Bush Control Manual

MINISTRY OF AGRICULTURE, WATER AND FORESTRY

german cooperation

Implemented by giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Beyond Bush De-bushing Advisory Service

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The Bush Control Manual serves as a practical information tool for farmers dealing with bush encroachment and is part of a series of eight production manuals produced by the Farmers' Support Project (FSP) in 2009, under the auspices of the NAU and NNFU.

OTHER PRODUCTION MANUALS IN THE RANGE:
Rangeland Management
Small Stock Management
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Labour Management
Crop Production
Animal Health
Mechanics
Farming Finances

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Introduction

Managing Land Successfully

As a farmer, you are also a land manager. Bush encroachment is an enormous and complex challenge. There is not a "quick fix" or a "one fits all" solution. Your management needs to be integrated, strategic, and long-term.

Know your land
Farmers have superior knowledge of their livestock and they need to extend that knowledge to their land and vegetation. What is the state of bush encroachment on my farm? Is it in a transitional state or am I facing full-fledged bush encroachment? Which is the encroaching species? The first chapter of this manual looks at reasons for and impacts of encroachment. It also introduces a set of tools that help to monitor the land and explains legal requirements. At the end of the manual you will find an overview of encroacher bush species in Appendix A and protected trees in Appendix B.

Create value
Encroacher bush can be valuable. The current economic utilisation of encroacher bush in Namibia focuses mainly on firewood for local communities and charcoal for exports. Buyers of woodchips for energy production are emerging. Some products require larger investments; others do not but may still lead to considerable value addition. The brochure "Adding Value to Namibian Encroacher Bush" gives on overview. It is available online at www.dasnamibia.org.

PRODUCTS MADE FROM ENCROACHER BUSH

Firewood

The demand for firewood in Namibia is expected to increase. Prices range from N$ 1,700 per tonne in Kavango to N$ 3,000 per tonne in Katutura (based on informal retail prices).

- Mixed species suitable
- Very low investment
- Labour intensive
- No additional production inputs (e.g. water, electricity) required

Charcoal

Namibian charcoal is mainly exported to South Africa and the UK. The market for barbeque charcoal is under-supplied and the gap between demand and supply is estimated to increase further.

- Mixed species suitable for high quality barbeque charcoal
- Low investment
- Simple technologies provided by local SMEs
- No additional inputs (e.g. water, electricity) required

Briquettes

Compressed fire wood is another product produced at an economic scale from encroacher bush. It is known as "biomass briquettes" or "wood logs" and the Namibian product is known as "bushbloks". The product is made through a process of grinding the biomass and subsequently compacting it. Compressed fire wood is mainly used for heating and leisure activities such as barbequing. Due to their high density, briquettes have longer burning times than conventional firewood.

Wood chips

The main off-taker of wood chips in Namibia is Ohorongo Cement near Otavi which uses chips from encroacher bush to fire industrial combustion chambers and O&L at the breweries in Windhoek.

- Farmers pay a small fee for harvesting
- Mobile chippers convert the bush wood chips

Consult the following document for further guidelines on potential products:
DECOSA 2015: Value added end-use opportunities from encroacher bush in Namibia
http://www.dasnamibia.org/download/brochures/Brochure_Debushing_Value-Chains-2015.pdf

Choose your bush control method

Chapter two gives an overview of bush control methods. You can also contact us, the "De-bushing Advisory Service" (DAS) for more technical advice on appropriate harvesting techniques and equipment. We can refer you to service providers and equipment suppliers. Please also find more information on the website www.dasnamibia.org such as our brochures on harvesting and quantifying bush as well as on financing options.

Avoid re-encroachment

Chapter three is dedicated to aftercare practices and sustainable rangeland management. Namibia's National Rangeland Management Policy and Strategy (2012) is based on Holistic Rangeland Management which implies principles, rather than rules and regulations. You can also find it in the download section at www.dasnamibia.org.

Bush Encroachment in Namibia

1

Bush encroachment is an increase in woody plants that results in the loss of grazing capacity, causing considerable productivity losses for both commercial (freehold) and communal (non-freehold) farmers in Namibia. The expansion of certain opportunistic indigenous shrubs in both density and area happens in response to various global and local drivers. Of these, rainfall, disruption of the grass: bush balance of a savanna and the suppression of hot fires are probably the most important. There are a few positive effects as well, such as increased soil stability and fertility. Bush is a valuable component of a savanna that provides invaluable services to the soil and animals. Encroacher bush should therefore never be eradicated, merely thinned to a more natural (acceptable) density.

Main encroacher tree and shrub species

- *Dichrostachys cinerea*
- *Acacia mellifera (Senegalia mellifera)*
- *Acacia reficiens (Vachellia reficiens)*
- *Acacia luederitzii (Vachellia luederitzii)*
- *Colophospermum mopane*
- *Terminalia prunioides*
- *Terminalia sericea*
- *Rhigozum trichotomum*

Other species of lesser importance as encroachers

- *Acacia erubescens (Senegalia erubescens)*
- *Acacia fleckii*
- *Acacia nilotica*

For a full description and characteristics of the species see Appendix A

Encroachment is not a steady process but one that happens occasionally or sporadically. It sometimes starts in specific, small patches which expand gradually over several decades. Often, the process occurs quietly and virtually unnoticeably so that land users don't realise what is going on until the whole landscape is covered in bush.

An open savanna overlooking Gross Barmen in 1876 (left); An encroached savanna overlooking Gross Barmen in 2009 (right)

Bush encroachment is primarily a process of thickening and expansion of bush species which have been observed in a certain area before. However, encroachment can also include an expansion of species that have not grown in that area before. For example, it appears that *Dichrostachys cinerea* is expanding into drier areas southwards while *Rhigozum trichotomum* is expanding into moister areas northwards.

Balance

In a savanna the balance between grass and bush is fairly stable. Bush encroachment disrupts this balance. The herbaceous, grassy component is degraded in quality (species diversity and nutritive value declines) and quantity (grass yield declines and is less persistent).

Growth rate

At a certain density, the growth rate of a bush group slows or stops due to intense intra-species competition between individuals and they remain locked in a sexually immature state. Once external factors cause thinning, individuals grow again. A thicket may therefore remain stable at a certain level of development for very long periods of time. Only once individuals are spaced widely enough to access sufficient resources will they become sexually mature and produce seed. The denser a stand of immature encroacher bush, the more stable it is.

Root system

Encroacher bush competes with itself and other plants because of its extensive root system. A grown bush has a lateral root system that extends seven times further from the stem than the bush's height. The shallow lateral roots utilise shallow ground moisture more effectively than grasses. The deep taproots of woody plants access deep ground water and keep them alive during dry phases that kill more shallow-rooted plants such as grasses. The root system of woody plants thus gives them a competitive advantage over grasses.

1.1 Causes of Bush Encroachment

There are global and local reasons for bush encroachment. Changing rainfall patterns, disruption of the balance between grass and bush in the savanna due to overgrazing and the suppression of fires are probably the most important ones.

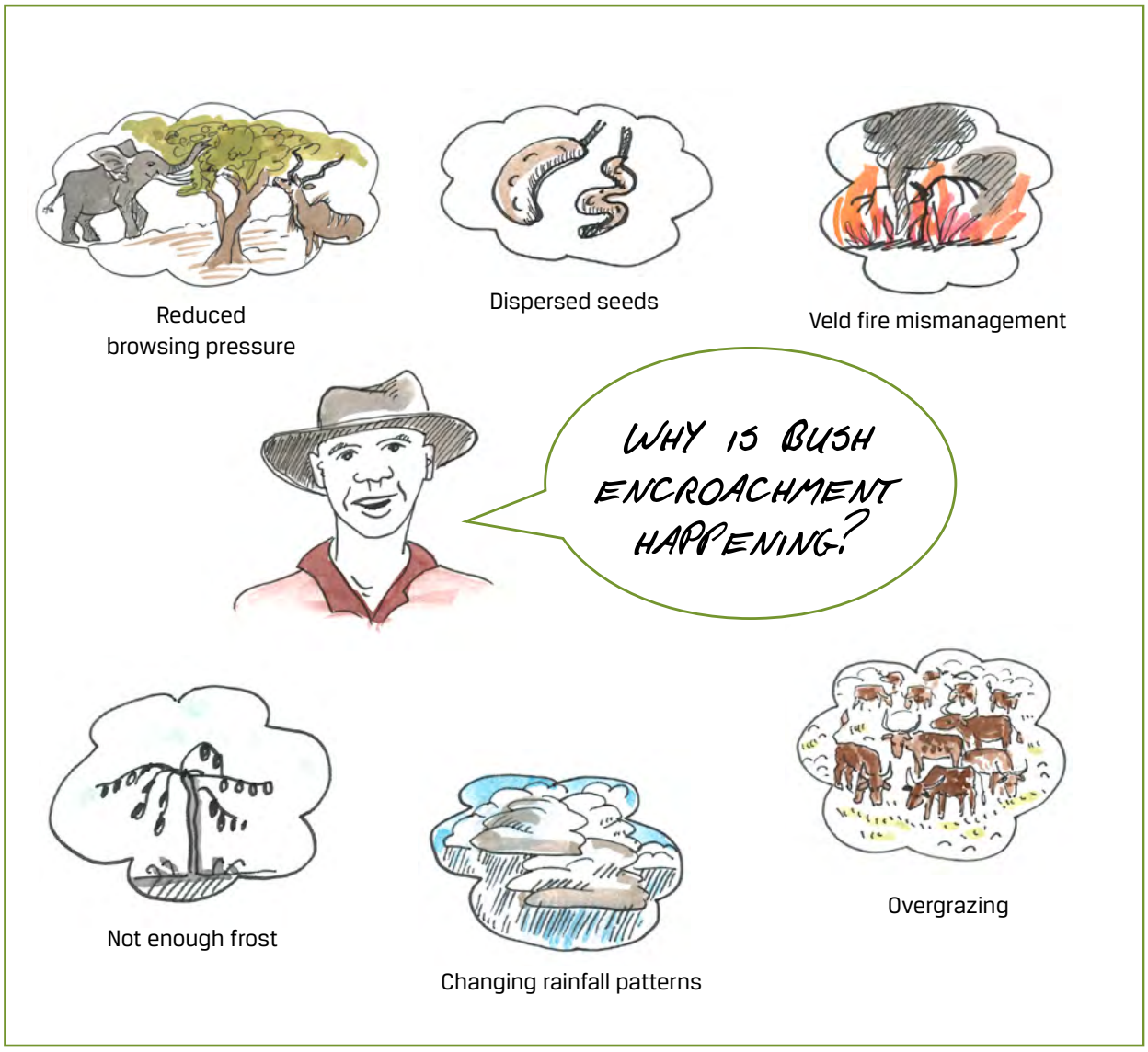


Illustration 1: **Causes of bush encroachment**

Unsustainable Livestock Management

Overgrazing or grazing at the wrong time weakens the roots of grasses. They do not take up water and nutrients effectively and suppress emerging bushes. The water and nutrients left in the soil are then taken up by bushes, fuelling their growth at the expense of grass growth and recovery. This can also happen when periods of drought, which reduce the grassy layer, are followed by periods of high rainfall – this creates very favourable conditions for woody plants to establish themselves in large numbers.

In present-day Namibia, the main forces that weaken a savanna grass sward are

- overstocking (too many animals) on the land
- for too long (continuous or semi-continuous grazing in the rainy season).

The desirable perennial grasses cannot adequately recover from grazing in the active growth season.

Fire

Fire stops the development of woody seedlings into mature plants: High-intensity fires, so called "hot" fires, would kill the seedlings and saplings of woody species. Farmers often suppress these fires. This way, they involuntarily speed up the rate of bush encroachment.

Over-frequent burning (as in the Western Zambezi) also facilitates bush encroachment. If a fire burns "cold" because it does not have a lot of fuel to burn, it is not fierce enough to kill woody saplings.

Rain

Changing rainfall patterns disturb the balance of a savanna. Emerging woody seedlings sink a long taproot, enabling them to survive dry periods better than their shallow-rooted grass competitors. At the same time, greater rainfall is also associated with higher densities of bush. However, it is assumed that the seeds of woody encroacher species need at least two, but probably three years of well above-average rainfall to establish.

Frost

Severe frost (ice cover) can kill woody seedlings. The taller a sapling grows, the less susceptible it becomes to frost. Frost typically occurs in patches in low-lying areas, resulting in a mosaic of living and dead bush.

Reduced browsing pressure

The displacement of browsers, such as kudu, by cattle or other grazing livestock puts extra pressure on the grassy component and relieves pressure on the woody plants. Mega-browsers such as elephants and black rhino stunt the development of woody saplings. Similarly, heavy browsing pressure by large populations of ungulate browsers (e.g. kudu, giraffe, impala), domestic goats and lagomorph rodents (e.g. mice, hares, rabbits) can prevent the transition of a weakened savanna towards full-scale bush encroachment. Over-browsing kills or suppresses the development of woody saplings, delays maturity in sub-adults and may reduce seed production.

Seeds

A weakened grass sward, a series of wet years and the absence of forces that kill woody seedlings leads to the sudden mass establishment of woody encroacher species with soft coated

seeds. Acacia mellifera, A. reficiens, A. luederitzii, A. erubescens and other soft coated seed thorny species form typical "same size, same age" mono-stands.

A SAVANNA CONTAINS THE SEEDS FOR ITS OWN ENCROACHMENT:

- Soft-coated seeds are dispersed mostly by the overland flow of rainwater following heavy rainfall.
- Hard-coated seeds are well protected and long-lived. The hard coat prevents germination, so it has to be damaged (scarred) first by fire, passage through the digestive tract of animals or attempted predation by seed-eating animals such as weevils and rodents before germination is possible.

1.2 Impacts of Bush Encroachment

Bush encroachment has a range of negative impacts. At the same time, the bush leaves and pods can provide animals with valuable nutrients – which is one of the positive impacts of the increase in woody plants.

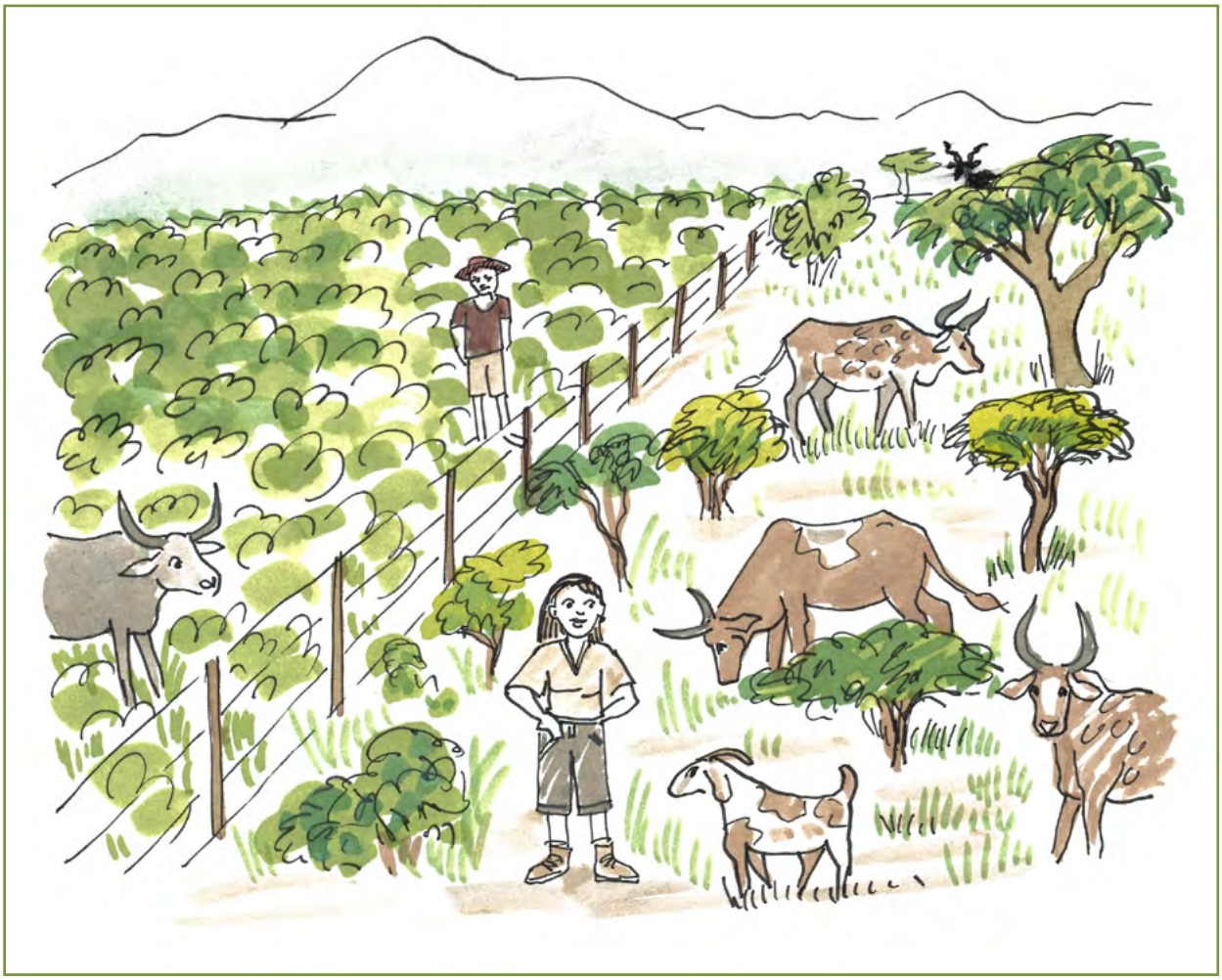


Illustration 2: **Effects of bush encroached land versus bush thinned land**

Negative impacts

- The carrying capacity of farmland is reduced. In extreme cases to as little as one-tenth of its original grazing potential.
- A bush-encroached landscape is less biodiverse than the original savannah state. As the grasses suffer, so do the grazing animals. Even browsing animals find it difficult to penetrate and harvest a thorny thicket.
- The landscape becomes dull and monotonous. This has implications for tourism as tourists are commonly drawn to Namibia's wide, open landscapes.
- Poor visibility due to bush encroachment has negative implications for farming security as it obscures livestock and game poachers from view.
- Preliminary results of a hydrological study in Namibia show that bush encroachment has a negative impact on groundwater recharge – not only reducing the moisture available in the soil but also reducing the probability of groundwater recharge to approximately by 1/3.

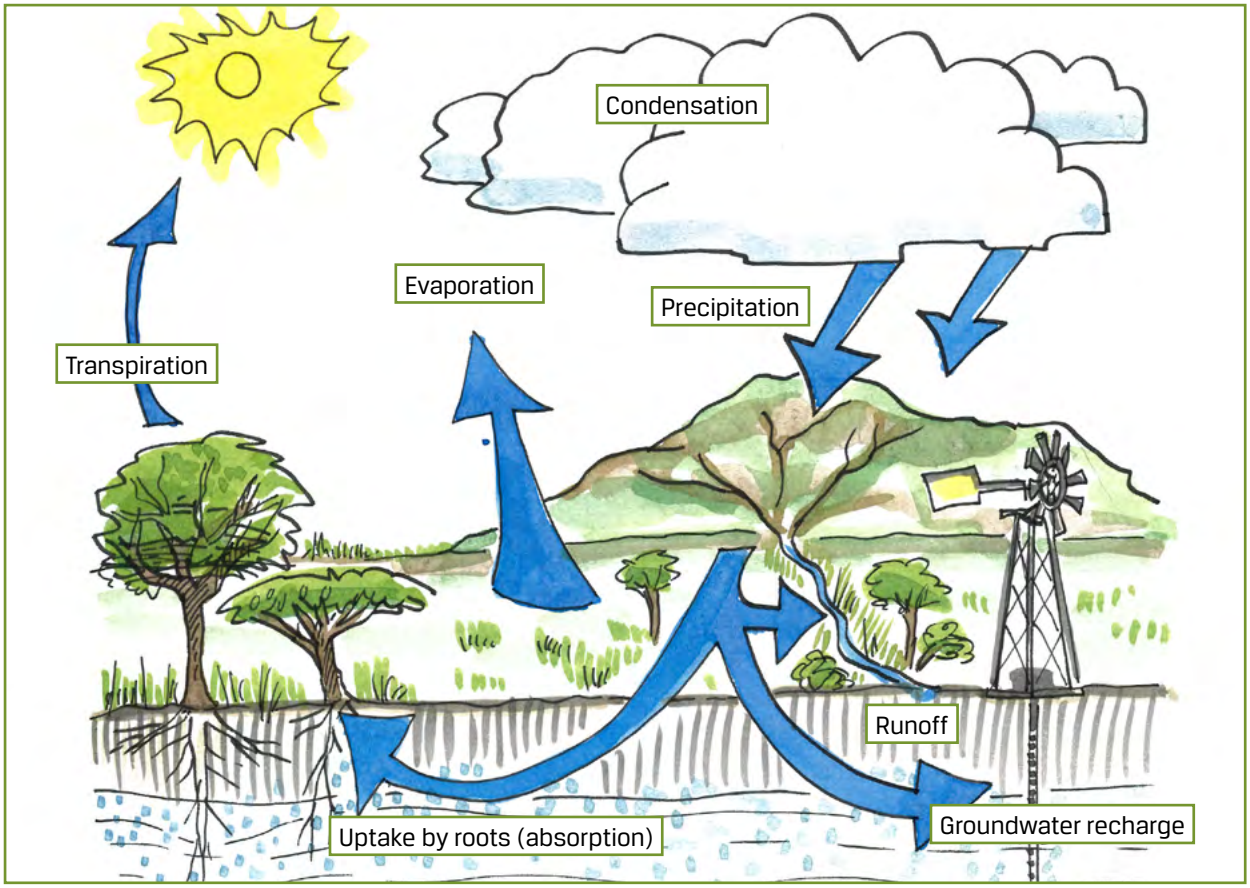


Illustration 3: **Water Cycle**

Positive impacts

- Ecologically, the soil under a bush thicket is well protected against erosion. The strong root network of bush binds the soil and the bush canopy shades it.
- Most encroacher bush in Namibia are leguminous and deciduous. This means it enriches the soil continuously with nitrogen and seasonally with leaf debris. The best proof of this ecological service is the "grass explosion" that takes place after bush control.

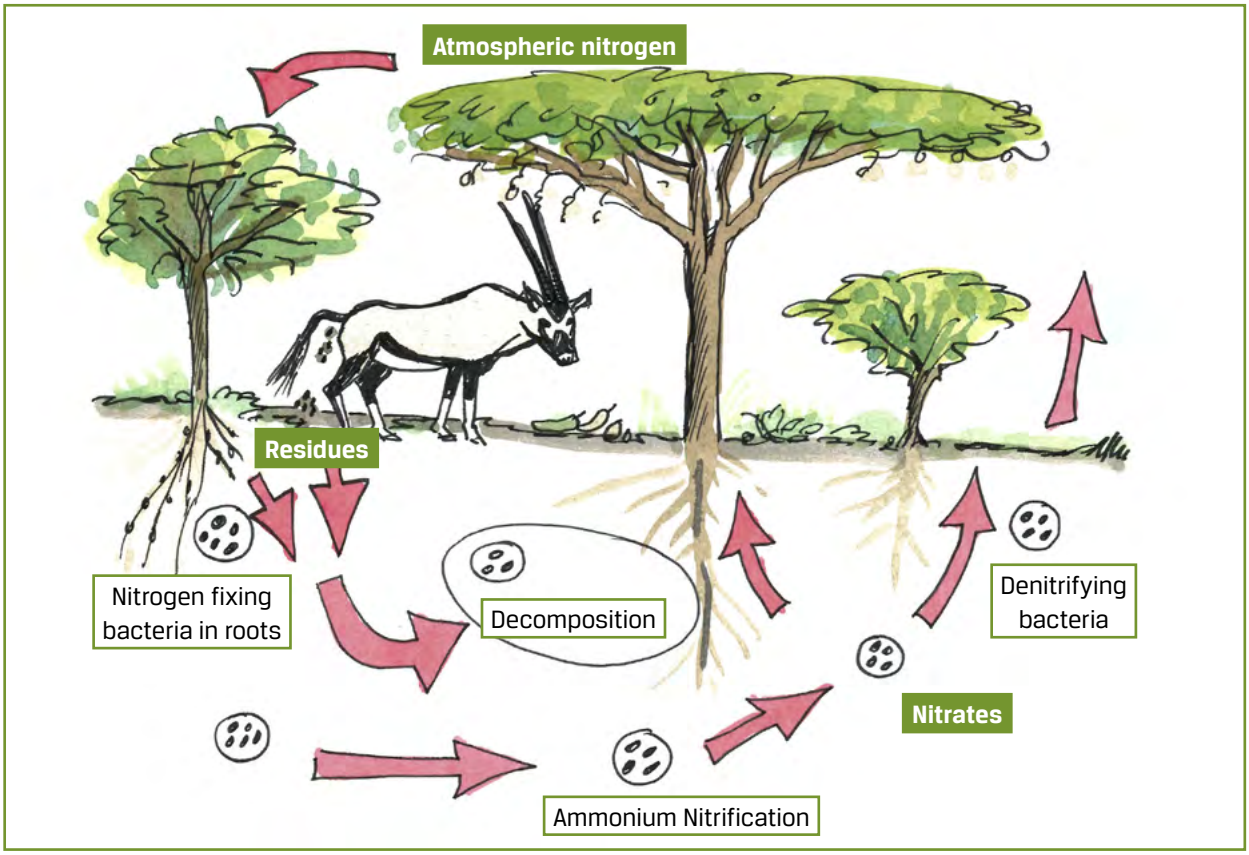


Illustration 4: **Nitrogen-fixing Cycle**

- Woody plants and their pods provide foraging animals with valuable nutrients. Even grazing livestock like cattle and sheep browse occasionally, especially during the annual dry season when grasses have withered. Compared to grasses, bush leaves provide significantly more dietary protein, minerals and vitamins than grasses but less digestible energy. Some may contain anti-nutrients such as tannins, or poisons such as alkaloids. Completely clearing bush would have a negative impact on the nutrition of wild and domestic animals.

- The most exciting aspect of bush encroachment is the inherent economic value of its wood. Bush encroachment results in lots of wood that can be used to make value-added products, create employment and grow the agricultural and processing sectors of the national economy. For example, encroacher bush should be the main target of the country's awakening biomass industry. Wood of encroacher bush also has a huge role to play as a renewable energy resource.

1.3 Monitoring Bush Encroachment

The best way to observe if bush establishment takes place in a weakened grass sward is to monitor certain patches of the savanna regularly, especially after good rainfall seasons, to see if woody seedlings are emerging.

Recognising the transitional state

If woody plants are emerging, the transition will advance to full-scale bush encroachment if not controlled. However, transition may take decades so there is a long window of opportunity to alert land managers to intervene. The best way to recognise the transitional state of a savanna is to know its climax and pioneer grass species. Pioneer species have a short life; they are annuals. Climax grasses are longer-living grass species that are usually palatable and nutritious. When climax grasses are replaced by pioneer grasses, competition with bush weakens and bush encroachment is supported.

When a savanna is in the transitional state of bush seedling establishment, the survival of woody seedlings and saplings depends on a number of forces:

- If the grass cover is open and low, frost may kill woody seedlings during severe winters.
- Heavy browsing pressure may stunt or kill woody saplings.
- If the grass cover is dense and lush after two or three successive years of good rainfall even in pioneer veld, a hot fire may kill off woody seedlings and saplings and prevent full-scale bush encroachment.
- Measures that increase the abundance and vigour of perennial grasses arrest the further development of bush saplings and may eventually lead to their death by increased inter-species competition or fire.

Density: How to calculate bush on your farm

A "bush equivalent" (BE) is a standardised, 1.5 m high bush. A density of encroacher bushes (BE per hectare) that exceeds twice the long-term average rainfall (in millimetres per year) represents bush encroachment. Commercial farmers often experience that bush exceeding 2,000- 3,000 plants/hectare which seriously degrades rangeland. At 5,000 to 6,000 plants/ha, thorn bush becomes impenetrable and density is no longer physically measureable. Yet it is estimated that densities of 24,000 plants/ha occur in Namibia.

A "bush equivalent" (BE) is a standardised, 1.5 m high bush.
Bush density can be measured on any small sample area that is representative of the larger area, the farm or rangeland generally. Plot measurements are then extrapolated to one hectare (10,000 m^2).

1. Select any small area (50 m^2 for example) that is representative of the bigger area.
2. Count the number of encroacher bush plants growing on the plot and measure the height of each one.
3. Record bush height in classes of 1.5 m (the size of one bush equivalent), e.g. 1.5 m, 3.0 m, 4.5 m, 6.0 m etc.
4. Multiply the number of bush in each height class with their height, e.g. 7 bushes x 1.5 m = 10.5 m, 4 bushes x 3.0 m = 12.0 m, 2 bushes x 4.5 m = 9.0 m and 2 bushes x 6.0 m = 12.0 m
5. Add all height class totals together and divide by 1.5 m, e.g. 43.5 m ÷ 1.5 = 29.
6. This is the number of bush equivalents on the plot, i.e. 29 BE/50 m^2.
7. Extrapolate this sub-total to 10,000 m^2 (one hectare) = 5,800 BE/ha.

Compare the measured bush density to the long-term average annual rainfall of the plot or farm. For example:
If the farm is in the Mariental district where the long-term average annual rainfall is 250 mm, the recommended bush density is only 500 BE/ha. The land user can remove the excess of 5,300 BE/ha.
If the plot is near Grootfontein with a long-term average annual rainfall of 650 mm, the recommended bush density is 1,300 BE/ha. The land user can remove the excess of 4,000 BE/ha.

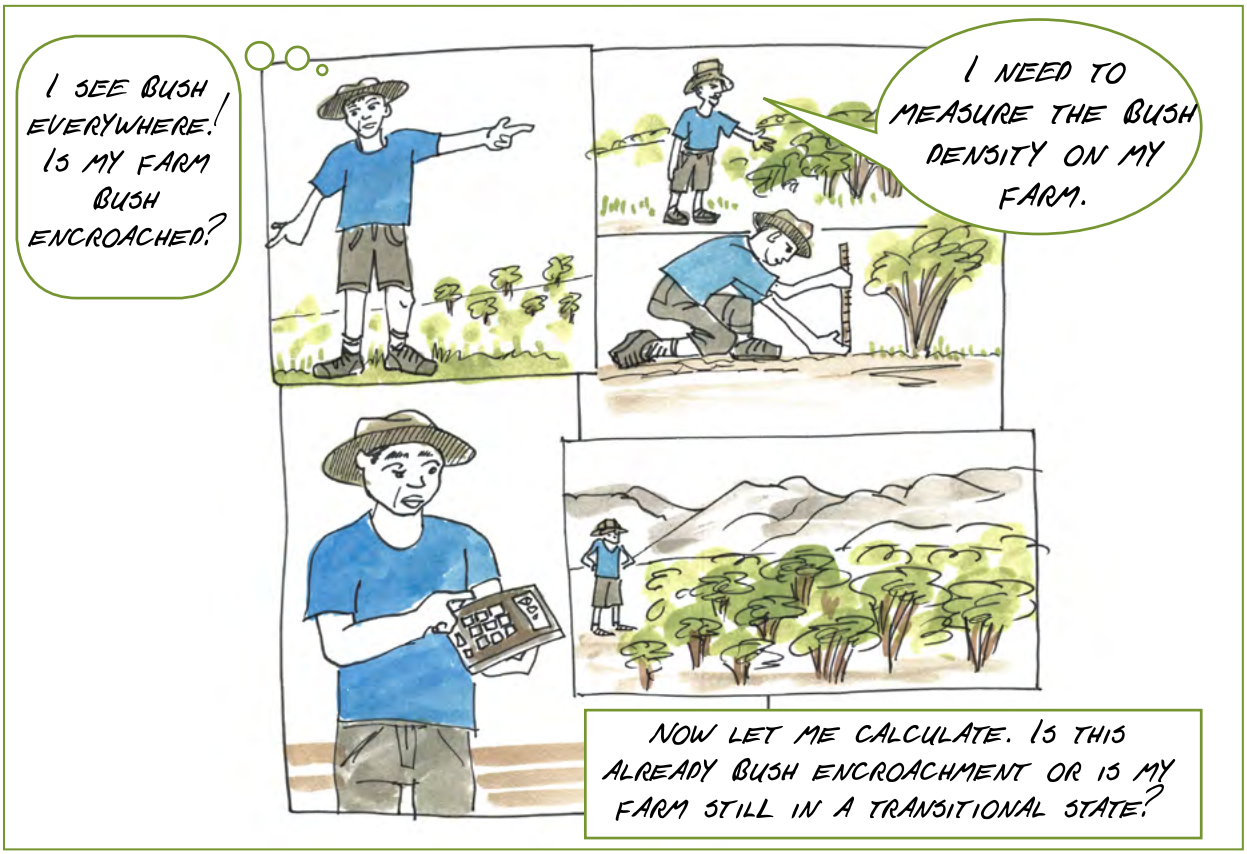


Illustration 5: **Measuring bush density**

1.4 Approaches to Bush Control

A system of calculating bush densities has been developed. This is called the rigid approach to bush control. The adaptive approach, on the other hand, is guided by a more intuitive understanding of nature. The adaptive approach to bush control is ecologically much more preferable than the rigid approach.

A rigid approach to bush control

What is, ultimately, the best density of woody plants on the land after bush control? To answer this question, a generalised, rigid system of ultimate bush densities has been developed.

Optimum density in a rigid system

- It is commonly assumed that the optimum density of all woody plants (in BE/ha) is twice the long-term average annual rainfall (in mm).
- In the moister north-eastern regions of Namibia, the optimum woody density should be increased to three times the long-term average annual rainfall to accommodate the natural woodiness of the area.
- Similarly, on coarse Kalahari sand, the optimum woody density should also be increased to three times the long-term average annual rainfall to allow for sufficient nutrient enrichment of the soil by woody plants.

How to apply the system

- First assess the existing density of all woody plants targeted for bush control.
- If the total density of woody plants exceeds the optimum or targeted density, some woody plants have to be removed selectively, starting with the encroaching species.

Leave on the land

Do not remove:

- Any protected woody species. Some protected woody species may become encroaching under certain conditions and specialist inputs may be required to decide on the thinning of protected woody species under these conditions.
- Any woody individuals with a stem diameter exceeding 18 cm at the base above the basal swelling. Such large individuals are protected by the Forest Act no. 12 of 2001.
- A significant number of woody plants from within 100 metres of a river course to protect this potentially flooded area from soil erosion. The Forest Act no. 12 of 2001 prohibits the killing of trees within 100 metres of a river course.
- Encroaching woody species completely. Larger specimen should be left in the interest of biodiversity and patchiness.

An adaptive approach to bush control

With this approach, you "read" the lay of the land and thin accordingly. The approach is not guided by hard-and-fast rules but by an intuitive understanding of local ecology.

Original versus invasive encroacher

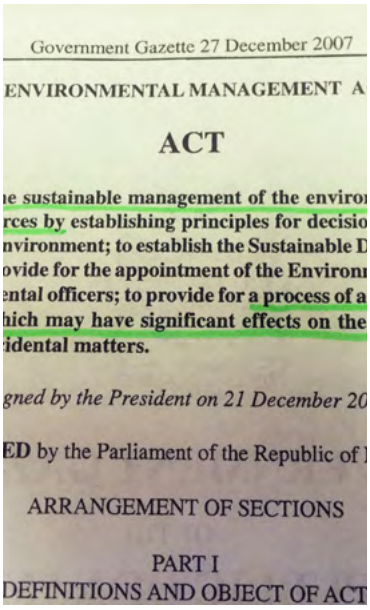
In most cases of bush encroachment, especially by the most important species (Acacias, Di

chrostachys cinerea), the difference in physical appearance of the "original" growth of woody plants which thrived on the land prior to rangeland degradation and the "invasive "encroacher species is clearly visible and remarkably distinct.

- The "original" growth consists mostly of larger, thicker, more mature plants of a variety of species, as well as the young ones growing up here-and-there to replace dying old trees. The "original" growth should be left standing.
- The "invasive" group of encroacher species is characterised by thin-stemmed, same-size, same-age bush of the same species or just a small variety of known encroacher species. They look distinctly different to the "original" growth and should be removed nearly totally. A few immature specimens should be left on the land because they are most likely part of the generational chain of the "originals" and are not true members of the "encroachers".

Further information on how to quantify bush density can be found in
De Wet (2015): Compendium of harvesting technologies for encroacher bush in Namibia
http://www.dasnamibia.org/download/brochures/Brochure_Debushing_Resource-Assessment-2015.pdf

1.5 Legal Requirements of Bush Control


Government Gazette 27 December 2007

ENVIRONMENTAL MANAGEMENT A

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ARRANGEMENT OF SECTIONS

PART I
DEFINITIONS AND OBJECT OF ACT

Caption for photos above

Environmental protection is enshrined in the Namibian Constitution and sustainable development has formed a cornerstone of the Vision 2030. Thus, the government is committed to actively promote and maintain environmental welfare by formulating and implementing policies that can realise sustainable development. These fundamental principles are supported by various international, regional and national legal instruments. Ultimately, the responsibility toward environmental protection and sustainable development is obligatory for everyone and every activity operating within Namibia. Below are key regulatory requirements that individuals and business entities involved in bush control and biomass utilisation should comply with.

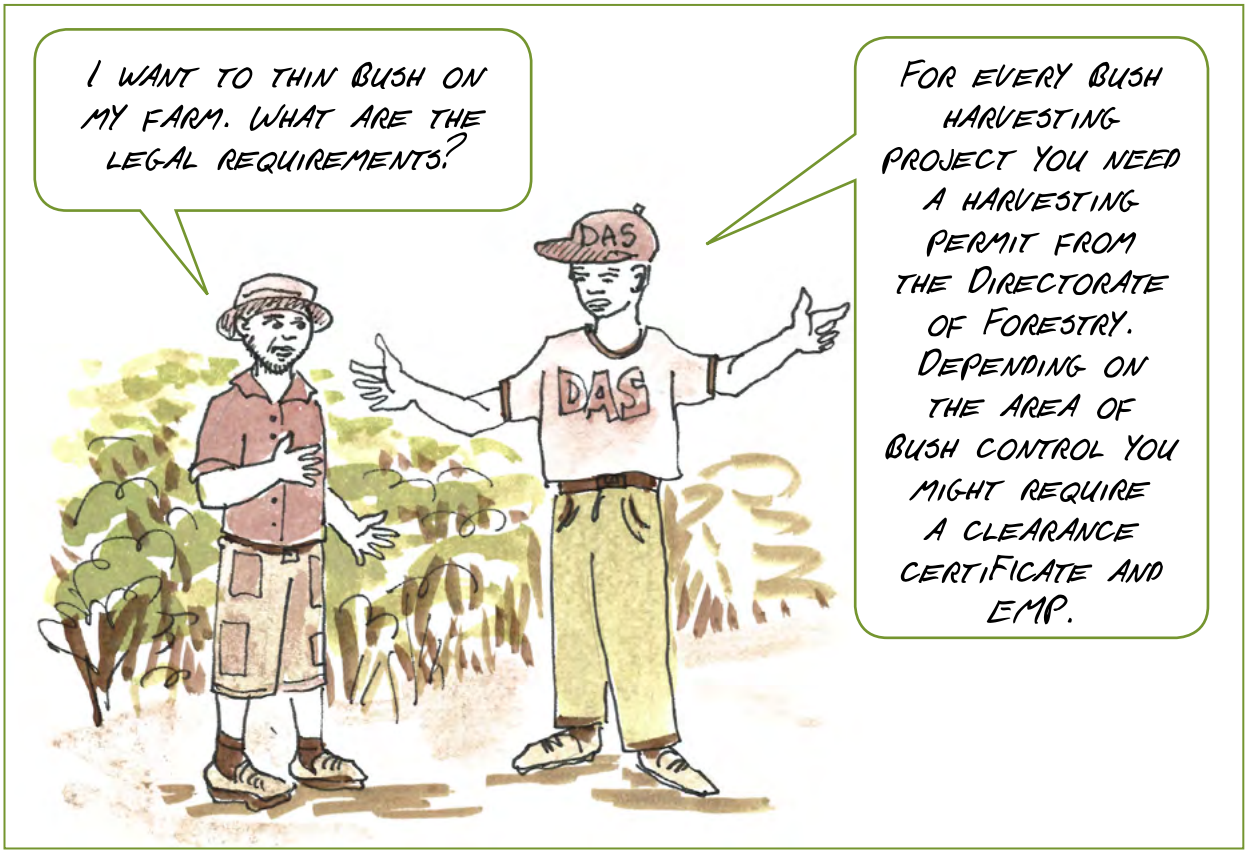


Illustration 6: **Regulatory processes for bush thinning**

Forestry Permits

All harvesting of trees and wood in Namibia is governed by the Forest Act and its Regulations. This Act is administered by the Directorate of Forestry (DoF) in the Ministry of Agriculture, Water and Forestry (MAWF).

Harvesting Permits

A Harvesting Permit is required for any tree cutting and/or harvesting of wood for commercial purpose. The permit is issued by a Licensing Officer. It stipulates conditions of the harvesting. Inspection of an area to be harvested is done before the permit is issued and when an application for renewal is made every 3 months.

Transport Permits

A Transport Permit is required to convey any wood or wood products (e.g. droppers, planks, charcoal, and firewood). It is obtainable from any Forestry Office, and is valid for 7 days.

Export Permits

An Export Permit is required to send any wood or wood products outside Namibia. It is obtainable from any Forestry Office and is valid for 7 days.

Marketing Permits

A Marketing Permit is required to enable the producer to sell his/her products to any other party. The permit is valid for 3 months in commercial areas while in communal areas the permit is valid for 1 month only.

Environmental Clearance Certificate

The Environmental Management Act is administered by the Environmental Commissioner in the Department of Environmental Affairs (DEA) in the Ministry of Environment and Tourism (MET). Normally, to get an Environmental Clearance Certificate, an Environmental Impact Assessment (EIA) has to be completed together with an Environmental Management Plan (EMP).

- An EIA is an assessment of the environmental damage that a project might cause. An EIA is usually carried out by an independent environmental practitioner. The EIA report is evaluated by the DEA, and if the Environmental Commissioner is satisfied that the negative impacts are minimised, an Environmental Clearance Certificate is issued.
- The EMP provides advice on how the negative impacts can be avoided or reduced.

For bush harvesting projects the application process has been simplified to avoid heavy costs and time delays. There are three categories:

1. **No Environmental Clearance Necessary:** All wood harvesting activities in areas less than 150 hectares per year require only a Harvesting Permit from the Directorate of Forestry (see above).
2. **Environmental Clearance based on generic EMP:** Medium-sized bush harvesting operations covering an area between 150 – 5,000 hectares require a Harvesting Permit (see above) and an Environmental Clearance Certificate. The area to be thinned should be less than 5,000 hectares altogether in one vicinity. The EIA can be customised from a generic Environmental Management Plan. You can find such a plan online (www.dasnamibia.org, Resources/downloads / Policies, "Forestry and Environmental Authorisations Process for Bush Harvesting Projects"). The level of consultations with interested and affected parties (I&APs) for this category should focus on the neighbouring farms. This is under the assumption that the potential impact is foreseen to be localised. The consent should be submitted to DEA with the application. If a farmer harvests individual areas that are less than 5,000 ha, but they contribute to a larger project that covers an area greater than 5,000 ha, then the activities fall into category 3 (full EIA).

3. **Environmental Clearance based on dedicated EIA and EMP:** Large bush harvesting operations covering an area greater than 5,000 hectares are likely to have extensive, complex and/or long-term environmental impacts. They require a full EIA and include a thorough EMP. The EIA must cover all the specific details of the source areas. Individual farms that contribute harvested wood to a large project will all be bound by the conditions described in the EMP.

Labour Act

The Labour Act no. 11 of 2007 concerns mainly the fair and safe treatment of workers involved in bush control. Regulations relating to the Health and Safety of Employees at Work (of 1997) needs to be adhered to in terms of the employment conditions of all people.

Aerial Application of Arboricides

Aerial spraying has been widely used in Namibia, with the justification by farmers that it is an 'emergency' treatment and more cost effective when bush is so dense that other methods of clearing are simply not practical. However, aerial spraying is now illegal as outlined in the Forestry Act Regulations, 2015 (Sections 22, 23/Regulation 12). Application of arboricides by hand is still allowed as this is more selective.

All wood harvesting activities requires a harvesting permit from the Directorate of Forestry in the Ministry of Agriculture, Water and Forestry.

2 Bush Control Methods

Which method of bush control works best? There is no universal answer to this question. It depends on farmers' objectives, the encroacher species they face, the landscape as well as the investments they are prepared to make. This chapter presents the common methods of bush control, every method has its benefits and disadvantages. The emphasis is on practical application of each method, how to implement it correctly, how to maximise the desired impact on encroacher bush while minimising collateral damage and unintended consequences. Guidance is also provided on the ultimate bush density aimed for after bush control. It is recommended to seek expert advice prior to embarking on a bush control exercise.

Main Principles for Bush Control

- ✔ Leave a mix of trees and bushes: The veld should have a variety of tree species (including some of the encroacher species) of different sizes. They should be spaced in a way that there are some open patches and some dense patches. This provides a variety of habitats for animals.
- ✔ Thin bush in a phased approach: Avoid to "shock" the land by an abrupt change from dense bush to open veld.
- ✔ Protected plants should not be harvested. Exceptions can be made under supervision of Forestry officials in cases of high densities.
- ✔ If arboricides are being used, foliar (leaf spray) and stem-applied arboricides are recommended. Pellets should not be used, as they tend to get washed along the surface by rain and end up in non-target areas.
- ✔ Dry river beds tend to carry more and larger trees. Forestry regulations state that trees should not be thinned within 100 metres of a river course. Thinning is required in densely encroached river margins, but one should leave a higher density of trees than on the adjacent habitat. It is especially important to leave large trees along a river course. The exception to this is Prosopis, which invades river beds, and should be eradicated completely.
- ✔ Training of the work force is necessary before harvesting starts. Workers need to know which trees to target and which to avoid. Work teams need to be managed so that any excessive harvesting or killing of the wrong species is noticed and corrected.

Illustration 7: **Planning for bush thinning**

COST OVERVIEW OF BUSH CONTROL

Method	Equipment	Labour Cost (NAD)	Further Reading
Manual	Axes, Pangas & Spades	1,200 – 3,000/ha	1. De Wet (2015): Harvesting Namibian Encroacher Bush 2. DECOSA (2016): Concept for Sustainable Labour-based De-bushing in Namibia 3. Cheetah Conservation Fund: https://cheetah.org/
Semi-mechanised	Conventional bush cutter, heavy duty bush cutter & chain saw	1,500 – 2,000/ha	
Mechanical	Heavy mechanised cutting machine with scissors, small bulldozer with circular saw, heavy bulldoze & bush roller	750 – 4,000/ha	
Chemical: manual application, arboricides only	Pump sprayers & by hand	500 – 2,000/ha	amagri: www. calculations that 1 hectare requires 5 kg of chemicals
Biological: Planned fire	Axe, Spade, shovels, hoe, picks (manual) and mechanised machinery such as graders and tractors	About 100/ha	Forest Act (2001) and Regulations (2015), Refer to Guidelines on constructing fire cutlines.

2.1 Manual and Semi-mechanised

Manual control of bush is achieved by hand labour and using hand tools only. Semi-mechanised control involves the use of hand-held power tools that are not self-propelled.

Manual

Manual bush control is most suited for small-scale operations where cost and time are less important than selectivity of control.

How it works

At its most elementary level, manual control is a person with the appropriate hand tools. Such manual control is highly selective if the worker has been well trained. However, chopped stems remain behind and can coppice if they are young enough and are not treated chemically or burnt.

Manual cutting of bush using a hand-held power tool.

How to apply

With a spade and a bush pick or axe, a worker can dig out a large Acacia mellifera bush in about 15 minutes by cutting its roots off 10-20 cm under the ground. The remaining rootstock has no "eyes" (active auxiliary buds) left and does not coppice. The speed of operations depends on the size of the bush and the sandiness of the soil. A good worker can control all large bushes on one hectare in 1-2 weeks while smaller bushes can be controlled in half the time.

In soft and/or wet soil, it is possible to pull out smaller bushes, exactly the size that is usually the problem in bush-encroached rangeland, roots-and-all using a leveraged gripper like the "Exit Tree Popper". Soil disturbance is negligible, output and costs are low and selectivity high. Thorny fines should be spread to counter soil erosion or protect grasses.

Costs

The disadvantage of this type of manual control is that it is very labour intensive and time consuming. To speed up manual bush control, many land users prefer to simply chop off the bush. The output increases tremendously (to 0.05-0.2 ha/worker/day), bringing unit costs down to N$1,000-3,000/ha. The costs below calculate only the felling process and not the further processing of the wood for value addition.

Ha/day/pp	0.05 – 0.2
Costs NAD/ha	1,000 – 3,000

Semi-mechanised

Semi-mechanised methods are becoming more popular by the day as they make the back breaking work of manual bush control much easier, faster and cheaper by shrinking unit cost due to improved productivity.

How it works

In an effort to retain the advantages of manual bush control (ease of implementation, high selectivity, low investment costs) but address its disadvantages (low output, hard work, medium to high operational costs), land users are increasingly outfitting their workers with hand-held power tools. Also with these methods a cut stump remains behind that may coppice unless killed off chemically or burnt.

Hand-operated saw-mobiles are useful against thorny encroacher bush as they keep the operator out of harm's way.

How to apply

One specific farmer had nearly only emerging bush saplings on his land; his rangeland was in the transitional stage from grassy to woody. Seeing his woody plants were nearly all thin-stemmed, soft-wooded individuals, he razed them with a Weed eater-like appliance with a solid blade rather than a string. Obviously, such a weak tool will only be effective against this particular group of very young woody plants.

Hand-held power tools are inappropriate for thorny bushes as the saw operator is too exposed to the thorns of the bush. Various patents of mobile, hand-propelled remote saws powered by small, mounted engines (so-called "saw-mobiles" or trolley saws) can be pushed underneath a bush to keep the operator away from thorns. These hand-propelled mobile saws come with horizontal or vertical saw blades for ease of use under all conditions and can often be made at home.

All semi-mechanised methods of bush control expose the machine operator to extreme danger. It is essential that machine operators receive thorough training in the safe operation of their machines. Operators should also be equipped with adequate personal protective equipment which should include ear muffins.

Costs

Productivity increases to about 3 to 5 times compared to the manual method. The table below calculate only the felling process and not the further processing of the wood for value addition.

Ha/day	3
Costs NAD/ha	1,500 – 2,000

The rate of bush control using these methods is very slow, and mainly done to produce charcoal and firewood and products such as poles.

2.2 Mechanical

The mechanical control of encroacher bush is achieved with self-propelled machines equipped with various appliances that vary in size from small, wheeled tractors (e.g. the "Bosvark") to heavy, track-mounted bulldozers designed to move earth (e.g. a "D6"). Selectivity of control and costs vary with the size of the machine. Small machines can generally extract encroacher bush much more selectively than larger machines, although some large extractors also handle every bush individually and are thus highly selective. Selectivity also depends on the level of alertness and skill of the machine operator.

Costs

Operating costs are linked to machine size, operator, maintenance etc. Most heavy equipment has to be operated by specialists and skilled operators. This tends to add to cost. Generally, mechanised bush control is just as expensive as chemical control. Operating costs increase with the fuel price and have recently come down noticeably thanks to the decline in commodity prices.

Depending on bush density, workers can control bush in an area from 0.5 – up to 4 ha with a mechanised cutting machine. Costs range from N$750-4,000/ha. In some instances, a large portion of the felling costs are offset by the subsequent value addition to the wood by selling the biomass.

Ha/day	0.5 – 4
Costs NAD/ha	750 – 4,000

How to apply

Bulldozers

A bulldozer can clear large areas (up to 5-8 ha/day) depending on bush density and the degree of selectivity. At 4 m wide, a bulldozer is not inherently selective but the huge machines are surprisingly manoeuvrable and can be steered around large non-target woody plants by a skilled and alert operator. Its blade is lifted slightly above ground level and the bush is then either flattened and broken off or, most often, pulled out of the soil, roots-and-all.

With this method, the topsoil is disturbed considerably. The tracks too cause considerable soil disturbance, noticeably more than by wheeled machines. When clearing, the ground is often left bare. Bare ground can easily lead to desertification. Clearing is suitable for the preparation of crop fields.

An example of the soil disturbance common to blade-equipped heavy machines employed against encroacher bush.

Heavy Saws, Clippers and Pullers

Wheel- and track-mounted heavy machines can be outfitted with saws, clippers and leveraged scoops to control encroacher bush. Since these tools are all designed to treat woody plants one-by-one, they are inherently selective, which is new and welcome.

They are comparable to bulldozers in cost as they often use a bulldozer base on which the specialised tool is mounted. However, "mini-heavies" have been designed which are easier to manoeuver and can reach difficult areas.

The wheeled "Bosvark" is purpose-built to control encroacher bush. It is fitted with a saw blade and protects the operator with a strong grid against falling tree parts. It is highly selective and can treat 3-5 ha/day depending on bush density and the desired selectivity. In contrast to track-mounted machines, its wheels and relatively small size cause very little soil disturbance. It is the ideal "mini-heavy" machine to control encroacher bush but its purchase price places it outside the realm of many land users.

A track-mounted behemoth with a highly flexible saw blade that can swing from vertical to horizontal has some of the Bosvark's advantages (selective and manoeuvrable) and most of the bulldozer's disadvantages (expensive to purchase and operate, tracks cause major soil disturbance). Therefore it is not a successful compromise and has not yet become popular in Namibia.

The newest development in heavy bush control machinery is a track-mounted tree clipper with several graspers and one basal cutting blade mounted on a long, front-end loader-type flexible arm. These machines are extremely expensive in purchase and operations and are only used in high-value applications of wood (e.g. making chips for industrial furnaces).
They cut woody plants at ground level and stack them in heaps and windrows, ready for collection by specialised machinery such as grinders which process the whole bush into high-value products such as wood chips. Tree clippers are extremely selective as every woody plant has to be grasped individually, which limits output to 2-4 ha/day depending on bush density.
Operators have to be highly skilled (not re-trained farm workers) as the control of the grasping arm is extremely complicated. While very effective, their specialist nature will probably prevent these machines from becoming common place on Namibian farms.

A much cheaper version of the tree clipper's long, front-end loader-type flexible arm is fitted with a scoop and can be mounted on the power-take-off of a tractor, to excavate rooted plants by pulling them up. It is the mechanised model of the tree popper discussed earlier. Even though relatively cheap and very selective, it is not in use much in Namibia, probably because its output (ha/hr) is low.

Heavy Rollers

Mechanised heavy rollers break bush off at the base (at ground level) due to their weight. The heavier, the more effective they are. Initial home-built models were a bit too light for the job at hand but were soon scaled up to heavyweight industrial machines with rollers of 4-6 tonnes in weight. The earlier models pulled the roller and thus subjected the tractor to a lot of wear and tear and the driver to whiplashing branches. The up-scaled, industrial model pushes the roller in front of the tractor, which requires relatively more power than rolling but is easier on man and machine.

In dense thickets, the heavyweight roller never touches the ground as it drives over a blanket of rolled encroacher bush, requiring adapted tyres with special chains to prevent tyre blow-out. The early model, though phased out by now, was largely home-built and cheap (about N$250/ha) while the up-scaled, industrial model can be rented from N$750/ha upwards, depending on bush density. It can treat 5-15 ha per day and is thus very efficient.

The stumps remaining in the ground can coppice if the bush was thin-stemmed and young and would have to be treated with chemicals to ensure they die off. Since the rollers are not as wide as a bulldozer blade, selectivity of which bush to roll is comparatively better. Heavy rollers work extremely well on sandy soil but stones and rocks can be a problem.

An early, largely home-built roller that proved too light to break large encroacher bush but is effective against smaller bush. The fact that the roller is pulled behind the tractor is a mechanical disadvantage.

A heavy industrial roller pushed ahead of the tractor is highly efficient and relatively selective.

Presentation of wood after heavy rolling. Note the minimal soil disturbance and stumps that may have to be treated chemically to die off.

A rolled thicket is an impressive sight: the rolled bush has been flattened and, unlike most other bush control methods, does not present a visual obstruction. The horizon is visible again, a sight long un-seen in many Namibian landscapes. Young, flexible bushes stand up again after rolling, leaving the treated veld with adequate live woody cover even if the driver treated the whole area. The thick wood of flattened bushes is presented nicely on the ground.

Even if the thick wood is removed in a subsequent operation for value addition, a lot of fragmented thorny fines will remain on the land, resulting from branches broken by the heavy roller, protecting the land against the elements like a wooden blanket. Impact of the heavy tractor and roller on the soil is minimal as they "float" on a layer of rolled wood that protects the topsoil from impact.

For least environmental harm, any mechanised thinning should create minimal disturbance to the soil, and should be able to select appropriate trees to be controlled, and avoid others that are desired.

2.3 Chemical Bush Control

Of all the bush control methods used in Namibia, it appears that chemical control is in most widespread use. A survey in 2014 amongst Namibia's commercial farmers found that two-thirds of those who control encroacher bush do so by chemical means, using arboricides. In general, controlling encroacher bush by chemical means is an effective method. However, it is applied much too often as a first step when it should really be an option of last resort. Incorrect use can cause more damage than good.

How it works

Chemicals used to kill woody plants such as encroacher bush are called "arboricides". They are a specific type of herbicide (chemicals that kill plants) designed specifically to kill woody plants (although they kill herbaceous plants too).

The four most common application routes of arboricides are

- to the soil,
- to the leaves and
- to the cut stem of woody plants.

ABOUT ARBORICIDES

An arboricide typically consists of one or more active ingredients that kill the plant and "adjuvants" that are added for other purposes than killing plants. Adjuvants could be soaps, stabilisers, colorants and similar chemicals. The most commonly-used arboricides appear to be non-toxic to larger mammals.

Arboricides kill all plants but are specifically effective against woody plants. Arboricides thus have to be applied selectively to kill targeted plants only. Arboricides are not supposed to have any residual effect, i.e. they don't kill woody plants for many years after application. The exception is when they are absorbed into the groundwater, where they can remain effective, it appears, for many years. The skeletons of bushes and trees remain standing for an unusually long time as arboricides kill off all micro-organisms needed for decay and decomposition of wood.

Limitations

Once treated correctly, chemically killed bush does not grow back. However, arboricides do not kill bush seeds. Bush seeds in the soil germinate rapidly when rainfall is favourable and establish within 2-3 years, potentially re-colonising the landscape soon after chemical bush control. Also, many small bushes below grass-emergent height survive chemical control. When the large bush is killed, the immature, small bushes rapidly grow up. As with other bush control methods, it is thus imperative to apply aftercare to treated areas to prevent their re-encroachment within a decade. This creates a practical problem to farmers whose exhausted financial means often do not allow the degree of aftercare that is required. It is thus not uncommon for farmers to not apply the required aftercare and then struggle with re-encroachment soon.

Costs

Compared to manual and semi-mechanised methods of bush control, arboricide application is expensive. The amount of arboricide that has to be used depends very much on bush density and soil properties. The cost of chemical application can be around N$ 920/ha if the bush densities are low or smaller bushes in sandy soils are treated. It can be as high as N$ 1,600/ha if densely encroached land in clay soils is treated, especially when Dichrostachys cinerea occurs.

Labour costs NAD/ha	500 – 2,000

How to use safely

Arboricide use has implications for human and environmental health.

Follow instructions

It is imperative with all chemicals to always read and follow the instructions of the manufacturer on the label. They spell out the basic handling, storage and safety requirements. Store safely. Avoid spills and accidental leakage.

Proper personal protective equipment, including water-resistant rubber gloves, a mouth mask and goggles protects the worker during foliar spraying of bushes, directing the spray downwards to ensure the safety of the operator.

Caution

The material safety data sheet (MSDS) of every active ingredient and every arboricide should be provided with the product or can be downloaded from the internet before use. While reliable, the problem with MSDS information is that chemical safety is usually determined by short-term experiments that do not consider long-term effects. In the Dordabis district for example, large riverine trees are dying off 15 years after upstream farms were treated intensively with arboricides from the air. This illustrates the extremely long residual effect of some of these substances in an arid environment.

Ensure safety of people

Personal protective equipment that prevents the chemicals from coming into contact with skin, eyes, mouth and nostrils is a basic requirement.

Mix carefully

Generally, it is safer not to mix different liquid arboricides unless it is stated expressly in the manufacturer's instructions that they are compatible. If they have to be mixed, it is always safer to add the smaller volume to the bigger volume. Mix in a place that is either far away from non-target vegetation or in the midst of a thicket to be treated anyway.

Protect water

Never wash spilled residues down a sewer system or clean and wash arboricide equipment near open bodies of water or boreholes. All arboricides are soluble in water and can be distributed to distant sites where they can cause unintended damage. Rather soak up the spill and discard absorptive material on a recognised waste dump site or burn it.

Wash equipment in buckets and discard the wash water in the midst of a bush thicket, or use it again the next day to dilute a concentrate solution. Be especially careful when washing vehicles that transported arboricides, applicators or equipment. Do not park the vehicle on a lawn or wash it under a favourite shade tree. This vegetation may be killed by traces of arboricide in the wash water.

Dispose responsibly

Dispose of empty arboricide containers by rinsing them several times with water. Add rinse water to the next spray mix and puncture and flatten the arboricide container so it is unusable. Follow the manufacturer's instructions on safe use and disposal meticulously.

Soil-applied Arboricides

Soil-applied arboricides are the most popular method of bush control in Namibia. They must be applied to the soil under bush canopies, near the stem. Once it rains, the active ingredient is leached out of the arboricide, enters the shallow soil moisture and is absorbed by bush roots. When the arboricide circulates through the bush it inhibits photosynthesis in the leaves which turn yellow and fall off. Soil-applied arboricides are best suited for first control of dense and monotypic infestations of encroacher bush.

Products

- Soil-applied arboricides used most often in Namibia contain the active ingredients "bromacil" or "tebuthiuron".
- These arboricides come by many different trade names such as "Hyvar", "Bushwhacker", "Brush-free" (containing bromacil), "Spike", "Graslan", "Grazer", "Limpopo", "Molopo" or "Reclaim" (containing tebuthiuron).
- They all have the concentration of active ingredients printed on the label, e.g. "tebuthiuron content 25 per cent". This means that 25 per cent of the arboricide consists of the active ingredient tebuthiuron and while 75 per cent consists of other chemicals that have other functions.

How to apply

Soil-applied arboricides come in three main formats.

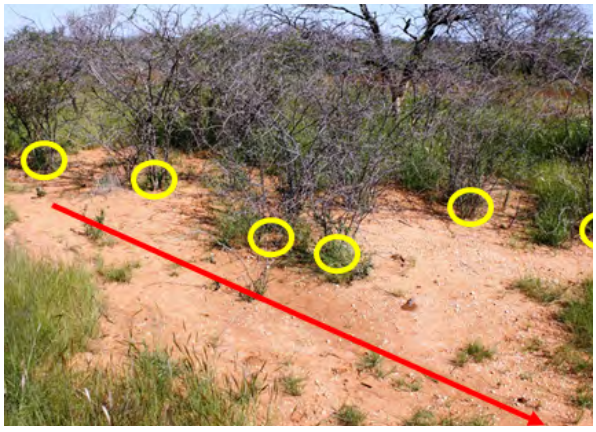
- They can be pelleted, in which case the recommended dose of pellets, e.g. one gram for every 1 m of bush height, must be strewn under the canopy of the targeted bush. Pelleted arboricides are often brightly coloured so it becomes easier to see where and how much has been applied.

- They come as a powder that must be mixed with water to form a solution,
- or as a soluble concentrate which must be diluted with water to the correct concentration. The diluted solution is then squirted with a hand-held applicator onto the soil below the bush or onto its stem at the recommended dose. Solutions to be sprayed onto the ground are often coloured bright pink, again making application easier.

A worker can treat 5-10 ha of land with pellets daily, or 3-10 ha if applying a solution. Soil-applied arboricides can be applied at any time of the year, even in the dry season, but they only become active once it rains. They should best be applied in the first half of the rainy season. However, if the first rains storms are violent, pellets get washed sideways quite easily. Pelleted arboricides should thus only be used on flat terrain where runoff water movement is not severe.

Although soil-applied arboricides have been tested to be non-toxic to humans, applicators should still protect themselves by wearing rubber gloves and long-sleeved shirts and boots to prevent contact with the skin. Applicators should follow the safety precautions on the label strictly.

Bright blue arboricide pellets are easily visible, applied under the canopy of a small bush and around its stems. However, the illustrated dose is too large for such a small bush and the danger exists that excess arboricide will be absorbed by roots of other woody plants growing in the vicinity and kill non-targeted individuals.



The encroacher Dichrostachys cinerea in the middle of the picture was targeted by arboricide pellets applied to the base of each bush (yellow ovals). However, pellets were overdosed and killed the tree right-of-centre, which was not targeted. The first rains of the season swept some pellets away from their area of application and they sterilised the soil, preventing grass growth (red arrow from back-left to front-right of picture).

Limitations and dangers

Soil-applied arboricides are formulated to bind to soil particles to prevent them being leached deeper into soil. This means that some active ingredient will remain behind in the soil for some time, causing a residual killing effect. Incidents are known from Namibian farms where soil-applied arboricides still kill non-target trees decades after the last application, indicating that the residual effect may be much longer than assumed in quality control tests and stated in MSDS.

It is best to use soil-applied arboricides only when faced with a very homogenous stand of encroacher bush. They are not suited for selective control in a botanically diverse setting or to control isolated bush patches and should never be used near open water or river courses.

Foliar- and Stem-applied Arboricides

Foliar-applied arboricides are applied on the leaves of plants. They are used to clear small areas selectively, e.g. along fences and power lines or patches of bush on the rangeland. Foliar-applied arboricides are not distributed in the soil or by groundwater. This makes foliar-applied arboricides much better to use in confined spaces or in bio-diverse settings

Stem-applied arboricides are used in combination with mechanical or manual control methods. Since it is applied in very small amounts to very small areas, it is one of the most selective and safe methods of chemical bush control, but as it is always part of a larger felling operation, this does not necessarily make the whole operation ecologically sensible.

Products

Foliar-applied arboricides come by various trade names such as "Plenum", "Browser", "Tordon" and "Access" (contain picloram), "Garlon", "Confront", "Ranger", "Triclon" and "Viroaxe" (contain triclopyr) and "Tordon Super" (contains both picloram and triclopyr).

These products are all concentrated solutions that have to be diluted with water to the recommended concentration of the spray mix. The concentration of active ingredients is printed on the label, e.g. picloram content 33 per cent. This means that 33 per cent of the arboricide consists of the active ingredient picloram while 67 per cent consists of other chemicals that have other functions than killing plants, e.g. they are soaps that dissolve the waxy layer of leaves, aiding penetration of the active ingredient into the leaf.

How to apply

Foliar-applied arboricides must be sprayed onto the leaves of the targeted bush to kill it, wetting at least 75 per cent of its leaves. It is absorbed through leaf stomata and circulates through the plant. Its active ingredients, most commonly "picloram" and "triclopyr" kill the plant by stimulating it to grow excessively, like a growth hormone, thus exhausting its carbohydrate reserves. It can only be applied when in summer woody plants are actively growing and have green leaves. Preferably, the targeted bush should be shorter than the human applicator so the spraying action is downwards and away from the body.

Limitations and dangers

Foliar-applied arboricides are not suited for the control of vast areas of bush thickets. The requirement that the human applicator has to be able to move freely around the targeted bush to spray it from all sides makes its use in a thicket highly impractical. Also, applicators tend to over-spray a bush until it drips because they cannot see the amount applied. It is thus always useful to mix the arboricide with a dye that makes it visible. The most common dye for this purpose is a blue dye available under various trade names such as "Eco-Dye Blue" and "Vulcano Blue".

A dye mixed into the arboricide spray makes it easier to see where and how much spray was applied. The blue coloration remains visible for some weeks, enabling supervisors to inspect work efficiency for some time after the work was completed.

No withdrawal period is specified for most foliar-applied arboricides and they are not toxic to larger mammals. It appears safe to allow livestock animals to utilise recently treated plants, although it is always best to wait for a month after treatment.

Foliar-applied arboricides are also absorbed through the stem of a woody plant. This makes them suitable to treat cut stems to kill the rootstock of felled bush, i.e. to be used as stem-applied arboricides. If bushes are felled manually or mechanically and the rootstock is not killed, it can re-grow (coppice) and soon, coppicing bush will again encroach. Treating cut stems with an arboricide prevents this.

➔ For least environmental harm, any mechanised thinning should create minimal disturbance to the soil, and should be able to select appropriate trees to be controlled, and avoid others that are desired.

2.4 Biological Methods

Biological bush control methods are often ineffective against the ultra-high bush densities observed currently in Namibia and although preferred, are more appropriately used as aftercare rather than first-line control.

Biological bush control happens when encroacher bush is killed by natural factors.
The most important biological control agents of bush in Namibia are:

- Fire, often managed and
- Fungal attack, which happens without human interference.
- Drought and water-logging are other biological control agents that can kill encroacher bushes, especially while immature.
- Intense browsing pressure by animals used to be an effective control mechanism in the past, but is no longer effective in modern times.

Of all bush control mechanisms, biological control requires the least human intervention. Despite seeming to involve whole landscapes covering thousands of hectares, biological control agents never affect all areas equally and do not homogenise the landscape. A fire for example always burns some areas more intensely than others and some not at all.

Planned Fire
Planned fires should not be used to control existing mature bush but rather to kill woody seedlings and saplings while they are still fire-tender. The best use of planned fires is for aftercare.

How it works
In pristine ecosystems, naturally ignited fire in the late dry season is most important to maintain savannas in a grassy state. These fires are "hot" as they burn the accumulated fuel of a complete growing season at a time when it is dried-out. Furthermore, late in the dry season bush buds are sprouting which makes them more vulnerable to fire.

Stem-burning or stump-burning is a fire control method that burns individual encroacher bushes off one-by-one by making a localised fire at the base of every stem. This is a cheap method and well applicable in communal areas or by small-scale farmers.

Limitations

An early dry season fire has less accumulated dry fuel available and thus burns much "cooler" than a late dry season fire. This late dry season fire has much more dry grass, for example, available to burn under thus burns "hotter". Hot fires effectively protect trees and are preferred from a forest management perspective.

A fierce fire may kill widely spaced mature encroacher bush outright but it is ineffective against bush thickets and merely singes it around the edges. A bush thicket does not have the dry plant matter needed to carry the fire into the thicket and kill the bush.

How to apply

Natural hot fires can be imitated:

- A dry herbaceous fuel load of at least 2 tons per hectare is required.
- Man-made infrastructure (e.g. fences and pipelines) has to be protected.
- Livestock and wild animals have to be evacuated from the targeted area and provided with alternative forage for the period that the burned area will be without adequate re-growth.

Any planned burn to counter bush encroachment must be coordinated with the Directorate of Forestry (DoF), which ensures that the planned burn meets all regulations of the DoF fire policy and can assist with fire control. Coordination with farming communities and neighbours is also important. Farmers can be held responsible for fire damage on other farms if the fire gets out of control.

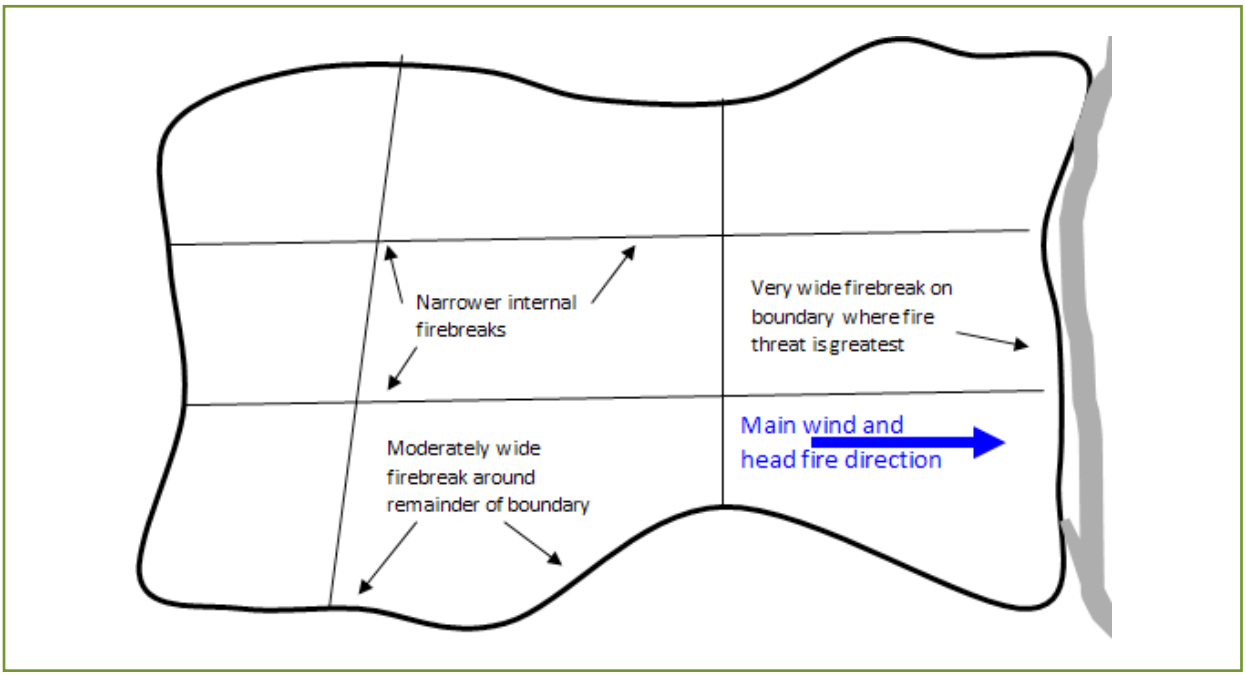


Figure 1: **The area targeted to be burned is surrounded by firebreaks used to light counter (back-) fires that control the main (head) fire. Sometimes, internal fire breaks are constructed as well for emergency fire control.**

The targeted area must be surrounded by fire breaks or by using natural features (e.g. river courses and mountain ranges) to restrict the burn to certain areas.

- Fierce fires burning with the wind easily jump 50 metres wide fire breaks as exploding wood particles and airborne sparks are driven over the fire break by the wind.
- The purpose of the fire breaks is to light "backfires" that burn against the wind and head towards the main fire. When these two fires meet, they extinguish each other as all fuel in all directions has been consumed. Backfires that control head fires on the front and sides have to be lit well before the main fire so they can clear an appropriately large area of fuel before the arrival of the main fire.

A fire break (in this case, a mere footpath) is used to light a back fire that burns slowly against the wind (easy to control) and in the direction of the main (head) fire to come, to contain the main fire by burning away fuel around and in front of it. The actual fire break itself would never stop the main fire. Lighting backfires early in the morning when the grass sward is still dew-laden makes it even easier to control as it will burn very slowly and gently

Costs

While the planned fire itself is cheap, limiting the burn to the targeted area may be quite costly. The greatest cost factors are the fire beaters who steer and direct fire and the firefighting equipment. Such costs are hard to come by but are probably around N$100/hectare. The initial procurement of firefighting equipment is expensive but as it is used against many fires over many years, its unit cost over time is quite low. If the planned fire burns out of control, the damage can be extremely expensive.

Wood Fungi

How it works

Fungi like Phoma glomerata have several hosts (including some crop plants) and badly spoil structural plant fibres, causing natural die-off. In Acacia mellifera, they attack the red heartwood so that it rots away and leaves a hollow core in the middle of the tree stem. Fungi are moisture-dependent and only active during the rains. The spores of Phoma are found all over the Namibian environment and can survive long inhospitable periods, awakening when conditions are conducive.

As fungi are only active in wet conditions, heartwood rot takes place while the mature bush appears to be flourishing, but it is actually damaged mortally. The next environmental stressor, e.g. a drought, kills the bush.

Limitations

Unfortunately, no-one has yet managed to collect and distribute spores to control encroacher bush by natural die-off. We are dependent on nature and as a result, this natural control mechanism is currently not part of our bush control toolbox.

Browsing Pressure

How it works

In a pristine savanna, browsing animals are a critical driver of bush control. Small animals (e.g. weevils, mice and birds) damage seeds of woody plants while larger animals consume the bark (e.g. porcupine) and leaves (e.g. browsing ungulate game animals), thus limiting the growth and distribution of woody plants and preventing landscape-level encroachment.

Limitations

Today, foraging pressure is exerted mainly by grazing domestic livestock. Once bush thickets have established, browsing appears ineffective. Trials at Omatjenne Research Station with domestic goats have shown that the browsing intensity required to significantly damage established bush thickets is so ultra-high that all the more palatable fodder bush species are completely wiped out, i.e. the outcome is not worth the damage.

Only mega-browsers like elephant could possibly damage an established bush thicket. However, it is not possible to farm with wild elephants roaming the grazing area. Browsing pressure is best used as aftercare method.

Domestic and wild browsing animals do utilise encroacher bush but not sufficiently intense to prevent bush encroachment

For further information on:

- Felling, chipping and grinding equipments: Compendium of Harvesting Technologies for Encroacher Bush
  http://www.dasnamibia.org/download/brochures/Brochure_Debushing_Harvesting-Technologies-2015.pdf
- Harvesters and economic factors: Namibia Biomass Industry Group
  http://www.n-big.org/

3 Aftercare: How to Control Re-encroachment

Aftercare is what happens after initial bush control to keep the rangeland in a productive state and prevent re-encroachment, as explained in this chapter, it is an essential component of comprehensive bush control but is, unfortunately, often overlooked. Aftercare keeps the rangeland in a productive state and prevents re-encroachment. There is a limited choice of aftercare methods, being biological and manual.

3.1 Importance of Aftercare

Nature's response to bush control is to compensate by growing more woody replacements. This is seen as re-encroachment. The time it takes for bush-controlled land to require follow-up is highly variable. It depends on the bush control method used and natural circumstances such as soil fertility and climate.

The land manager has to monitor the growth of coppicing bushes and the emergence of woody seedlings to decide when aftercare is required. Fortunately, it is easy to see when aftercare has to be applied:

Situation 1: cut stumps coppicing
Harvested woody plants were not killed and their cut stumps are coppicing again. Coppicing occurs quickly after bush thinning. This situation can be monitored by casual observation while inspecting the grazing area.

Dozens of Acacia mellifera seedlings emerging per square meter. If this event is picked up by regular monitoring, the land manager knows to intervene soon to prevent full-scale bush encroachment

Situation 2: seeds of woody plants germinate

If re-encroachment occurs mainly via establishing bush seedlings, it may take much longer before aftercare becomes essential. The emergence of woody seedlings is best monitored by fixing a site within a former bush thicket that was thinned or cleared. The site can be situated at a landmark or marked with metal poles driven into the ground. Every year in the late dry season, when most grass has been removed and small woody seedlings are most easily visible, the site has to be inspected. If seedlings are emerging, aftercare has to follow within a couple of years, before seedlings grow higher than grass.

Aftercare must be part of the farm Management Plan of any bush harvesting operations to keep the rangeland in a productive state and prevent re-encroachment.

3.2 Aftercare Methods

In all cases of aftercare, it is small, immature woody plants (mainly low coppice growth and saplings) that have to be removed unselectively to return the rangeland to the bush density achieved after first control. In the interest of the environment, it would be best to practice selective aftercare with chemicals to control these small woody plants so that the footprint of the land manager can be minimised.

In exceptional cases the land manager is interested in sustainable harvesting of woody plants. Aftercare for woody re-growth would allow a larger number of woody saplings or cut stems to survive, but at a lesser density and well-spaced out so that they can grow out quickly into large bush with thick wood suitable for further processing. This is achievable with highly selective manual aftercare. The other aftercare methods, browsing and fire can be relatively unselective and destroy more young woody plants than desirable for sustainable harvesting.

Biological aftercare

Browsers

The most profitable way is to have the sprouting and emerging bush eaten down by browsing animals. Young and small woody plants are entirely within the reach of goats and are very palatable and nutritious and thus much sought after. Most thorns are not yet hard so that small woody plants are relatively easy to harvest. Goats and other browsing animals are specially equipped to deal with physical and chemical plant defences (e.g. thorns and tannins, respectively). A split upper lip enables goats to grasp small leaves in-amongst the thorns while their saliva and liver contains tannin-neutralising substances that prevents a protein deficiency being induced.

Keeping a large goat flock on the bush-controlled land will take care of most re-growth. While containing woody re-growth, goats earn money by producing quality meat. Even though goats are hardy, goat farming is a relatively specialised enterprise and needs to be well prepared for in terms of predator control, kraaling and fencing requirements. Depending on the browsing pressure, the goats would have to stay on the land for years to continually control woody re-growth.

Fire

More difficult than goats, it is burning the bush-controlled rangeland to kill off immature, small woody plants and soft-coated seeds in the soil seed bank. The planned fire does not need to burn as fiercely as required to contain mature bush. An aftercare fire requires only 1.5 tons dry herbaceous matter per hectare as immature bush is more fire-prone than mature bush. However, the other requirements of planned burning discussed earlier apply to aftercare fires as well. Compared to goat browsing, the advantage of a planned fire is that woody seed and small bush is killed completely. Woody re-growth is thus impeded for a considerable period of time, relieving pressure on the land manager.

➔ For least environmental harm, any mechanised thinning should create minimal disturbance to the soil, and should be able to select appropriate trees to be controlled, and avoid others that are desired.

Manual aftercare

Small bush and saplings are very easily removed by chopping them off about 10 cm below ground level, thus killing the whole plant. This aftercare method is quick and easy even on hard ground because the targeted woody plants are small. However, it is very difficult to control coppicing cut stems in this manner so that the method is less appropriate for situations were woody re-growth is caused by coppicing stems. One worker alone can apply manual aftercare to a large area (several hectares) each day, depending of course on the density of emerging woody plants. The biggest drawback of manual control is that some saplings may be overlooked.

3.3 What Comes after Aftercare?

In most cases in Namibia, bush encroachment is caused by inappropriate land use and unsustainable rangeland management. Controlling encroacher bush treats the symptoms of the problem, not its cause. To address its cause and prevent bush encroachment recurring, land management practices need to be changed.

Sustainable rangeland management

Namibia's National Rangeland Management Policy (2012) is a farmer driven policy. It works with "principles of sound rangeland management" rather than with rules and regulations. These principles find their origin in "Holistic Rangeland Management" which recognizes ecosystem health as a core of rangeland management. The implementation of the policy is organized through farmers' unions and farmers' associations.

Implementing the policy's eight principles of sustainable rangeland management will enable the land user to utilise rangeland sustainably and avoid the danger of man-made bush encroachment. It can still happen due to natural drivers, but it will be much less frequent and probably more manageable. The eight principles are:

1. **Know the resource base:** Know the perennial species of grass that naturally dominate in your area; ensure their continued vigour and abundance. This also requires knowledge of

soil, nutrient hotspots and general rangeland ecology. Know the bush, its density and impact.

2. **Manage grasses for effective recovery and rest:** Perennial and preferred species of grass are usually grazed first and most intensively. They need to recover from previous grazing completely before being grazed again.
3. **Manage for effective utilisation of grasses and shrubs:** Grazing domestic livestock like cattle and some sheep breeds do not browse much. The browse components of a savanna rangeland are not often over-utilised; browser based livestock enterprises are encouraged. In contrast, the herbaceous (grassy) component usually is over-utilised. Grazing should stimulate grass production and not inhibit it.
4. **Enhance soil condition:** For grasses to flourish, the top layer of soil has to be in good condition, allowing rainwater to infiltrate easily (proper water cycle) and binding plant nutrients so they do not leach out (proper mineral cycle). This is achieved mainly by always keeping the soil well covered with living plants or mulched with dead plant matter to prevent soil erosion by wind or water.
5. **Control bush encroachment:** … as discussed in this manual.
6. **Plan for droughts** by timeous reduction of the livestock stocking rate in synchrony with the advancing fodder deficit and by growing more fodder to compile a fodder bank to be used during a drought.
7. **Monitor the resource base** by keeping a variety of records of the veld that inform rangeland management. The establishment of woody seedlings is an important indicator: The grassy-state savanna can be in transition to the bushy state unless management intervenes.
8. **Plan land use infrastructure** to make sustainable rangeland management easier, e.g. by providing enough camps per herd of livestock to facilitate rotational grazing management.

A look at the land after bush control

A diverse landscape

The treated landscape should not appear homogenous. After bush control, there should be thicker patches of bush (mostly on more fertile soil, near seasonally-wet depressions, south-facing hill slopes, etc.) and thinner patches (on infertile soils and in exposed, hot, windy locations such as plains and north-facing hill slopes).

You should have a mix of tree and bush species and an adequate number of large trees that suppress woody saplings by competitive suppression.
Leave the occasional bush clump of 1 to 4 hectares for the sake of providing shelter for those animals who seek it in denser clumps.

Minimal soil erosion

Bush control on steep slopes should be done extremely cautiously to avoid soil erosion.

Leave woody fines on the land to improve soil organic matter, moisture and nutrient levels and reduce erodibility.

Rich grass

Where grass growth was stunted by dense bush, a "grass explosion" can occur after bush control.

Such an explosion tapers off after about 7 years because the grasses have depleted the residual soil fertility left when encroacher bushes were removed. The level at which grass production stabilises depends on the number of bush left intact, as woody plants improve soil fertility. It also depends on the abundance and vigour of perennial grasses in the post-bush grass sward: the more perennial grasses managed to establish in bush-controlled veld, the more stable its long-term grass yield.

Bush thinning alone does not alter the botanical composition of the grass sward. Too often, only those ephemeral, opportunistic grass and weed species that managed to survive bush encroachment are the only herbaceous species left. They flourish but form an unstable layer with too few nutrients to maintain grazing animals throughout the year. Long-lost perennial grass species have to be introduced artificially to improve the grass sward permanently. Only then will the post-bush grass yield stabilise at a relatively high level, offer more acceptable nutrition to grazing animals (i.e. reduce the need for nutrient-dense licks) and contribute to a better spatial distribution of grazing animals.

If the grass sward on the treated land is very poor, it may be advisable to initially leave more bush than desired to ensure an adequate feed supply to the animals and only thin it to the ultimate density once the grass sward has recovered.

Useful contacts and websites

CONTACT	VALUE/FUNCTION
De-bushing Advisory Service Namibia http://www.dasnamibia.org	"a national information sharing and capacity building platform for providing advice to farmers on sustainable bush control and value addition opportunities". The website has a number of downloadable documents, videos, and other information media, relevant to decision making regarding bush encroachment. For suppliers of equipment, refer to the Directory at the back of "Harvesting Namibian Encroacher Bush".
Namibia Biomass Industry Group (N-BiG) http://www.n-big.org	Information gathering and sharing related to value addition from encroaching bush; supporting members to enter markets; workshops. There are interesting and informative videos on the topic of bush utilisation.
Namibia Charcoal Association (NCA) http://www.ncanamibia.com	"a non-profit voluntary membership Association created to serve the charcoal industry in Namibia from producers and processors to suppliers and all other stakeholders"..... "... provide professional support to charcoal stakeholders with respect to the implementation of environmental and social standards, quality assurance, market identification, modernisation of production, advocacy and public communication". Aims to strengthen the charcoal industry in a sustainable manner.
MAWF Directorate of Forestry http://www.mawf.gov.na/forestry-services	Issues permits for harvesting, transporting, and exporting and marketing of forest resources, including from bush encroached savannas. Website includes downloads for applicants, explanation of requirements, various reports and articles of relevance to bush harvesting. Forest Act (2001).
MET (Ministry of Environment and Tourism, Directorate of Environmental Affairs). http://www.met.gov.na/about-met/environmental-affairs/273	Issuance of Environmental Clearance Certificated.
Namibia National Farmers Union (NNFU) http://www.nnfu.org.na	"....a mouthpiece for Namibian communal and emerging farmers". Aims to improve food production in these systems

Key definitions

Adjuvants
Soaps, stabilisers, colorants and similar chemicals that are added to arboricides for other purposes than killing plants.

Alkaloids
A group of naturally occurring chemical compounds that act in humans and other animals. Most of them have a bitter taste.

Animals
Foraging animals search for food.
Ruminants ferment plant-based food in a specialized stomach prior to digestion such as cattle, goats, sheep, giraffes, antelope.
Ungulate browsers: diverse group of primarily large mammals that includes odd-toed ungulates such as horses and rhinoceroses, and even-toed ungulates such as cattle, giraffes, hippopotami.
Lagomorphs (rabbits and hares) eat plants. Rodents (mice, rats, porcupines) will eat both meat and plants.

Aquifer
An underground layer of water-bearing rock, gravel, sand, or silt.

Arboricides
Chemicals used to kill woody plants such as encroacher bush. They are a specific type of herbicide (chemicals that kill plants) designed specifically to kill woody plants (although they kill herbaceous plants too).

Biodiversity
Refers to the variety of organisms in ecosystems. Biodiverse ecosystems can better withstand and recover from destructive events.

Bush control
This manual assumes that the most common objective will be to restore rangeland to a grassy state that enables optimum livestock production. Bush is an integral part of Namibian rangelands and controlling it implies its careful thinning and not clear-cutting or eradication. Bush control involves preventative measures (e.g. sustainable land management), active rehabilitation measures (e.g. bush thinning through harvesting of a defined number of bushes per hectare) and follow-up measures (i.e.aftercare).

Bush thinning
Thinning refers to the selective harvesting of bush.

Bush equivalent (BE)
A "bush equivalent" (BE) is a standardised, 1.5 m high bush.

Coppice
New growth from the stump or roots after the plant has been cut down.

Deciduous
Trees or shrubs that lose their leaves seasonally.

Desertification
Land degradation in which a relatively dry area of land becomes increasingly arid, typically losing its bodies of water as well as vegetation and wildlife.

Dystrophic
High concentrations of dead organic matter and organic acids

Erosion
Soil, rock, or dissolved material is removed mainly by water or wind.

Ephemeral herbs
Grow only for a short time, then disappear.

Grasses
Grass sward: a top ground layer containing a mat of grass and grass roots.
Perennial grass: A perennial is a plant that lives for more than two years.
Climax and pioneer grass: Bare soil is colonised by grass species in succession (after another). Pioneer species have a short life (annuals). At the next stage more stable, longer-living sub-climax grass species grow. The final stage is reached when the climax grasses that are usually palatable and nutritious replace the weed-like pioneers.

Isohyet
Line on a map of equal rainfall in a certain period of time.

Legume / leguminous
A plant or its fruit or seed in pods and containing root nodule bacteria for fixing nitrogen in the soil. Well-known legumes are alfalfa, clover, peas, beans, lentils. Most legumes fix nitrogen in the soil.

Microphyll
A microphyll is a type of plant leaf with one single, unbranched leaf vein.

Palatable
Tasty

Tap root / lateral root system
There are two main types of roots. Tap roots grow deep and enable the plant to anchor better in the soil and obtain water from deeper sources. Lateral or fibrous roots extend to the side. They are more vulnerable to drought but quick to absorb surface water.

Summary of main encroacher plant species in Namibia

It is not yet well-understood what causes a certain species to become dominant in a certain area. However, the preferences and characteristics of the main encroacher species can easily be observed in the field. The table below provides an overview of some of the bush species considered to be problematic in Namibia.

For a detailed botanical description of encroacher woody species, the reader is referred to regular field guides or botanical handbooks such as Le Roux and Müller's Field Guide to the Trees and Shrubs of Namibia, 2009.

SPECIES	PROPERTIES	VALUE / USAGES	CONTROL METHODS
Acacia mellifera (Senegalia mellifera) Black Thorn, Swarthaak, Omukono, Omusaona 	• Medium height, usually 5-7 metres tall, compact form and a flattish or rounded crown. • One of the first trees to come into flower, producing small 'powder puff' balls in white, cream or pinkish. • Deciduous, very thorny, hooked thorns are black. • Flat, papery bean pods. • Prefers fertile soil. • Large trees suppress the growth of young trees near their canopy.	• Wood has high calorific value, larger specimens make excellent charcoal. • Pods of are not fleshy but still palatable and well eaten by animals. • Small leaves are highly nutritious for animals but difficult to harvest.	• Most easily controlled by felling but coppices readily, especially the thinner stems. • Can be dug out if the soil is sandy. • Can be controlled by burning as long as it is small. • Is easily killed by / very susceptible to arboricides.

SPECIES	PROPERTIES	VALUE / USAGES	CONTROL METHODS
Dichrostachys cinerea Sickle Bush, Sekelbos, Ongete, Omutjete 	• Mainly in central, northern and north-eastern Namibia. • Forms dense, impenetrable stands of up to 12,000 plants/ha. • Usually a multi-stemmed small tree, tangled appearance. • Leaves have very fine leaflets. • Curly seed pods in tight bunches. • Hard-coated seeds are not destroyed by digestion and are spread by animals. • Plant also grows easily from root suckers.	• Makes excellent charcoal. • Good for fence droppers as it is resistant to termites. • Pods are very palatable and eagerly eaten by livestock.	• Completely ineffective to control by felling, digging out or burning, as this stimulates vegetative growth. • Germination is stimulated by increased light intensity; seeds are more likely to germinate when the thicket is cut. • Best controlled by chemical means. • Often requires more than one treatment. • Most arboricides have to be applied at double the usual concentration as it is more tolerant of plant poisons than Acacias.
Acacia reficiens (Vachellia reficiens) Red thorn,Rooihaak, Omutsiyatsi, Omugondo *Acacia luederitzii (Vachellia luederitzii)* Kalahari Acacia, Baster haak-en-steek,Omushu 	• Life cycle and properties similar to A. mellifera. • Thorns in pairs, hooked or straight. • Leaves, flowers, barks and branches are browsed by a variety of animals.	• Very good for animal food. • Wood is relatively soft.	• React like Senegalia mellifera (Acacia mellifera) to control methods. • Are easily controlled by digging out the root stump. • The species are very susceptible to arboricides.

SPECIES	PROPERTIES	VALUE / USAGES	CONTROL METHODS
Colophospermum mopane Mopane, Mopani, Omusati, Omutati 	• Grows in the north-west and north-east but not in the Kavango region. • Protected species that encroaches in disturbed areas.	• Leaves are main feed source of caterpillars which are a delicacy for local people. • Wood is exceptionally hard with a high calorific value, is used in construction and	• Single-stemmed tree. • Coppices when felled. • Best controlled by chemical or mechanical means as manual control can easily result in re-growth.
Terminalia sericea Silver Cluster-leaf, Sandgeelhout, Omugolo, Omusejasetu 	• Single-stemmed tree (not a bush) grows only in the North East. • Limited to dystrophic (less fertile) sandy soil. • Limited distribution makes it an encroacher species of lesser importance.	• Straight poles for fencing. • Wood is said to be termite-resistant. • Very good for animal fodder.	• Tree does not coppice readily and is easily controlled manually or mechanically.

SPECIES	PROPERTIES	VALUE / USAGES	CONTROL METHODS
Rhigozum trichotomum Three-Thorn, Driedoring, Okatakambindu 	• Limited distribution but main encroacher in southern Namibia. • Hardly ever grows taller than 2 metres.	• Stems are thin (3 cm in diameter), wood not profitable to harvest. • Flowers are very palatable but leaves offer little feed to small ruminants.	• Grows from a creeping root-stock so manual and mechanical control is generally ineffective. • Digging-out only effective in spring, when plant's reserves are low. • Chemical control is most effective for this species.
Acacia erubescens (Senegalia erubescens) Yellow-Bark Acacia, Withaak, Omungongomwi, Omugumba 	• Dominant encroacher species in western Namibia. • Has a whitish-yellowish appearance. • Has a flaking, papery bark. • Seeds are soft-coated, life cycle and properties are similar to A. mellifera.	• Nutritive value of leaves is high but is extremely thorny and difficult to browse. • Makes good charcoal. • Makes fence droppers although the wood is not insect resistant.	• Coppices when felled. • Easily controlled by digging out the root stump. • Very susceptible to poisoning. • Easily killed by fire when still small.

List of common protected plant species in Namibia

Protected species are those that have been extensive over-utilised and/or have high ecological value as listed in Forest Act, 2001 (Act no.12 of 2001) and Forest Regulation 2015.

These species should not be harvested as part of bush thinning initiatives. For a complete list of all protected plant species, please refer to the Forest Act.

SPECIES	PROPERTIES	VALUE / USAGES	CONTROL METHODS
Peltophorum Africanum African wattle, Huilboom, ,Omupalala Omuparara 	• Commonly found in bushveld often in sandy soils. • Small to medium sized tree with a dense crown. • Young shoots densely covered with fine, rusty brown hair. • Have feathery leaves and yellow petals. • Pods are flat, winged, with fine velvety hair.	• Leaves are browsed by game. • Bark and roots are used for medicinal purposes. • Wood is suitable for carving. • Several butterflies breed on the tree, sap-sucking insects known as spittle bugs occur in large number on the branches during certain times of the year.	• Protected species that should not be controlled. • Hardly ever densifies and if, only very small areas (<100m^2) are affected.

SPECIES	PROPERTIES	VALUE / USAGES	CONTROL METHODS
Philenoptera nelsii Kalahari Apple leaf, Apelblaar, Omupanda,Omupanda 	• Commonly found in hot dry bushveld often on deep sand. • Small to medium-sized tree with yellow autumn colours. • Has a yellow bark. • Has large, dark green, leathery leaves, velvet when young and less hairy with age.	• Both leaves and seeds are very palatable, it is a prime fodder tree. • Wood is very tough and flexible, was used for making ox-wagon wheels .	• Protected species that should not be controlled. • May densifies in overgrazed rangeland but affects small areas (<1 ha) • "Thickets" easily
Acacia erioloba Camelthorn, Kameelboom, Omuthiya, Omumbonde 	• Commonly found in bushveld and grassland and usually on deep sandy soil or long water-courses in arid areas. • Has a medium or large-shaped crown. • Has golden-yellow flowers scattered along the branches. • Have velvet grey, large, thick and semi-woody pods.	• Pods are eaten by stock and game and can be collected and sold. • Wood is very strong and durable.	• Often scattered amongst encroacher bush and should remain standing. • Densifies in north-eastern Namibia in response to over-grazing or felling of old (huge) specimen. • Control should only be in consultation with Forestry Directorate. • Very susceptible to arbori-cides.

SPECIES	PROPERTIES	VALUE / USAGES	CONTROL METHODS
Boscia albitrunca Shepards tree, Witgatboom,Omunkuzi, Omungwindi 	• Commonly found in semi-desert area and bushvelds. • Small tree with a rounded, much-branched crown. • Evergreen with pale grey stems. • Bark is smooth, grey to whitish. • Leaves stiff and leathery. • Flowers in dense clusters on short lateral shoots and small, yellowish green without petal. • Hairless, yellowish berries, about 10mm in diameter.	• Heavily browsed by game and livestock; valuable fodder for livestock in times of drought. • Roots are edible (pounded and made into porridge or roasted and used as a substitute for coffee or chicory). • Leaves and roots are used as medicine.	• Often scattered amongst encroacher bush and should remain standing. • Protected species that should not be controlled. • Does not densify. • Tolerant to arboricides.
Commiphora Corkwood/Kanniedood 	• Multi-stemmed shrubs or trees with stems branching repeatedly at ground level, or trees with a single upright stem, often spiny, with smooth or papery bark. • Species from arid areas often have a swollen, nearly succulent trunk. • Leaves vary between simple and compound. • Has small white flowers. • Deciduous and for most of the year without leaves. • Bark of most species peels off in papery pieces and flakes, often with a greenish layer underneath.	• Historical and biblical association as providers of the earliest healing balms and fragrances.	• May densify in north-west in response to overgrazing. • Small specimen easily destroyed manually.

SPECIES	PROPERTIES	VALUE / USAGES	CONTROL METHODS
Burkea Africana Wild seringa, Sandesering, Omutundungu 	• Sandy soils in dry deciduous bushveld and woodlands; widely distributed in tropical Africa and in sub-tropical regions southwards to Namibia. • Medium-sized, spreading, flat-topped tree up to 8 m high, deciduous. • Silvery leaves 100–350 mm long; leaflets oval and silvery when they are young and marked with brown spots. • Flowers are creamy white and fragrant.	• Bark is toxic, rich in alkaloids and tannins and used for tanning leather.	• Protected species that should not be controlled. • Does not densify. • Valuable timber tree species.
Albizia anthelmintica Worm Cure Albiza, Aroeboom, Omupopo, Omuama 	• Thorny/spiny, deciduous, multi-stemmed, medium canopied tree, about 8m high. • Smooth, gray to brown bark. • Flowers usually on leafless twigs. • Straw coloured, papery, pointed pods. • Seeds are round and flattened.	• common medicinal use for deworming	• Protected species that should not be controlled. • Densifies in response to overgrazing but limited by slow growth and high palatability. • Very susceptible to arboricides.

SPECIES	PROPERTIES	VALUE / USAGES	CONTROL METHODS
Combretum imberbe Leadwood, Hardekool, Omukuku, Omumborombonga 	• Almost white trunk and gigantic main branches. • Medium to large, semi-deciduous tree, up to 20 m high. • Extremely slow growing. • Snake skin type of bark. • Yellowish cream-coloured flowers with sweet fragrance.	• Wood has high calorific value.	• Protected species that should not be controlled. • Densifies in response to overgrazing but limited by slow growth and high palatability. • Very susceptible to arboricides. • Valuable timber tree species.
Sclerocarrya birrea Marula, Maroela, Omungongo,Omukongo 	• Species is idely distributed in Namibia. • Medium to large tree, usually 9 metres tall, but can grow up to 18 metres high. • Single-stemmed with a dense, spreading crown, deciduous.	• Drought resistant species. • Yields exceptional fruit per tree, up to 500 kg per year. • Wood has been traditionally used for carving pestles and mortars, bowls, drums, beehives and stools and even canoes.	• Protected species that should not be controlled. • Does not densify. • Valuable fruit tree species.

Notes

Bush Control Manual

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OTHER PRODUCTION MANUALS IN THE RANGE:
Rangeland Management
Small Stock Management
Large Stock Management
Labour Management
Crop Production
Animal Health
Mechanics
Farming Finances