Formal conservation areas are by no means the only way of conserving biodiversity, including mammal species. From an overall national perspective, informal areas such as conservancies and private game reserves, particularly those adjoining formal areas or enveloping habitats or species of particular concern, can increase the protection of some populations to the point of long term viability. Recent private initiatives adjoining the Naute Recreation Resort and Ai-Ais/Hunsberg Complex have effectively doubled the area set aside for biodiversity protection in this area, and the long term viability of cheetah in Namibia may be in the hands of sympathetic private landowners.

Market incentives, if strongly guided and controlled by a competent conservation authority, can also be an invaluable tool in a coordinated national programme to preserve biodiversity. However, even private game reserves, which cater to the expectations of the ecotourist or trophy hunter, and manage resources to optimise those expectations, often neglect or unwittingly eliminate other less visible components of biodiversity, leaving these areas with conservation values equal to those of open-air zoological gardens.

2.10 Namibia's unwanted biodiversity: alien invasive species

Compared to some countries in Africa, Namibia has comparatively modest problems with alien invasive species (species which are introduced from elsewhere, did not occur here naturally, and can outcompete and displace indigenous species). However, the modest scale of Namibia's problem may mean that we can control many alien invasives in this country before they become widely established. Of lower organisms, the only real information is on agricultural pests and pathogens (Appendices 5, 6 and 9, which list mostly alien species). These organisms affect human enterprise and food security, but they may or may not have broader ecological impacts. This section therefore focuses on what we know of alien invasive plants and animals, some of which are of significant economic and ecological concern.

Alien invasive plants

As an arid country, Namibia does not have to cope with the problem of invasive alien plants to the same extent as do more mesic regions, such as South Africa's Cape fynbos. Nevertheless, alien invasive plants do occur in Namibia and must not be allowed to spread. Areas most affected and prone to invasion are rivers (both perennial and seasonal), especially those close to human habitation. This means that invasions occur across national borders. Control programmes thus require national and regional cooperation to be effective. South African agencies make huge and costly efforts to control the spread of alien invasive plants, partly because of their damaging effects on catchment management and water supply. The control programmes of other neighbouring countries, if any, are unknown.

The only comprehensive published data available on alien invasive plants in Namibia were collected during a two-day workshop held in 1984. That report identifies problem alien plants in Namibia and gives some qualitative estimates of distribution, severity and ecologi-
cal threats. From National Herbarium records, other published taxonomic papers and species lists for the southern African region, 228,231,232,403-407 subsequent information on alien species within Namibia was gathered. The reliability of some of these sources is questioned by Namibian botanists, and this account should be regarded as preliminary until a proper scientific survey has been done.

Namibia has no official list of alien invasives or noxious weeds, and no effective legislation to govern their introduction and control. The National Herbarium has a list of naturalised alien plants, but the categorisation of invasive species is incomplete. Scheepers lists ten important alien invasive plants in Namibia (Box 2.30). More objective, scientific research is needed to confirm and amend this priority list, using established methods. By far the largest number of alien plants are dicotyledons, with several monocotyledons and one pteridophyte (Table 2.47).

**Box 2.30 Ten important alien invasive plants in Namibia**

<table>
<thead>
<tr>
<th>Family</th>
<th>No. of species</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asteraceae</td>
<td>28</td>
<td>13.5</td>
</tr>
<tr>
<td>Poaceae</td>
<td>23</td>
<td>11.1</td>
</tr>
<tr>
<td>Fabaceae</td>
<td>23</td>
<td>11.1</td>
</tr>
<tr>
<td>Solanaceae</td>
<td>14</td>
<td>6.8</td>
</tr>
<tr>
<td>Amaranthaceae</td>
<td>13</td>
<td>6.3</td>
</tr>
<tr>
<td>Chenopodiaceae</td>
<td>10</td>
<td>4.8</td>
</tr>
<tr>
<td>Amaranthaceae</td>
<td>9</td>
<td>4.3</td>
</tr>
<tr>
<td>Malvaceae</td>
<td>8</td>
<td>3.9</td>
</tr>
<tr>
<td>Polygonaceae</td>
<td>5</td>
<td>2.4</td>
</tr>
<tr>
<td>Other families with 4 or fewer spp. per family</td>
<td>74</td>
<td>35.7</td>
</tr>
<tr>
<td>Total dicotyledons</td>
<td>178</td>
<td>86.0</td>
</tr>
<tr>
<td>Total monocotyledons</td>
<td>28</td>
<td>13.5</td>
</tr>
<tr>
<td>Total gymnosperms</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total pteridophytes</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Total</td>
<td>207</td>
<td></td>
</tr>
</tbody>
</table>

**Distribution and abundance**

The distribution pattern of naturalised alien plant species in Namibia generally reflects the distribution pattern of rivers, human habitation or disturbance. Very few alien species are collected for herbaria, but distribution data urgently need to be updated and gaps filled. Very few quantitative data exist on the density and size of alien plant populations or their impact on natural vegetation in Namibia. Few reports contain quantitative data. Others indicate the size of the areas infested, but no densities. Only Tarr and Loutit state densities as well as methods. The limited data show that large, dense, populations which have replaced natural vegetation occur around Windhoek, Katima Mulilo, Waterberg and almost all westward flowing rivers, particularly the Kuiseb, Omaruru and Ugab Rivers. Along all other major rivers, alien vegetation seems limited to either few species, such as Prosopis on the Nossob and Olifants Rivers, or very localised populations.

The distribution patterns of herbaceous naturalised aliens are extremely variable over time. Populations and seed of species like Argemone and Datura in riverbeds can be washed downstream by floods to establish themselves elsewhere. Dams in rivers also stop seeds from washing down into the ocean.
and contribute to the establishment of new populations. The location and density of such populations is therefore highly variable. Woody, perennial species are not displaced as easily.

Table 2.48 Origin of naturalised alien plant species in Namibia

<table>
<thead>
<tr>
<th>Region of origin</th>
<th>No. of species</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Americas</td>
<td>80</td>
<td>38.6</td>
</tr>
<tr>
<td>South America</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(included in above)</td>
<td>53</td>
<td>25.6</td>
</tr>
<tr>
<td>Europe &amp; Asia</td>
<td>65</td>
<td>31.4</td>
</tr>
<tr>
<td>Australia</td>
<td>5</td>
<td>2.4</td>
</tr>
<tr>
<td>Others*</td>
<td>57</td>
<td>27.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>207</strong></td>
<td></td>
</tr>
</tbody>
</table>

* includes unknown, uncertain, cosmopolitan, pantropical

**Control measures**

Namibia has no national policy or programme on the introduction or control of alien plants. As biodiversity conservation is now an explicit objective of Namibia’s state protected areas, the control of alien invasives is implicitly contained in park management plans.\(^{417}\) In the late 1980s efforts were made in national parks, particularly Etosha, to control alien plant species, mainly by mechanical means.\(^{417}\) Since then, there has been no concerted effort to control alien invasives in park areas.

On privately owned farmland and in communal areas, there is no control over the spread or introduction of aliens. The only method of control over introduction of new alien species is through the phytosanitary control system, which has inadequate facilities, enforcement powers and staff numbers.

In some municipal areas, local laws exert some control. The City of Windhoek, for instance, has included the removal of *Prosopis* as a prerequisite for urban property buyers and developers since 1995. Prior to this date, the buyer undertook contractually to remove *Prosopis* from a property. These provisions were not retroactive.

To control the spread of alien plants in Namibia, national legislation and policy are needed to prohibit the introduction, sale or propagation of species listed as problem aliens. The legislation should also oblige landowners to eradicate listed species on their property. A national effort at controlling alien vegetation would be futile, however, if no control measures were taken in neighbouring countries. A regional policy or law for the SADC Region would be ideal, and in the interim Namibia should attempt to reach agreements with its immediate neighbours.

**Broader implications**

The most obvious effects of invasion of natural vegetation by alien species are changes in habitat, species and even genetic diversity.\(^{418}\) Invasions of *Prosopis* in Namibia displace indigenous species almost entirely. Also, ecological processes depend on species composition and interactions, both of which may be affected by severe invasion and displacement.\(^{418}\) These issues have not been analysed in Namibia, but highly specialised plants and their associated organisms are expected to be most vulnerable to invasion by alien species.\(^{418}\)

African control methods can themselves have negative effects on natural vegetation.\(^{418}\) Very few control measures against invasive alien plants have been taken in Namibia, and no scientifically sound publications exist on their environmental impacts.

The economic implications of alien invasive species on Namibian agriculture are potentially significant. Arable weeds, which very often are alien species, can cause considerable crop losses.\(^{419-421}\) although this has not been analysed in Namibia. Alien invasive plants can also have negative impacts on rangelands, due for instance to livestock poisonings by species such as *Melia azedarach*,\(^{422}\) loss of indigenous forage species, or structural changes which make rangelands inaccessible to livestock.\(^{423}\)
Finally, Namibia promotes itself as a country of pristine beauty. The effect of invasions by alien species and associated changes in indigenous vegetation, should these become more widespread or severe, could affect the tourism industry significantly.

Legislation

Existing legislation in Namibia is outdated and inadequate. Enforcement of existing laws such as phytosanitary control measures is inadequate, mainly due to lack of qualified staff. The lack of quarantine facilities need not be a problem, as facilities are available in South Africa for the few introductions into Namibia which need quarantine measures. This will be more cost effective than maintaining and staffing a Namibian station. Legislation on the control of alien plants in neighbouring countries is not uniform and should be harmonised along the lines of legislation governing seeds (Box 2.31).

— Herta Kolberg

**Box 2.31 Recommendations for controlling alien invasive plants**

- initiate a quantitative survey to identify all naturalised aliens, their distribution in Namibia, and (in the case of aliens with severe negative impacts) sources and methods of their invasion;
- conduct and encourage research on the impacts of alien plant species on the habitats they occupy;
- initiate appropriate control programmes where necessary, taking into account any likely impacts;
- revise and update national legislation;
- strengthen the phytosanitary control section of the Ministry of Agriculture, Water and Rural Development and any support services needed;
- address at SADC level the need for regional harmonisation of control methods and legislation for alien invasive plants.

**Alien invasive animals**

Alien animals can invade some habitats and not others, depending partly on the presence of potential competitors, predators and parasites. Freed of organisms which may have limited them in their original habitat, alien species in new environments can become invasive. Namibia’s policy is to eliminate alien animal species from natural habitats whenever feasible, and to restrict the introduction of species which could become invasive.

About three snails, one slug, six fish, three birds and eight mammals, as well as at least five livestock parasites and an unknown number of insects, are known to be alien invasive species in Namibia, as well as 402,425 (Table 2.49, see also Appendix 9). Little relevant animal research has been done since Namibia’s 1984 workshop on alien invasives, so rather than repeat these data, this brief account looks at broad conservation concerns.

**Biological control agents**

The success of using natural biological pests in the control of invasive aliens such as Kariba weed *Salvinia molesta* (Box 2.8) and *Opuntia* cacti is well known. However, as we always have incomplete understanding of ecosystem function and species composition, the choice of biological control agents is extremely risky. For example, once mice had become established on many oceanic islands through human carelessness or intent, cats were often introduced to control them, and themselves became significant pests. The use of influenza viruses to control these cats on sub-Antarctic islands, and rabbits in Australia, is fraught with unknowns, even though many viruses do not infect unrelated hosts.

**Genetic pollution**

Genetic pollution through hybridisation is known or suspected in Namibia from fish (*Oreochromis mossambicus* freely interbreeds with other tilapia), birds (the domesticated ostrich is a slurry of genes from northern and southern African subspecies) and
mammals (see Boxes 2.11 and 2.32). The African wild cat *Felis sylvestris* interbreeds freely with domestic cats throughout Namibia, making it unlikely that this species remains genetically distinct anywhere but the most isolated areas (Box 2.32). Deliberate interbreeding of local and alien subspecies may often be rationalised as producing more robust hybrids, but there are likely to be frequent cases where preservation of the integrity of local Namibian gene pools has to be judged more important. This is particularly so where distinctive Namibian animals with economic value are involved (see Box 2.11).

The cross-basin transfer of water in Namibia, raised in sections 2.1 and 2.9, is of great concern to biodiversity conservation in this country. Such water supply infrastructure makes the introduction of alien invasive aquatic species virtually inevitable. In the case of water supply pipelines and canals from the Okavango River, it also raises the possibility of bilharzia parasites and their snail hosts being introduced to Windhoek and the country’s central storage dams. The introduction of invasive aliens may be one of the most insidious forms of biodiversity loss, because these species frequently go unnoticed until genetic pollution or establishment occur and eradication becomes impossible. There is little consultation between government ministries, development projects and NGOs about the invasive potential of some deliberate imports. The eradication of invasive aliens from our fragile arid ecosystems should remain a priority, as should the prevention of the introduction of new aliens.

— Mike Griffin & Rob Simmons

### Table 2.49 Namibia’s most important known invasive alien animal species

<table>
<thead>
<tr>
<th>Parasites*</th>
<th>Earthworms</th>
<th>Molluscs</th>
<th>Fish</th>
<th>Birds</th>
<th>Mammals</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Oestrus ovis</em></td>
<td></td>
<td></td>
<td><em>Oreochromis mossambicus</em></td>
<td><em>Passer domesticus</em></td>
<td><em>Felis catus</em></td>
</tr>
<tr>
<td><em>Damalinia spp.</em></td>
<td></td>
<td></td>
<td><em>Cyprinus carpio</em></td>
<td><em>Columba livia</em></td>
<td><em>Mus musculus</em></td>
</tr>
<tr>
<td><em>Linognathus sp.</em></td>
<td></td>
<td></td>
<td><em>Micropterus salmoides</em></td>
<td><em>Sturnus vulgaris</em></td>
<td><em>Rattus norvegicus</em></td>
</tr>
<tr>
<td>Haematopinus sp.</td>
<td></td>
<td></td>
<td><em>Poiilia reticulata</em></td>
<td></td>
<td><em>Rattus rattus</em></td>
</tr>
<tr>
<td><em>Taenia saginata</em></td>
<td></td>
<td></td>
<td><em>Xiphophorus helleri</em></td>
<td></td>
<td><em>Oryctolagus cuniculus</em></td>
</tr>
<tr>
<td><em>T. solium</em></td>
<td></td>
<td></td>
<td><em>Carassius auratus</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Gasterophilus intestinus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 species</td>
<td>unknown</td>
<td>4 species</td>
<td>8 species</td>
<td>3 species</td>
<td>8 species</td>
</tr>
</tbody>
</table>

* Parasites of livestock. The tilapia *O. mossambicus* is at present found naturally in southern Namibia, but if introduced into northern regions would become invasive.
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“Former Owambo” is the area currently in the Oshana, Oshikoto, Ohangwena and Omusati Regions (map 1.10).


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