing licenses to restrict the herders' range.

Thirty years later, land managers in the State of Israel initially shared the negative perception of goats. In 1950, the Plant Protection Law, also colloquially called the "Black Goat Law," was passed. This law limited the number of goats allowed to graze on public lands (Tal 2006a). The Ministry of Agriculture was empowered to confiscate goats found in violation of this rule.

But Israeli ecologists who studied the actual impacts of sheep and goats on open spaces reached a consensus that grazing at optimal levels of intensity actually could confer key benefits. Grazing removes biomass that otherwise (particularly in Mediterranean environments) could be fodder for bush fires. Grazing also controls the growth of shrubs, can foster the spread of seeds by trampling in manure. Trampling by livestock can assist the growth of grass and can break detrimental soil crusts (De Haan et al. 1997). The right level of grazing can actually enhance biodiversity, because without enough grazing certain plants will become dominant (Perevolotsky and Seligman 1998).

The length of time an area has spent under grazing influences its resilience. Areas with no native herbivores that are harnessed for grazing typically show more damage than areas that have been under grazing systems for a long period of years. Because Israel has been

inhabited continuously by humans for between 5 and 10,000 years, there is no natural state or "climax state" to which it might possibly return.

Ecologist Imanuel Noy-Meir points to two different models that reflect the effects of grazing. In the "worst case" scenario, as grazing intensifies, the conservation value of the landscape drops following a square root curve. He suggests that this is the case for lands such as Australia's rangelands or Patagonian steppe in Argentina, due to the absence of a history of grazing by herbivores there. The chart for Mediterranean rangelands, however, is different. At a grazing intensity of zero, the conservation value of the land is low. It increases initially, reaching a peak. The initial increase in biodiversity is because in ungrazed lands, dominant species crowd out others. Grazing controls the population of the dominant species, and allows the other species to thrive. The level of biodiversity increases and reaches its highest level with moderate grazing. This is typically below the level of grazing that might produce a maximum value for animal production. The decline in either conservation value or production value is not considerable between the two peaks. The production value for livestock decreases after the peak is attained in part due to the decline in value of the vegetation and pasture (Noy-Meir 2005).

The implication for Israel is clear: grazing that is carefully managed offers meaningful ecological benefits. Avi Perevolotsky and Noam Seligman, government researchers at the Ministry of Agriculture's Volcani Institute and arguably Israel's leading authorities on grazing and ecology, argue that "degradation" took place in the northern Mediterranean long ago, at some point after the domestication of animals in 7,000 BCE. Yet, since that time the landscape has been in a dynamic flux that has never reached irreversible "degradation" (1998).

It has taken some time for this ecological consensus to be integrated into public policy. For instance, the workings of the Green Patrol were at first partially justified by the Black Goat Law, and its objective of preventing land degradation. In fact, the Black Goat Law was reinforced in 1977 with a Plant Protection Declaration (Damage by goats), which stated that goats would not be allowed in natural reserve areas (ISRAEL: Plant Protection Declaration (Damage by goats) (Prohibited Goats grazing areas) 1970).

In retrospect, a turning point on the issue can be identified in the form of a letter to the leading Israeli daily—*Haaretz* by three of Israel's leading local ecologists, Michael Even-Ari, Emanuel Noy-Meir and Ze'ev Naveh, that was published on June 15, 1978. They argued that that the black goats actually have a positive effect on the ecosystem and that the black goat law should be overturned. This did not stop the passage of an additional bill, providing a policy for goats confiscated while in violation of grazing statutes. In 2009, however, all signs point to a change in orientation among authorities who now ignore the draconian provisions and are more accommodating towards goats, whose presence in flocks is tolerated and occasionally encouraged.

For example, the Jewish National Fund serves as Israel's forestry service, and welcomes livestock into its forest areas. The livestock serve the important purpose of controlling forest fires by eliminating flammable biomass on the ground that can spread fires. The benefits to ongoing management are sufficiently great to trigger JNF deliberations as to whether it should pay pastoralists to graze areas in the central region where recently they have not frequented as intensely (Gershon Avni, personal interview 2009). Herders are invited to graze stubble on cropland after harvest, on military training areas and natural reserves; these lands provide multiple purposes.

In conclusion, while in the past, overgrazing in some regions may have posed a serious driver of desertification, livestock husbandry is not currently a strong cause of land degradation in Israel's drylands. Land used for grazing is multi use, and industrial systems of

livestock management use little land. This should have important ramifications in Israel, since it is a small country. Land degradation due to Israeli livestock husbandry may be felt abroad, in countries that export feed grains to Israel. But this surely is not a basis for attacking grazing policies in Israel.

Climate Change and Livestock in Israel

Israel has surprisingly high per capita carbon dioxide (CO_2) emissions (US Department of Energy Ranking of the world's countries by 2004). Israel is not considered an Annex 1 country under the UN Framework Convention on climate change so is not obligated to reduce its emissions, but it is creating a plan to reduce them voluntarily. Agriculture contributes practically nothing to Israel's carbon dioxide emissions but is a more important contributor to the generation of nitrous oxide (N_2O) and methane (CH_4), two more potent greenhouse gases. Livestock is an important segment of the agricultural greenhouse gas emissions (Koch et al. 2000).

In 2000, livestock were responsible for 43.81 Gg of methane emissions, approximately 10% of Israel's total methane emissions, which were 439.3 Gg, 38.33 Gg, or 87% of the livestock emissions, were from cattle, sheep, and goats. Livestock production causes methane emissions by enteric fermentation (representing 75% of the total methane generated by livestock) and manure processing (which represents 25% of the total methane generated by livestock). Enteric fermentation occurs in the digestive system of ruminants. 90% of the methane emissions caused by enteric fermentation were caused by cattle, both dairy and beef branches. The emission factor for Israeli dairy cattle is 148 kg CH_4/head/year, a relatively high level because of the herds' high milk productivity. It would be higher, but because cattle manure is stored in dry conditions, it does not lend itself to the anaerobic decomposition that emits a high level of methane (Koch et al. 2000).

Nitrous oxide emissions from agriculture in Israel are derived from the following: direct emissions from soil, livestock waste management, grazing, volatilization, and leaching from fertilizer and waste. While clearly emissions from volatilization when manure is applied to fields are related to livestock, they are not considered here. Grazing animals produced 0.42 Gg of N20 in 2000 from their droppings. Manure handling and storage made up 0.83 Gg (80% of that is due to storage). Of this, between 0.5769 and 0.6463 Gg is the contribution from cattle, sheep, and goats (Koch et al. 2000; Koch and Shofet 2002).

Sheep, goats', and cattle's contribution to Israel's methane emissions in 2000 were equivalent to 804.93 Gg of CO_2, using a multiplication factor of 21. Their contribution of between 0.565 and 0.6314 Gg of N_2O represents between 8 and 9% of the total nitrous oxide emissions. This is equivalent to between 175.15 and 195.7 Gg of CO_2, using a multiplication factor of 310. This means that livestock was responsible for between 980.08 and 1,000.6 Gg of CO_2, or 1.4% of Israel's total greenhouse gas emissions in 2000 (figures from Koch 2002; Fig. 4).

This figure constitutes an understatement. Agriculture also drives other sectors of the economy that contribute to greenhouse gas emissions. Agriculture and Forestry used 4.2% of the energy produced in Israel in 2004. Transport is needed to carry milk to dairies to be processed. Packaging materials are produced. Some of the nitrogen produced for fertilizers in Israel is produced to help the growth of feedcrops. Livestock production is accountable for much wastewater production and solid waste production. And manure spread on fields

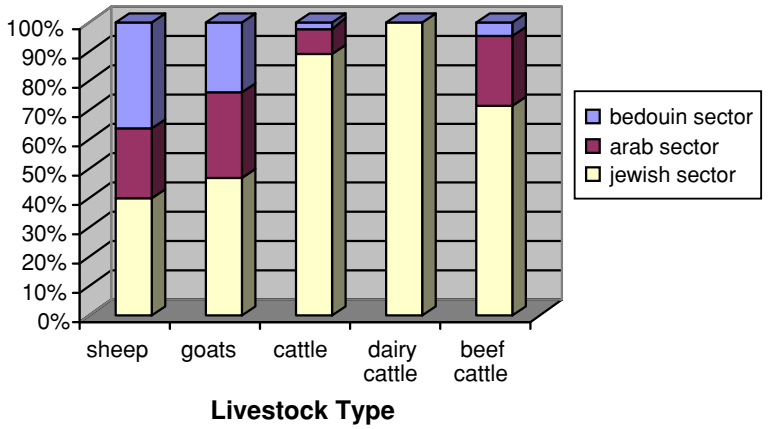

Fig. 4 Ownership of livestock in Bedouin, Arab and Jewish sectors. Data from Israel veterinary services, 2005

can release N_2O. Other emissions effects from industrial livestock systems come through energy use, which releases carbon dioxide into the atmosphere.

Water Use in Israel

Globally, livestock uses 8% of freshwater resources (Steinfeld et al. 2007, p. 24). Pimental et al. estimate that bovine meat requires 43,000 l of water per kilogram and that the production of sheep meat requires even more, 51,000 l/kg (based on US livestock husbandry practices). This dwarfs the water use per kg of monogastric livestock meat, like chickens (3,500 l/kg) and pigs (6,000 l/kg) (Pimentel et al. 2004). Most of the water used by livestock is used for irrigating feed crops. Very little of the water used is for direct consumption by livestock.

After five consecutive drought years, water conservation is a critical environmental issue in Israel. It is important to emphasize that grazing livestock in Israel clearly utilize a fraction of the water consumed by livestock raised under intensive conditions. While grazing, livestock consume plants that are grown with water that is not being captured for other use. The differing rates of consumption are made clear in Table 3, where the water use in the non-Jewish sector makes up only 16% of the total livestock water use in 1998, 10.4% in 1999, and 10.9% in 2000.

As mentioned, water usage is of special concern in Israel. The agricultural sector is the chief consumer of water in Israel. In 2005, agriculture was responsible for 62% of Israel's

Table 2 Israel water use by livestock

Water use, in thousands m^3	1998	1999	2000
Total agricultural use	1,225,251	1,254,690	1,159,992
Total livestock use	29,680	30,849	29,836
Non-Jewish livestock use	4,888	3,220	3,263
Moshavim livestock use	10,982	12,473	12,876
Kibbutzim livestock use	13,021	14,046	12,422
Other Jewish farms livestock use	789	1,110	1,275

Data from the Central Bureau of Statistics (Sternick et al. 2002)

total water consumption (Animal Census Publication 2005). This is less than the global statistic, 70% of freshwater (Steinfeld et al. 2007). Israel's livestock sector used 29,836 thousand m^3 of water in 2000, 30,849 in 1999, and 29,680 in 1998 (Table 2).

Considering livestock's importance in Israel's agriculture, it uses a relatively minor amount of water, even in intensive systems. The water usage is increased in the processing stage, but there are no data available on this for Israel. The cultivation of feedcrops, especially if irrigated, consumes additional water. Since that chiefly is grown outside the country, its importation constitutes what is called "virtual water" (Allan 2003) and does not constitute a major domestic environmental problem.

Water Pollution

The livestock sector also has been assessed as one of the primary drivers of water pollution on a global level. The pollution originates from animal waste, antibiotics, hormones, chemicals (tanneries), fertilizers, pesticides, and sediments (caused by erosion of pastureland). Other effects of livestock on soil conditions involve compacted soil, reduction of infiltration, land degradation near water flows, lower groundwater tables, and drying floodplains. Other water issues globally are caused by the deforestation that takes place in order to clear grazing land (Steinfeld et al. 2007) and results in sedimentation and other types of nonpoint source water pollution.

While utilization of wastewater for irrigation, fertilization, and pesticide runoff has typically been the single greatest source of water pollution from agriculture in Israel, (Tal 1998) livestock, especially from dairies and feedlots, has also been a substantial contributor of pollution to surface waters. The Ministry of Environmental Protection concludes:

> The pollution generated by some 350,000 heads of cattle in Israel, including both milk and beef cows, equals the pollution generated by the entire human population of the country Israel Ministry of Environmental Protection (2007a).

At the end of the twentieth century, the Ministry found that dairy cows were producing more than 300,000 tons of solid waste, with 7,000 tons of pure nitrogen. This meant that livestock might be responsible for discharging 31,000 tons of nitrates that infiltrated ground water supplies via nonpoint source runoff annually (Capua and Oren 2001). Since this figure was first recorded, a major effort has been undertaken to reduce the damage done to Israel's water supply by cattle.

The Ministries of Agriculture and Treasury, together with the Ministry of Environmental Protection enacted a major Reform of the Dairy Sector in 1999, called the Dairy Farm Reform. Its goals were twofold: to encourage the consolidation and increased efficiency of producers due to increasing liberalization of trade, and to address environmental concerns (Kimhi and Rubin 2006). The reform sought to address the environmental impacts of dairy farms, particularly soil and water contamination from nutrients, nitrates, brines, organic matter, and pathogens; bad odors, flies, and ugly aesthetics.

The Dairy Reform provided the dairy industry with guidelines to prevent discharge and groundwater pollution. In order to receive their business licenses, suppliers were required to adhere to strict guidelines specifying how waste was to be treated and disposed, the installation of roofing, flooring, drainage, manure collection and storage in their feedlots and dairies, along with the separation of solids and sewage treatment. While the regulatory stick was relatively harsh and dozens of criminal actions were filed against recalcitrant dairy operations, an uncharacteristically generous carrot was also provided. The reform

provided substantial grants to enable dairy farmers to make the necessary infrastructure adjustments.

Close to two billion shekels have been spent on the Dairy Farm Reform—57% of that sum used specifically on measures for environmental protection. This was primarily invested in improving farm infrastructure, with additional sums being spent on waste treatment. The intervention appears to have been highly successful: approximately half of Israel's dairy farms were fully compliant with the new regulations by the end of 2006 with a full 98% of Israel's dairy farms either fully compliant or in the process of compliance. Regional waste treatment centers have also been established as part of the reform, among them the biogas treatment center in Emek Hefer, which produces renewable energy used in the treatment process and in the local area Israel Ministry of Environmental Protection (2007b).

There have been critiques of the initiative because of its failure to differentiate between climatic regions. For example, in hyper arid regions like the Arava, the waste from cattle is dry, and the potential to reach the watershed practically nil (Marjorie Strom, personal interview 2007). Yet the infrastructure requirements for dairy farmers are the same from north to south. It is also important to note that feedlots for beef production have not been addressed by environmental regulation. Without a similar government aid in this sector, the modifications in infrastructure needed to prevent the waste corrupting local water supply will be too expensive to be attempted (Shafran, personal interview 2007). Ultimately, when considering Israel's water pollution portfolio, animal waste discharges are a conspicuous point of light. Sustainable policies were designed and sufficient resources and political will invested for effective implementation.

Today the major concern linking livestock to water pollution involves the process of kosher slaughtering, where religious law requires the utilization of copious amounts of salt. Water quality regulations were promulgated to require separate discharge of salty effluent from slaughterhouses, but the problem is not entirely resolved (Israel's Jewish farmers engaged in intensive farming of sheep and goats also face *economic* difficulties due to the stringency of kosher slaughtering requirements. The cost of "koshering" these animals was estimated in 1989 as tripling the price of the meat from sheep).

Endangered Species and Ecosystem Services in Israel

Livestock husbandry is a contributing factor to species loss in Israel, through a number of mechanisms including overgrazing, undergrazing, habitat destruction, hunting by foreign workers, poisoning, changes in veterinary care, and water pollution (Dolev and Perevolotsky 2004). Species loss in Israel is especially important because Israel and the Mediterranean have high species diversity. The whole Mediterranean region was classified as a "hotspot" by Mittermeier et al. in 1998. Medail and Quezel made a narrower definition of hotspots, but still included the northeastern region of Israel as a "Biodiversity Hotspot" for its flora (Medail and Quezel 1999). The Mediterranean region contains 10% of the world's plant species and takes up only 1.6% of the world's land area (Medail and Quezel 1997).

Yom-Tov and Mendelssohn characterized hunting by Thai agricultural workers as the "most serious threat to Israeli wildlife today (2004)." An increasing number of Israel's dairy workers are temporary workers from Thailand. The conversion of coastal sand dunes to agricultural land was a contributor to habitat loss for many species of fauna. Land "reclamation" projects that drained wetlands to allow for crop cultivation, especially in the Hula Swamp, caused the disappearance of several species. Among them are the *Migrogrex*

hulensis (fish), *Nun galilaeus* (fish), *Tristramella simonies intermedia* (fish), *Discoglossus nigriventer* (Israel painted frog) (although evidence indicates that it was already a relic before the drainage according to Gafny 2004), and *Arvicola terrestris* (Northern Water Vole) (Dolev and Perevolotsky 2004). Water pollution has also caused severe significant threats to several fish species (Yom-Tov and Mendelssohn 2004) and exacerbates the precarious condition of every local amphibian species, all of which are now considered vulnerable or endangered (Dolev and Perevolotsky 2004). Livestock production has historically been a major water polluter in Israel, so it shares the blame for the damage done to amphibian and fish species.

Poison used by livestock owners to target predators is a serious threat to many species. Carnivorous mammals, such as jackals, wolves, the red fox, the Egyptian mongoose, the jungle cat, and the wild cat, are affected. Poisons also have a secondary effect on birds of prey, particularly the griffon vulture (Yom-Tov and Mendelssohn 2004), Egyptian Vulture, Bonelli's Eagle, Lanner Falcon, Raven, and Golden Eagle (Dolev and Perevolotsky 2004).

Cultivation by Bedouin on loess soils (often part of a mixed farming system) reduces reptile populations (Bouskila 2004). Reptile populations can also be adversely affected both by intensive grazing and the lack of grazing in formerly grazed areas. Intensive grazing causes damage by trampling, which upsets soil crusts, in the southern Negev, and by changing the vegetation composition in the northern Negev. When grazing is absent, a soil crust can form that does not allow reptiles to dig burrows, or vegetation that is too dense for reptiles to penetrate can grow (Bouskila 2004). The Testudo werneri (Negev Tortoise) is currently critically endangered, and overgrazing is listed as one of six factors of disturbance. The Stenodactylus doriae (Middle Eastern Short Fingered Gecko) is also critically endangered, and over-trampling by both livestock and humans (hikers) are listed as one of three threat factors (Dolev and Perevolotsky 2004). Bouskila (2004) recommends monitoring and limiting grazing in order to protect reptile populations.

Loess and sand flats in the Negev and Arava have been identified as the country's second most critical habitat area for birds (Mayrose and Alon 2004). Savannization or the planting of diverse tree stands, in part to expand grazing ranges, has facilitated the penetration of species suited to Mediterranean climate at the expense of native species. Temporary grazing permitted on military lands damages native birds when they are breeding (particularly if the herds are accompanied by dogs). Species affected include Cursorious cursor (Cream–Colored Courser), Pterocles coronatus (Crowned Sandgrouse) (Dolev and Perevolotsky 2004). Other causes not related to grazing are also significant, such as the expansion of farmland, military activity, and increased human settlement (Mayrose and Alon 2004).

Changes in the level of available veterinary care have had varying effects on animal species who prey on livestock or who scavenge their remains. Prior to the British Mandate period, livestock disease was more prevalent due to almost total reliance on ethno veterinary care. Rinderpest was one of the biggest killers of livestock, but no longer. Modern medicine has drastically lowered livestock mortality and a major food source of scavengers such as vultures, raptors, jackals, hyenas, and wolves has nearly disappeared. Quite simply, there not as many carcasses left to rot—and feast on. At the same time, present animal disposal practices have helped the populations of some mammalian scavengers. Garbage dumps for animal carcasses continue to provide a food source for some of these animals (particularly the mammals) although vultures, particularly the griffon vulture, do not utilize them. This phenomenon led Israel's National Parks Authority to initiate a project to supply carcasses for scavenging birds (Yom-Tov and Mendelssohn 2004).

Table 3 Israel's livestock breeds with the population information listed in the FAO domestic animals diversity information system

Breed	Population #	# of females	# of males	Effective population	Trend	Year
Ass						
Damascus	No information	No information	No information	NA	Not listed	NA
Syrian	No information	No information	No information	NA	Not listed	NA
Cattle						
Arab	No information	No information	No information	NA	Not listed	NA
Israeli friesian	>105,070	105,000	70	280	Stable	ca. 1986
Simford	No information	No information	No information	NA	Not listed	NA
Goat						
Israeli saanen	No information	No information	No information	NA	Not listed	NA
Mamber	No information	No information	No information	NA	Not listed	NA
Negev	No information	No information	No information	NA	Not listed	NA
Sinai	170,000	120,000	1,000	3,967	Stable	ca. 1993
Sheep						
Assaf	No information	No information	No information	NA	Not listed	NA
Awassi	No information	No information	No information	NA	Not listed	NA
Israeli improved awassi	No information	No information	No information	NA	Not listed	NA

The Biodiversity Cost of Industrial Livestock Production

The breeding practices that industrial livestock husbandry systems employ also serve to diminish biodiversity. The FAO estimates that close to half of the genetic resources of domestic livestock exist at the breed level (FAO 2003). Intensive breeding programs can drastically reduce the effective population of livestock species (Cunningham 1995). It is not clear how Israel's livestock industry manages these risks. Israel does provide data to the FAO Domestic Animal Diversity Information System, and recorded that 12 breeds of livestock, including asses, cattle, sheep, and goat breeds, are raised in large numbers (Table 3). However, Israel has neither collected nor provided complete information for the livestock, as shown in Table 3. In addition, Israel has not updated its account with the DAD-IS for many years.

Conclusions

The present review suggests some basic dynamics about the environmental effects of animal husbandry in Israel. Jews and Arabs have different and highly separated systems of livestock husbandry in Israel. Jewish farmers essentially produce all of Israel's cow milk and most of Israel's dairy products from sheep and goats, usually in intensive, mechanized production systems. Arabs grow most of Israel's sheep and goat meat, and a large portion of Israel's beef. Much Arab production is extensive in nature.

The major environmental problems to emerge from Israel's livestock husbandry over the past century have been water pollution, damage to some animal species, and green

house gas emissions. Species loss is an important but complex issue, with many of livestock's effects indirect or localized. Specific, site-specific, interventions may be needed to ameliorate these impacts. Climate change is an issue about which awareness is now growing. While livestock is not a major contributor to Israel's greenhouse burden, as the country seeks to reduce its footprint, it will need to better control this source, especially as new technologies emerge to reduce livestock emissions.

Since the establishment of the State of Israel, domestic policies regulating grazing were driven by two major goals: establishing state sovereignty over land and protecting the quality of the environment. Regarding the latter, much of early environmental criticisms levied against the extensive grazing common throughout pre-1948 Palestine were partisan and anecdotal—perhaps the result of European thinking in a very different, Middle Eastern ecological reality. While overgrazing undoubtedly occurred, the blanket attribution of damage to the environment involving land degradation from overgrazing in many cases was exaggerated.

In the early part of the twentieth century, overgrazing in some parts of Israel's semi-arid regions continued, but for several decades, the most pernicious impacts have been largely obviated due to Israeli regulation and stock limits (Tal 2006b). Many degraded areas have been restored and now support productive and sustainable crop cultivation. Grazing today actually seems to provide important benefits to the environment such as aiding biodiversity and assisting in fire control.

Water pollution from dairy production for much of the country's history constituted an acute insult to the integrity of water resources. Yet, during the past decade, the problem has been addressed on a large scale via the Dairy Farm Reform, although feedlots still need to be addressed in a similar manner. Climate change as an animal husbandry issue, as mentioned, is not yet being addressed and will need to be part of the government's nascent climate change mitigation policy. Israel also plays a part in the global dynamics of climate change due to utilization of imported feedstuffs.

While deforestation is not occurring within Israel, Israel imports feed crops to support its agriculture. Israel is a major importer of soy—16th worldwide. Israel imported 26.9% of its soy from Brazil and 10% from Argentina in 2004 (Tips and AusAid 2005). Brazil's soy production is a notorious contributor to deforestation of the Amazon region, and in Argentina soy production is a leading cause of deforestation in its Chaco region (Grau et al. 2005). Soy is used principally as livestock feed. The FAO's very high estimates for livestock's contribution to climate change are in large part based on the high greenhouse gas emissions caused by deforestation in the tropics. Israel's dependence on feed crops grown in these areas may be contributing to this deforestation, and thus to global climate change.

From the perspective of sustainability, it is not possible to directly compare the environmental effects of the intensive and extensive livestock production systems in Israel. Accordingly, policies directed at Jewish and Bedouin livestock growers should be different, due to the disparate sociological and environmental dynamics. While Jewish farmers have been able to benefit from policies that aid the intensification of livestock growing, Bedouin often see the government only as an enforcer with no stake in their economic prosperity. The major reason for this perception may involve relative productivity. With the intensive systems of dairy and meat production, Israel is now able to supply a major portion of its meat consumption and all of its dairy consumption. Extensive systems are responsible for a much more marginal proportion of consumption.

It is important to note that the Bedouin pastoral community, in fact, appear to be increasingly interested in intensification. Intensification will present new challenges to Bedouin growers because exotic livestock breeds require a different level of care (Gootwine, personal interview 2007). Comparative advantage among Bedouin can undoubtedly

be found in extensive systems, with its seasonal migrations and sustainable foraging. But, ultimately, the primary reason that the Bedouin continue raising livestock is cultural.

Pastoralist systems of livelihood are disappearing all around the globe. The Israeli Bedouin are a remnant of a type of culture that once dominated large areas of the globe. But no longer. Increasingly Westernized countries cannot tolerate the structure of nomadic groups, and they are becoming sedentarized or disappearing. Protecting these systems will also be beneficial to the environment, because they can be used to protect the breed biodiversity of small ruminants. Animal grazing is also frequently beneficial in nature preserves for supporting biodiversity and in forests where it prevents conflagrations.

In many parts of the world, European cultures have wiped out native cultures, sometimes by design and sometimes by chance. Israel has a unique opportunity to learn from these mistakes, and surmount them. There is a place for grazing in the country's future agricultural strategy, since methods of food production can bring special benefits in terms of nutrition and provide a source of livelihood. Further development of cottage industries related to nomadic grazing is also possible, as in Bedouin hospitality tents or through the expansion of authentic Bedouin restaurants.

For Bedouin grazing to become sustainable, more effective government involvement will be required. Almost all grazing land in Israel is state owned or managed. Yet, despite the increased sophistication regarding biodiversity and controlled grazing among decision makers, most rangelands are still not managed professionally (Kressel 2003). No comprehensive master plan for the future of either Bedouin or Jewish flocks has been prepared, much less peer reviewed by experts. Flocks are increasingly held in pens and fed on concentrate instead of grazed in the fields (Kressel 2003). While the Ministry of Agriculture operates an extension service that transmits valuable information and veterinary care has vastly improved, ecological assistance in the field remains deficient (Dr. Bertrand Boeken, personal interview 2006).

The Grazing Authority's staff does include ecologists, although as previously mentioned for the most part they do not work with the Bedouin anyway. The lack of a scientifically managed grazing policy in the south of Israel is unfortunate because a critical tool for managing protected species remains unutilized. This turns out not to be especially relevant, as paradoxically, livestock grazing appears to generally improve biodiversity in Israel. Part of the problem is legal, and statutory reform will be important. Much of the existing legislation regarding grazing and the environment in Israel still remains focused on old and discredited paradigms of land degradation and biodiversity loss.

Grazing has been part of the landscape of Israel from time immemorial. The Biblical heroes that inform much of religious culture were shepherds. Indigenous cultures of the region preserved the pastoral experience for millennia. While overgrazing and more recent intensive dairy and beef farming brought with them environmental impacts, increasing awareness along with a series of policies and concrete measures have reduced these hazards dramatically. Looking to the future, it is important that in the zeal to preserve the ecology of the region, a key element of the local heritage is not lost.

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