

Executive summary

Bush encroachment is defined as “the invasion and/or thickening of aggressive undesired woody species resulting in an imbalance of the grass:bush ratio, a decrease in biodiversity, and a decrease in carrying capacity”, causing severe economic losses for Namibia – in both the commercial (freehold) and communal (non-freehold) farming areas.

The phenomenon of bush encroachment in Namibian savannas is seen to be part of the process of desertification.

The main species causing the encroachment problem are *Acacia mellifera* subsp. *detinens* (Black thorn), *Dichrostachys cineria* (Sickle bush), *Terminalia sericea* (Silver terminalia), *Terminalia prunioides* (Purple-pod terminalia), *Acacia erubescens* (Blue thorn), *Acacia reficiens* (False umbrella thorn¹) and *Colophospermum mopane* (Mopane). *Prosopis* species also occur in high densities, mainly in the Nossob, Olifants and Auob Rivers and are spreading outside the river lines into the Kalahari. Large areas in the southern parts of the country are also affected by mainly *Rhigozum trichotomum* (Three thorn) and even Black thorn.

Phase 1 of the Bush Encroachment Research, Monitoring and Management Project was launched to determine

- the causes of bush encroachment
- the methods most suitable to combat invader bush
- the impact of problem bushes on land productivity, biodiversity and the socio-economic situation of farmers
- the best methods to monitor long-term changes in terms of bush densities and composition
- shortcomings in existing policies and legislation related to the problem, and to propose policy reform, and
- outputs such as creating an awareness about bush encroachment and networking to combat the problem.

The causes of bush encroachment

The causes of bush encroachment are elaborated upon against the background of two important models:

- **Walter’s Two-layer Model**, which maintains that, if the grass layer is overutilised, it loses its competitive advantage and can no longer use water and nutrients effectively. This results in a higher water and nutrient infiltration rate into the subsoil. Such a scenario will benefit trees and bushes and allow them to dominate.
- **The State-and-Transition Model**, which recognises the dynamic nature of savanna ecosystems. Savannas are event-driven where rainfall and its variability plays a more important role in vegetation growth (and composition) than the intensity of grazing. It implies, therefore, that bush encroachment is not a permanent phenomenon and a savanna could be changed to its grass-dominated state by favourable management or environmental conditions.

The major factors determining the functioning and dynamics of savannas are the following:

- **PRIMARY DETERMINANTS**, such as **rainfall, soils and nutrients**, are functions of a specific geographical region and are to a certain extent beyond the farmer’s control. Rainfall, together with soil moisture balance, has an overwhelming effect on vegetation structure, composition and productivity. Rather than a gradual annual increase in bush numbers, the general view is that woody plants establish in large numbers during certain years, and at varying intervals. Prolonged denudation of soils caused by droughts and grazing, followed by above-average rainfall years with frequent rainfall events, favour mass tree recruitment.
- **SECONDARY DETERMINANTS**: These act within the constraints imposed by primary determinants. They can often be directly modified by management. The exclusion of occasional hot veld fires, the replacement of most of the indigenous browsers and grazers by livestock, injudicious stocking rates, poor rangeland management practices, and artificial water points are regarded as the major causes of bush encroachment.
 - In the past, **high-intensity** fires played a major role in maintaining open savannas. With the introduction of cattle farming, veld fires were suppressed – and this is regarded as a major factor contributing to bush encroachment. Although fires kill tree seedlings and saplings, mature woody plants are seldom killed and most coppicing species are able to regenerate and grow actively.

¹ No differentiation is made between *Acacia reficiens* subsp. *reficiens* and *Acacia luederitzii* var. *luederitzii* (Ross 1979); any reference to *Acacia reficiens* in this document includes both these subspecies. (Full reference is given in the list at the end of Chapter 2.)

High-intensity fires are regarded as a prerequisite for effective burning. These fires depend largely on the amount and structure of the fuel, its moisture content, the prevailing atmospheric humidity, and wind speed. Thus, fire is not effective where high bush densities occur, but it can serve as an effective management tool for modifying the structure of the woody layer and as an aftercare treatment.

- Together with an increase in domestic livestock (grazers) and a **decrease in game numbers (browsers)**, the pressure on the grass layer has increased, the competitive advantage of a vigorous perennial cover has declined, and a more favourable environment for the woody component has been created. Invader bushes have started to produce seeds in abundance and so create opportunities for the establishment of new generations of bush. Each generation has been able to reach maturity and has produced more and more seeds. Although some research findings indicate that the seeds of *Acacia mellifera*, for example, are not transferable from one season to another, for many of the other problem species this is known not to be the case. Because of factors like seasonal dormancy, hard-seededness and the presence of allelochemicals, the seed content in the soils has gradually built up, resulting in several hundred – even several thousand – seeds per square metre. Furthermore, the absence of ungulates in tandem with the suppression of fire creates favourable conditions for bush encroachment.
- Although relatively **high stocking rates** were applied during the above-average rainfall cycle from 1948 to 1957/8, stocking rates declined dramatically during the ensuing years. Since 1966, the applied stocking rate has never exceeded 10 ha per large stock unit (LSU). Even with stocking rates between 20 and 30 ha per LSU during the 1990s, farmers have not succeeded in reversing the process. It can further be concluded that grazing pressure, even with declining stocking rates, was still inherently too high to utilise the rangelands in a sustainable way and resulted in a form of vicious cycle. Fear has been expressed that the bounds of resilience of the former ecosystem have been exceeded. Only by means of external inputs will the original status of our rangelands be able to be restored.
- There are indications that **other factors beyond farmers' control**, like poor rainy seasons or droughts followed by years with above-average rainfall with frequent rainfall events, have probably made a substantial contribution to the problem of bush thickening. It is reasonable to hypothesise that new generations of bushes established themselves during the first half of the 1960s, after 1973 and again after the 1980s. These periods represent a few dry years followed by a few good rainy seasons. It should be emphasised that the natural rangelands have deteriorated to such an extent that the process has not been reversed – even with much lower stocking rates.
- **Other determinants influencing the composition and structure of savanna vegetation** are comprehensively discussed. These include the interaction and competition between trees, bushes and grass, the impact of temperature on bush encroachment and the mechanisms of seed distribution.
- **Other important restraining factors** seemingly beyond farmers' control relate to the socio-economic policy framework in which they perform their task. This framework includes factors such as –
 - the restriction of animal movement and the marketing of animals as a result of foot-and-mouth in the early 1960s, preventing farmers from timeous destocking
 - poor marketing policies during the late 1960s to the end of the 1970s, which delayed the issuing of permits for cattle to be slaughtered and therefore the off-take of marketable cattle
 - fire policy and legislation: the Soil Conservation Act, 1949 (No. 6 of 1949; implemented in then SWA in 1952; as amended in 1969) prohibited the burning of veld and only applied in commercial farming areas), and
 - drought subsidies, which encouraged farmers to keep more animals during periods of grazing scarcity.

The impact of bush encroachment

The impact of bush encroachment on land productivity, biodiversity and the farmers' socio-economic welfare was studied. The following findings are of importance:

- Bush encroachment on approximately 26 million ha of woodland savannas in Namibia resulted in a loss of land productivity of as much as 100% or more. This means that the carrying capacity declined from 1 LSU per 10 ha to 1 LSU per 20 or 30 ha, for example. In the entire bush-affected area, only Okombahe can be regarded as low-density in respect of bush encroachment. Epikuro, Grootfontein, Okahandja, Okakarara, Okonjatu, Otavi, Otjinene, Otjituuo, Otjiwarongo, Outjo, Tsumeb and Windhoek fall in the

“very high” density areas, while densities in the remaining districts vary from high to medium. In this respect it is important to note that present cattle numbers in the commercial farming areas represent only 36% of what they were in 1959. The concomitant economic loss of more than N\$700 million per annum has had a direct impact on the livelihoods of 65,000 households in communal areas and 6,283 commercial farmers and their employees. Especially in communal areas, bush encroachment exacerbates prevailing problems like lower food security and nutrition, increased efforts to maintain living standards, and higher demands on wages and income transfers. Losses related to increased artificial drought events caused by bush encroachment are not included in the loss figure calculated above, but they have a drastic negative impact on the economy. Namibia, being a drought-prone country, cannot afford an artificial increase in vulnerability to droughts.

- Bush encroachment also impacts adversely on biodiversity, water-use efficiency and underground water tables, thereby contributing to the process of desertification. Surveys done in bush-affected areas show a highly significant negative correlation between increasing problem bush densities and the occurrence of a perennial and total grass cover. Furthermore, although bush densities in commercial areas are higher compared with communal areas, the high number of bushes smaller than 0.5 m in communal areas is a matter of great concern since they are the source of future bush thickening.
- A large number of mammals, bird species, reptiles and anthropoids are associated with problem bush species in one way or another and would be affected positively or negatively by bush control measures, depending on the method implemented. Bush thickening is seen as a major threat to the botanical diversity in Namibia and may even change the mammalian diversity, with the net effect likely to be negative. However, with the right densities and a sound mix of trees, bushes and shrubs, a more favourable sub-habitat is established, resulting in a greater variety of herbaceous species. Farmers should, therefore, include biodiversity considerations in their bush-thinning programmes.
- With respect to the large amounts of water intercepted by invader bushes it is reasonable to conclude that the underground water table is being negatively affected by bush encroachment through increased evapotranspiration, water run-off and less infiltration to subsoils.
- The value of the various bush species as a source of fodder is recognised, especially during times of drought, and many communal farmers rely heavily on this source when grazing is scarce. The complete removal of bushes, therefore, should not be considered.
- The huge potential for increased carrying capacity and productivity implies that the introduction of effective bush control programmes at a national level will simultaneously make an important contribution to the objectives of the land reform programme in Namibia. Once the encroachment problem is solved, many of the present land units that are uneconomical to manage can provide much higher returns and, consequently, create room for more farmers. In communal areas, more people can earn their living from the land, and those that reside there will benefit in terms of increased income and quality of life. At the same time, the high national unemployment rate could be addressed through labour-intensive bush control techniques.

The magnitude and occurrence of invader species

The magnitude and occurrence of invader species together with their interaction with the herbaceous layer were also investigated. The main findings are summarised as follows:

- Except for Omaruru, all the non-treated sites in commercial farming districts showed highly significant amounts of (a) total problem bushes, (b) thorny problem bushes, (c) non-thorny problem bushes, and (d) total bushes and trees, compared with communal farming areas in the east and west of the country. Even if commercial sites are compared with sites in eastern communal areas, the difference in the prevalence of problem bush is still highly significant. The fact that veld fires were suppressed and controlled for a much longer period in the commercial area seems to be one of the main reasons for this difference. Total bush densities in more than 80% of the affected area varied between 2,000 and 4,000 bushes per hectare, with the Tsumeb district being the worst off.
- There is no pattern showing a clear relationship between agro-ecological zones (AEZs) and bush density. Most of the AEZs are interspersed with problem bush densities varying from low to very high. The trend, however, is that 77% of the “very high” and 52% of the “high” density sites lie north-east of the Otjiwarongo-Gobabis axis, while 58% of the “medium” and 58% of the “low” density sites lie south-west of this same axis.
- Treated areas showed an alarming increase in total problem bush numbers for the height classes <0.5 m and 0.5–4.0 m. This phenomenon clearly illustrates how important follow-up treatments are.
- With an increase in the number of total problem bushes, thorny problem bushes, non-thorny problem bushes, and total bushes and trees, a highly significant decline in the percentage of perennial grasses as well as total grass cover (perennial plus annual) was found for each of these groups.

- For sites with more than 600 thorny bushes per hectare, the percentage of perennial grasses was highly significantly less than sites with less than 600 bushes per hectare.
- There was a significant positive correlation between the percentage of bare areas and the percentage of forbs with problem bushes.
- The survey showed that natural mortalities of invader bush varied between 2–3% and do not seem to pose the long-term solution some had hoped for.
- When the occurrence of invader bush is considered against the various vegetation units in the study area, only the Acacia Hilly Shrubland and Inselbergs are least encroached, with 15% of plots in either the “very high” or “high” density category. The Tamboti Woodlands, although represented by only 18 sampled plots/sites, show the highest degree of encroachment, with 83% of plots in the “very high” density category and a further 11% in the “high” density category. The Loam and Turf Karstveld, the Dolomite Karstveld, and the Tree Savanna and Woodlands all show a very high degree of encroachment, with more than 75% of sampled plots in either the “very high” or “high” density category. The Camelthorn Savanna has 62% of plots in the two highest density categories. The remaining vegetation units show intermediate levels of bush encroachment.
- There is a strong trend of increasing bush density in the four categories (“very high”, “high”, “medium” and “low”) with increasing rainfall. The “very high density” plots predominantly occur in the 400–450 mm interval, with a considerable number in the 350–400 and 450–500 mm intervals. One set of analyses showed that rainfall could contribute between 80–85% to the density distribution of bush on a macro-scale. The conclusion is that rainfall has a significant effect on bush density, but is not the only contributing factor.
- *Acacia mellifera* is clearly the most widely distributed encroacher species, with *Dichrostachys cinerea* in a strong second place.
- *Colophospermum mopane* is concentrated towards the north-west, while *Terminalia prunioides* is found mainly in the Otavi–Tsumeb–Grootfontein–Mururani area. *Terminalia sericea* is found overwhelmingly (95% of problem bush plots) east of an axis through Omitara and Otavi.
- It is interesting to note that each of the vegetation units is characterised by a specific dominant encroacher, namely –
 - *Acacia mellifera* dominates in the Highland Shrubland, Thornbush Shrubland and Camelthorn Savanna
 - *Dichrostachys cinerea* dominates in the Burkea–Baikiaea Woodlands, the Dolomite Karstveld and the Tamboti Woodlands, while showing a strong presence in the Loam and Turf Karstveld, the Shrubland of the Central Escarpment, the Thornbush Shrubland and the Tree Savanna and Woodlands
 - *Terminalia prunioides* is the dominant species in the Loam and Turf Karstveld, while showing a strong presence in the Dolomite Karstveld
 - *Terminalia sericea* is significant in the Burkea–Baikiaea Woodlands, Camelthorn Savanna, and the Tree Savanna and Woodlands
 - *Acacia reficiens* dominates in the Acacia Hilly Shrubland and Inselbergs, and the Shrubland of the Central Escarpment
 - *Dichrostachys cinerea* is widely distributed north of the Windhoek–Gobabis road (91% of problem bush plots), and
 - *Acacia reficiens* is distributed widely and occurs further west than any of the other encroachers.
- The occurrence of the six main encroacher species shows a strong correlation with rainfall. *Acacia reficiens* dominates the lower rainfall plots (150–250 mm) and shares dominance with *Acacia mellifera* in the 250–300 mm range. In the 300–450 mm range, *Acacia mellifera* takes over dominance. *Dichrostachys cinerea* appears at the 250–300 mm range, and increases steadily in importance up to 600 mm, which is the maximum rainfall of the study area. *Terminalia sericea* peaks around 400–450 mm, while *Terminalia prunioides* forms a constant percentage of problem bush in the 450–600 mm range.

Policies and legislation

For many years we have thought that problems in the agricultural sector should and could be counteracted through scientific and technological solutions alone. Today we realise that the degradation process, with bush encroachment as a prominent symptom, could also be ascribed to policy failures, mainly in the socio-economic field.

This problem has already been acknowledged by Government and is reflected in several new policies and laws, namely the National Agricultural Policy, the National Drought Policy and Strategy, the Soil Conservation

Act, the Namibia Forest Development Policy, and the Poverty Reduction Strategy of Namibia.

Article 95(l) of The Constitution of the Republic of Namibia stipulates that the State is obliged to actively promote and maintain the welfare of the people by, amongst other things, adopting policies which regulate the maintenance of ecosystems, essential ecological processes and the biological diversity of Namibia; and the utilisation of living natural resources on a sustainable basis for the benefit of all Namibians. Addressing the problem of bush encroachment is, therefore, a matter of obligation.

Indeed, Namibia can boast a policy environment that is conducive to resolving the problems it faces in respect of bush encroachment. As far as these problems are concerned, Government has committed itself in terms of direct involvement and support to the agricultural sector. However, the study showed that there are still certain shortcomings in policies and legislation which need some attention. These include the following:

- The formulation of a policy to manage woodlands and savannas needs to be seen as an urgent priority. In this regard, the use and control of veld fires as a management tool should be provided for.
- A woodland management policy and plan should be introduced under the Forestry Act, 2001 (No. 12 of 2001) to incorporate issues pertaining to woodlands that fall outside the current definitions of *forest* and areas classified as forests.
- It is also recommended that policy instruments provide the Namibia Woodland Management Council (NWMC) with statutory powers similar to those of the Meat Board of Namibia and the Namibian Agronomic Board.
- The NWMC should function under the Ministry of Environment and Tourism and mainly be responsible for legal aspects and law enforcement pertaining to harvesting and bush control programmes.
- Extension and research, the implementation of sustainable management practices, marketing, and long-term monitoring should fall under the Ministry of Agriculture, Water and Rural Development.
- There is an urgent need for proper coordination at a very senior level of all strategies and activities relating to natural resource management. For this purpose it is recommended that a national Forum for Integrated Resource Management be established.

Proposal of a long-term research, monitoring and management strategy

The action plans and activities needed to achieve the overall goal to combat bush encroachment are discussed in relation to each of the expected results, namely that –

- environmentally sound principles of bush control are established and adhered to at national and local levels
- guidelines for sustainable harvesting are established
- target species are identified, and
- methods to control invader bush are selected, which include –
 - chemical control with foliar, stem and soil-applied herbicides, and
 - economically viable biological and manually-oriented mechanical methods. These include sound rangeland management practices, labour-intensive methods (stumping/felling) focusing on job creation, and the use of veld fires, stem burning, browsers and bio-agents.

All the recommended methods were subjected to an environmental impact assessment and found to be environmentally friendly when used in a judicious way.

The first operation in regard to combating bush encroachment should be the often drastic one of **thinning** down to some predetermined density. In this regard the following rule of thumb is proposed:

- The number of tree equivalents per hectare should not exceed twice the long-term average rainfall (mm). A *tree equivalent* (TE) is defined as a tree (shrub) of 1.5 m in height. Thus, a 3-m shrub would represent 2 TE, a 4.5-m shrub 3 TE, etc. Land should, therefore, never be completely cleared.

Post-thinning management programmes will also be needed to keep the area open. If such management is neglected, it could lead to even worse problems. Methods recommended for this purpose are discussed in the text in detail.

Where wood harvesting is considered, it is imperative that such operations do not become more important than ecological considerations.

Since most of the methods to combat bush encroachment are expensive, recommendations are also made herein to Government to introduce a number of socio-economic incentives that would encourage farmers to participate

in restoring the land, this precious Namibian asset, to a more healthy and ecologically balanced state.

Information management

The project also attended to the establishment of practical information systems. In order to monitor changes in bush density and composition over the long term, certain indicators of pressure, state and response were identified for future use. This report recommends a monitoring system that land-users can employ to measure changes in vegetation on their own farms. The data so obtained will be stored in a database known as the *Mandarax Decision Support System*. It is proposed that this database be managed and maintained by an appropriate institution at national level. This information will serve a very important purpose for decision-makers involved in natural resource management, allowing for decisions to be based on sound knowledge and an understanding of what the indicators have measured.

Access to information regarding environmentally sound methods to carry out bush control programmes seems to be a serious problem, especially in the communal areas. Apart from information obtained from research data, the results originating from a large number of case studies on commercial farms were recorded in a database (Bush Expert), developed under the Bush Encroachment Research, Monitoring and Management Project. The database is designed to allow data to be accessed via the Internet by anyone who wishes to embark on a bush control programme. For those who only have access to a computer with a CD-ROM drive, all the information will be available on CD. The database will be jointly managed and maintained by the two Namibian agricultural unions.

Socio-economic incentives for participating in bush control programmes

Bush encroachment should explicitly be regarded as a community and societal problem and not simply as a private problem for farmers. This means that it should be approached as a problem that Government, farmers, the public and the private sector need to take ownership of. The following recommendations are made for future support to farmers affected by the problem of bush encroachment:

- **An institutional framework:** A future wood industry would benefit from the establishment of a suitable institutional framework. This could be in the form of a cooperative, parastatal or private company responsible for buying and marketing wood products at a national as well as an international level. Government, with the assistance of donor countries should provide strong financial and technical support for the stabilisation and growth of a wood industry. In the long term, a wood industry offers the best option for a sustainable solution of the problem, and will simultaneously create job opportunities for several thousand people. The potential wood available for harvesting varies between 10 and 20 tonnes per hectare in the different areas studied and therefore, if the full potential for charcoal production in Namibia is utilised, a labour force of 44,000 contractors will be needed.
- **Subsidisation of labour-intensive bush control measures:** Almost all the practices recommended herein for controlling bush encroachment are very expensive. The vast majority of farmers, particularly communal farmers, cannot afford to launch bush-clearing programmes on a significant scale. It is of paramount importance, therefore, to consider subsidising labour-intensive bush-clearing methods by means of the following:
 - Subsidies for the manual clearing of 5 million ha of commercial and communal land over a 20-year period will cost Government N\$17.5 million per year. Five labourers can clear about 200 ha per annum, which means a potential of employing 6,250 people each year.
 - By subsidising 4% of the prevailing interest rate on loans granted by the Agribank of Namibia to farmers for undertaking bush control programmes, Government will spend N\$5.3 million per annum so that 4 million ha can be cleared over a 20-year period.

Government can expect to retrieve the cost of either form of subsidy within 13–15 years through increased tax revenues.

- **Loans for small-scale entrepreneurs:** The production of poles and droppers would be a viable industry for entrepreneurs, especially in the communal farmlands. However, the prevailing lack of start-up capital for this kind of business should be resolved by means of soft loans for those that can provide a sound business plan.
- **Food-for-Work Programme:** Bush-clearing programmes could also form part of this Government initiative.
- **Drought-mitigating strategy:** Bush-clearing programmes can play a very important role in mitigating the effects of drought because farmers will become less vulnerable and less dependent on financial

support from Government. In this way important aspects of Namibia's Drought Policy and Strategy will be addressed.

Other incentives elaborated upon in the document include addressing the research needs related to a viable wood industry, political assurances, and training programmes for farmers and extension staff.

Conclusion

The study concluded that bush encroachment is the single most important factor hampering sustainable livestock production and improved standards of living in rural areas. Addressing this problem effectively will also offer significant opportunities for employment and settlement, and should be taken up as an integral part of the Second National Development Plan (NDP2) and "Vision 2030".