



agriculture, land reform
& rural development

Department:
Agriculture, Land Reform and Rural Development
REPUBLIC OF SOUTH AFRICA

Management of Bush Encroachment

Training Manual



Land Use & Soil Management

Department of Agriculture, Land Reform & Rural Development



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1. Purpose of this manual

The purpose of this manual is to inform officials of the Department of Agriculture on how to approach the management of bush encroachment in LandCare projects or as guidance to extension officials who need to inform and educate landowners on the control and management of bush encroachment. The contents of this manual provides an overview of the basic principles of bush encroachment, the impact thereof and a selection of probable control and management options.



2. Legal obligations

Conservation of Agricultural Resources Act (CARA), Act 43 of 1983.

Landowners are obligated to manage bush encroachment on their land. The Act provides a list of species regarded as indicator plants for bush encroachment. Regulation 16 of the Act stated that:

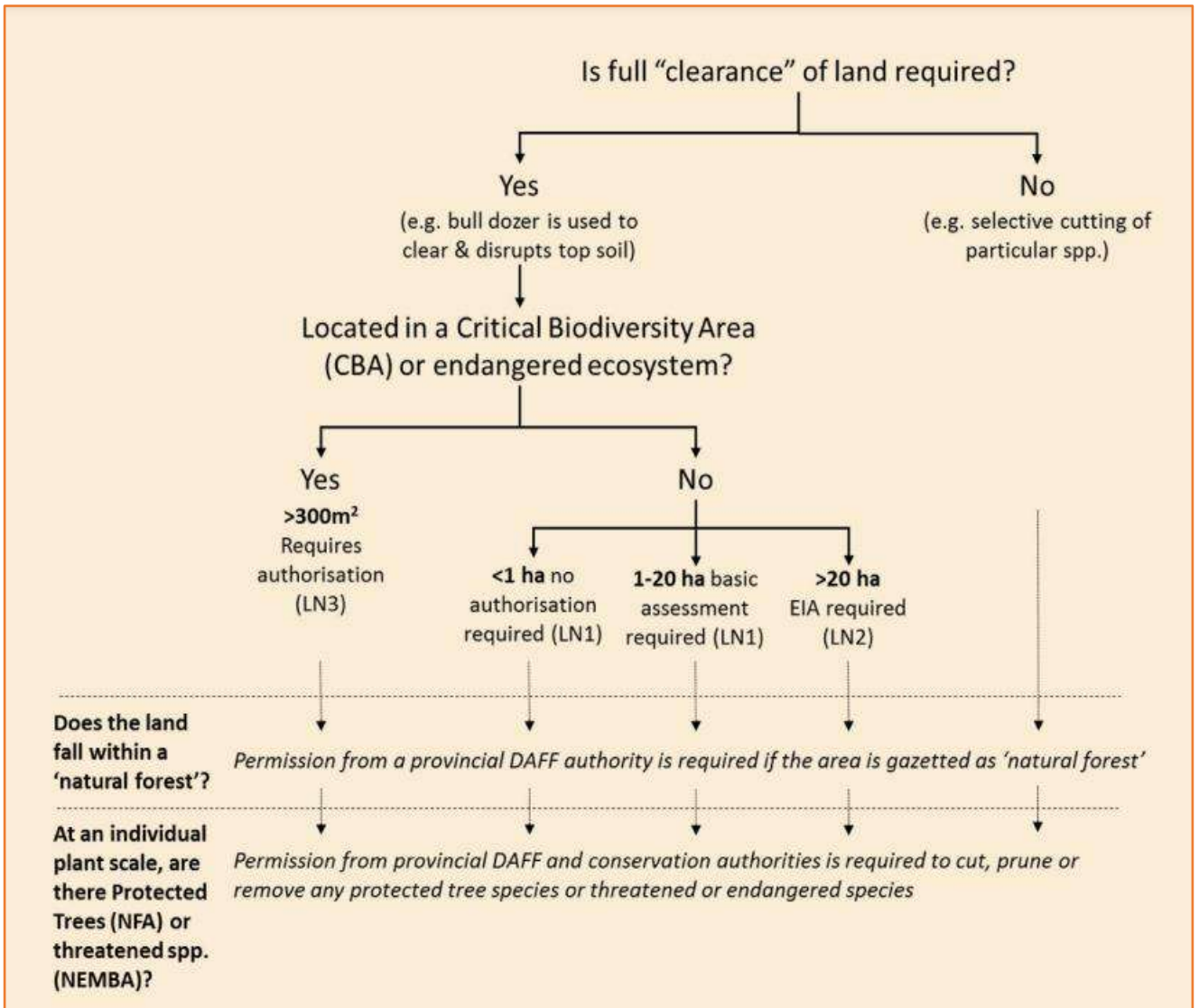
“A land user of an area in which natural vegetation occurs and that contains communities of indicator plants shall follow practices to prevent the deterioration of natural resources and to combat bush encroachment where it occurs.”

In terms of the control methods that may be used and after-care of rehabilitated veld, the Act stated that:

One or more of the following practices shall be followed with regard to communities of indicator plants contemplated in sub-regulation (2) in order to remove the cause of the deterioration of the natural resources and to improve and maintain the production potential of the natural pastoral land:

- (a) Uprooting, felling or cutting;*
- (b) Treatment with a weed killer that is registered for use in connection with such plants in accordance with the directions for the use of such a weed killer;*
- (c) The application of control measures regarding the utilisation and protection of veld in terms of regulation 9;*
- (d) The application of control measures regarding livestock reduction or removal of animals in terms of regulations 10 and 11;*
- (e) Any other method or strategy that may be applicable and that is specified by the executive officer by means of a directive.*

National Environmental Management Act (NEMA), Act 107 of 1998, Ammendments 2002 & 2004, Listed notices 1-3



- “If implementation is done through the **selective cutting of individual woody plants, without disturbance to topsoil**, it may not trigger NEMA and NEMBA regulations.
- Stay away from natural indigenous forests.
- Check for endangered species in the area.

National Forest Act (NFA), Act 84 of 1998

DOCUMENT	SECTION	TEXT
NFA 1998	12	<p>Protection of trees Part 3 allows the Minister to declare a tree, a group of trees, a woodland or a species of trees as protected. The procedure for and the effect of this declaration are set out. An emergency procedure is included to protect trees threatened with immediate harm.</p> <p><i>12. Declaration of trees as protected. (1) The Minister may declare:</i> <i>a. a particular tree;</i> <i>b. a particular group of trees;</i> <i>c. a particular woodland; or</i> <i>d. trees belonging to a particular species, to be a protected tree, group of trees, woodland or species.</i></p>
NFA 1998	3	<p>Principles to guide decisions affecting forests <i>a. natural forests must not be destroyed save in exceptional circumstances where, in the opinion of the Minister, a proposed new land use is preferable in terms of its economic, social or environmental benefits;</i> <i>c. forests must be developed and managed so as to--</i> <i>i. conserve biological diversity, ecosystems and habitats;</i> <i>ii. sustain the potential yield of their economic, social and environmental benefits;</i> <i>iii. promote the fair distribution of their economic, social, health and environmental benefits;</i> <i>iv. promote their health and vitality;</i> <i>v. conserve natural resources, especially soil and water;</i></p>
NFA 1998	7	<p>Part 1 prohibits the destruction of indigenous trees in any natural forest without a licence. <i>Prohibition on destruction of trees in natural forests.--(1) No person may cut, disturb, damage or destroy any indigenous, living tree in, or remove or receive any such tree from, a natural forest except in terms of--</i> <i>a. a licence issued under subsection (4) or section 23; or</i> <i>b. an exemption from the provisions of this subsection published by the Minister in the Gazette on the advice of the Council.</i></p>

- No removal or thinning allowed of trees on the “**protected trees**” list.
- May include individual trees, groups of trees or even a complete wooded area.
- No trees in natural indigenous forests may be removed.

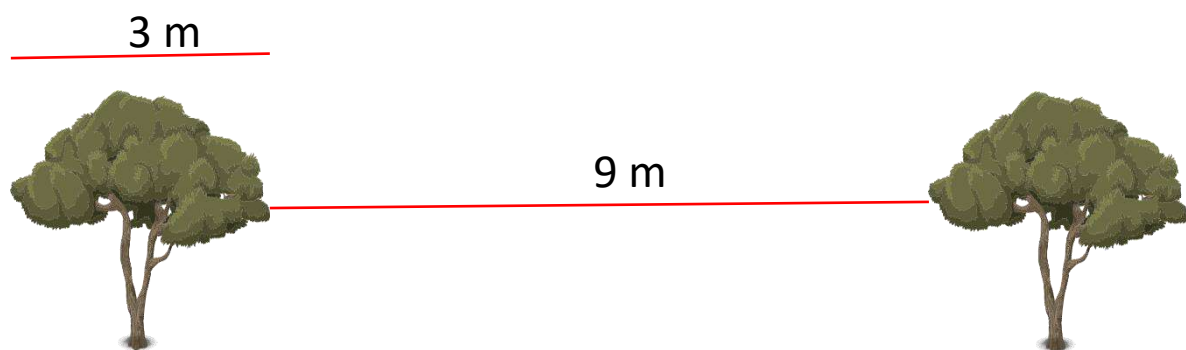


3. Introduction to the principles of Bush Encroachment



1. What is bush encroachment?

The Conservation of Agricultural Resources Act, 43 of 1983 (CARA), define bush encroachment as homogenous stands of indigenous woody plant species where individual plants are closer to each other than three times the mean crown diameter.



Bush encroachment can also be defined as an area of land where woody species increased in numbers and area of distribution to such an extent that it impacts negatively on the production potential and ecosystem services of the landscape.

Two processes primarily bring about an increase in woody plant abundance: The first is by an increase in the biomass of already established plants (vegetative growth) and the second is by an increase in tree density, mainly from the establishment of seedlings (reproduction). Any Savanna landscape consists of different strata (layers) of vegetation i.e. an herbaceous layer, shrub layer, medium and tall tree layers. The woody component has a very important role to play in the ecology of Savannah's, so it will definitely not be very wise to eradicate all woody species just to benefit the herbaceous layer. The question is however, what density of trees is regarded as "normal" for a specific vegetation type in a specific rainfall zone.

The table below provides broad density classes for trees and shrubs in a typical Savanna landscape: (Van Oudtshoorn 2015):

Table 1. Density classes for Trees and Shrubs

Density Class	Plants/ha
Low	< 1000
Medium	1000 - 2000
High	> 2000

The CARA definition is however more applicable to large woody species such as trees or shrubs, but is not applicable to smaller woody species such as dwarf shrubs. Dwarf shrubs usually has more plants per hectare and is spreading at a much higher rate than larger woody plants. The following table provides broad density classes for dwarf shrub encroachment:

Table 2. Density classes for Dwarf Shrubs

Density Class	Plants/ha
Low	< 3000
Medium	3000 - 5000
High	> 5000

The numbers indicated in Table 2 are mostly for mature plants, but is the case of smaller plants and seedlings, counts as high as 30 000 plants/ha were recorded (Avenant 2015).

2. Difference between bush encroachment and bush densification

Bush **encroachment** refers to the spread of a woody plant species from its original population into an adjacent area where it previously did not occur, thus **enlarging the area of distribution**.

In the case of **densification**, the area occupied by the respective plant community does not extend its boundaries, but the **number of individuals inside the community increases**.

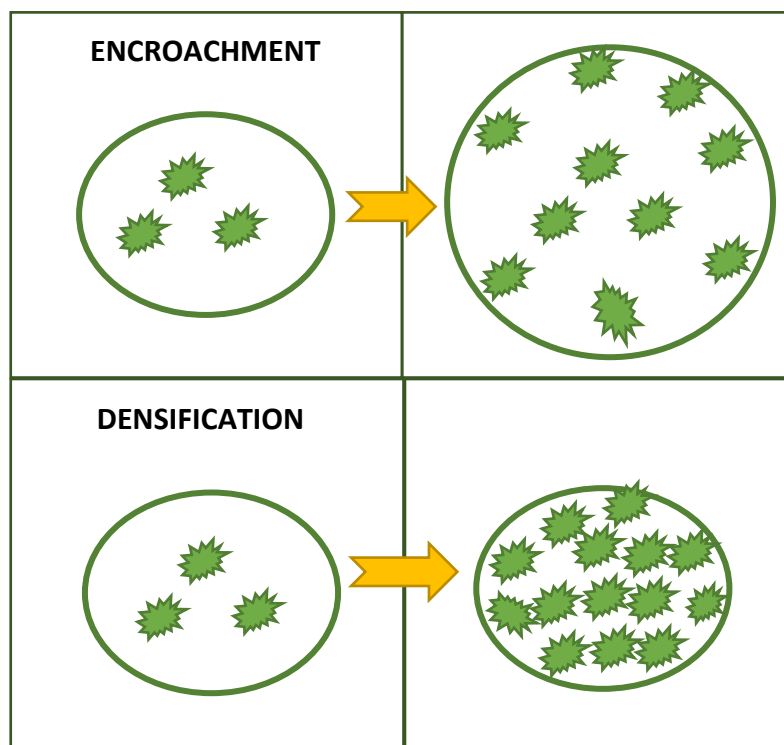


Figure 1. The difference between bush encroachment and bush densification

3. Thinning versus Eradication

The practice of **thinning** implies that plants in a community will be removed in such a way that some larger specimens will be left to create an artificial landscape with a specific density of woody plants needed for a balanced and healthy ecosystem.

In many cases these larger specimens will also suppress the germination of seedlings through competition or chemical suppression such as allelopathy.

Definition: *Allelopathy* is the chemical inhibition of one plant by another, due to the release of substances acting as germination or growth inhibitors into their populated environment.

The practice of total **eradication** is usually done where encroacher species are not desirable or beneficial to a healthy ecosystem, and where individuals may reproduce at such a rate that encroachment will be inevitable within a very short period unless they are completely removed, i.e. *Seriphium plumosum* (Bankrupt bush).

Eradication will unfortunately lead to large bare and unprotected surfaces and must always be followed by rehabilitation of the area. Also, take into account that the habitat of certain animal species may be destroyed in the process and take the necessary precautions or relocate where possible.



4. Difference between bush encroachers and alien invasive species

Encroacher species are defined as INDIGENOUS species that may increase to such an extent that they have a negative impact on the environment.

Examples: *Various Vachellia and Senegalia species (formerly known as Acacia), Terminalia sericea (Silver leaf), Dichrostachys cinerea (Sickle bush).*

Alien invasive species are defined as NOT INDIGENOUS to the country; usually increase uncontrollably due to the lack of natural enemies or environmental control factors.

Examples: *Acacia mearnsii (Black wattle), Pinus species, Eucalyptus species.*

4. Causes of Bush Encroachment

1. Unsustainable grazing management

Inappropriate grazing weakens the roots of grasses. They no longer take up water and nutrients effectively and are unable to suppress emerging bushes.

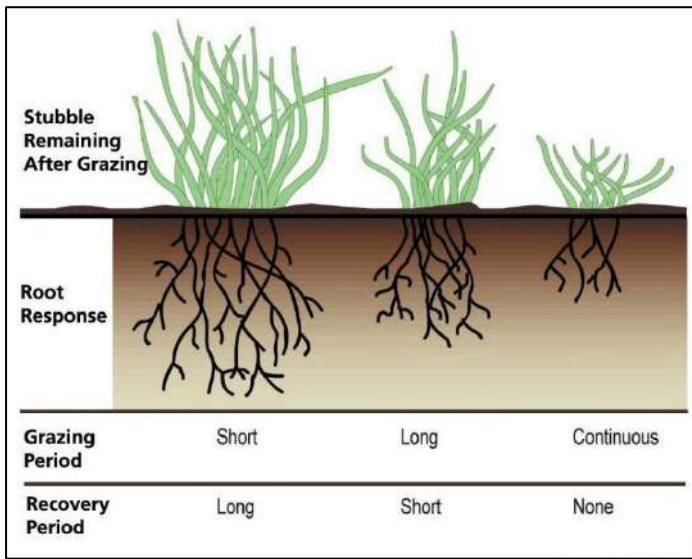


Figure 2. Grass root response to different grazing regimes

(Source: OSU Extension Catalogue - Oregon State University)

The water and nutrients left in the soil are 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.

The main forces that weaken a Savanna grass sward are:

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

Desirable perennial grasses cannot adequately recover from grazing in the active growth season; they weaken and allow woody plants to start dominating.

2. Veld fire suppression

Fire stops the development of woody seedlings into mature plants. High-intensity fires, so called “hot” fires, 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 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, but still weakens the grass sward. A weakened grass sward benefit growth of woody species due to the lack of competition.



Cool fire



Hot fire

3. Climate change

The change in the world’s climate is a global driver of bush encroachment. It is however not as visible as local drivers of bush encroachment and more difficult to comprehend. Global warming is caused by an increased concentration of atmospheric CO₂, which in turn benefit woody plant growth (C₃ plants) and allows encroacher bush to grow faster and stronger than grasses, which are mainly C₄ plants.

Woody plants rely on the adequate availability of water in the soil profile. It takes however, a series of above-average rainfall seasons to initiate bush encroachment from seed. The emerging bush seedling soon establish a long taproot that can access deeper soil moisture than relatively shallow- rooted grasses can. This gives it an adaptive and competitive advantage over grasses during dry spells.

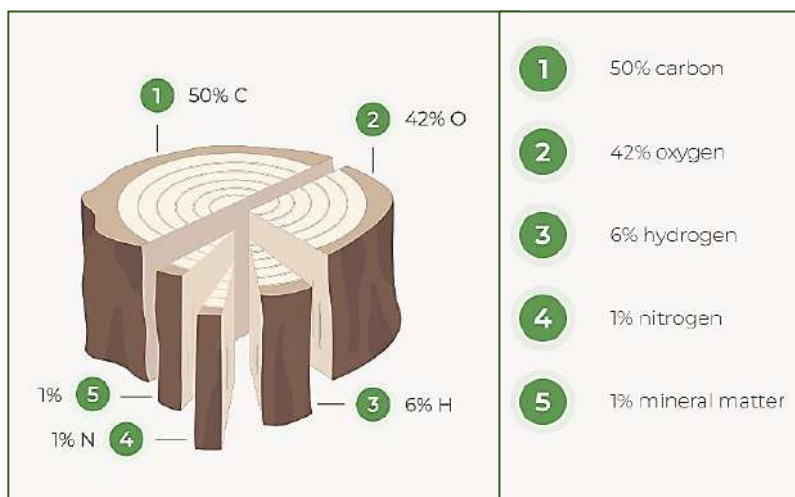


Figure 3. The chemical composition of wood

(Source: <https://ecotree.green/en/how-much-co2-does-a-tree-absorb>)

4. Frost

Severe frost can kill woody seedlings. This is the reason why there is not many indigenous tree species in the Highveld areas. Trees indigenous to very cold-climate areas such as Pine trees from the *temperate coniferous forest* in the northern hemisphere, will however easily survive our winter season. The taller a sapling grows, the less susceptible it becomes to frost damage. Cold air tends to collect in low-lying areas and saplings in these areas will be more vulnerable to frost damage. With rising temperatures due to climate change, some areas may become more suitable for the establishment of woody species and in some cases, encroachment.

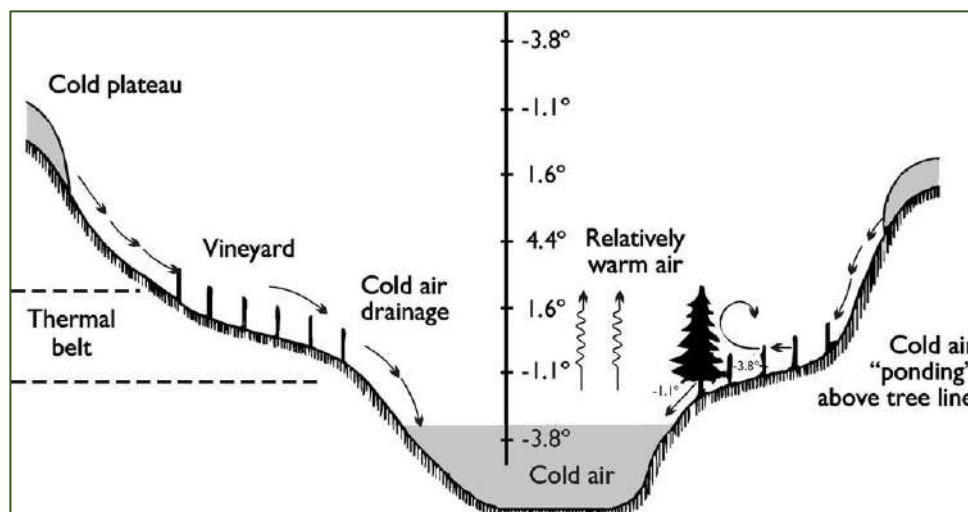


Figure 4. The drainage of cold air from high-lying areas to valley bottoms

(Source: Hortscience vol. 43(6) october 2008, NC State University, USA. p1653.)

5. 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 and impala) or domestic goats 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.



6. Seed availability

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 if these are present in the seed bank.

Senegalia mellifera, *S. erubescens* and other thorny species with soft-coated seeds form typical “same size, same age” mono-stands, reflecting episodic establishment, whereas encroacher species with hard-coated seeds (e.g. *Dichrostachys cinerea* or *Vachellia karroo*) are thought to establish much more consistently over time.

Some seeds germination are stimulated by fire. *Eucalyptus* and *Acacia mearnsii* (*Black wattle*) seeds are some examples of exotic species that needs fire to germinate.

Most Savannas carry enough seeds in the top layer of soil to sustain its woody component. These seeds can lay dormant for many years until environmental circumstances became favourable for germination and establishment of seedlings.



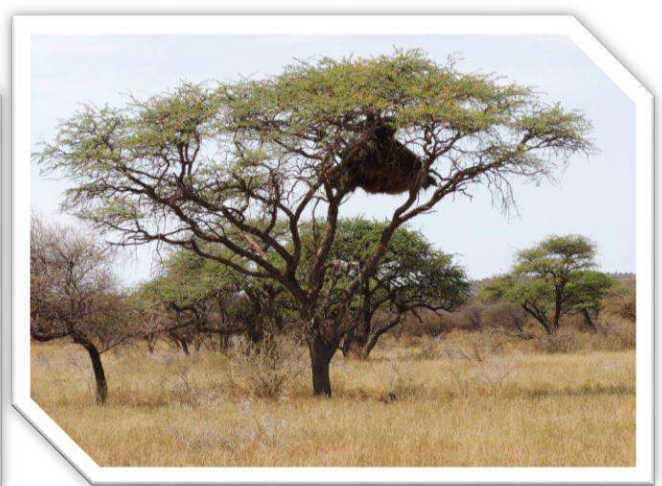
Some environmental factors may cause a natural, dense woody vegetation to prevail.

Some **vegetation types**, especially those in higher rainfall areas, may be naturally much denser than so-called “open woodland” vegetation types. These naturally dense vegetation types cannot be regarded as encroached unless there is evidence of a single species that cause severe densification. Normally these vegetation types will consist of a wide variety of woody species that exist in balance with one another. By start thinning threes in such an environment may disrupt the whole ecosystem and will lead to rapid encroachment of some woody species.

Rainfall is maybe one of the biggest drivers of vegetation density. High rainfall areas can sustain a much bigger standing biomass and, depending on climate, will include a large component of woody species.



Natural dense woodland vegetation in high rainfall region with high biodiversity



Natural open woodland in arid region

Northern **aspects** of the landscape are usually exposed to higher temperatures and have less moisture available in the soil profile. Southern slopes are cooler with higher levels of soil moisture that usually leads to naturally denser woody vegetation.



Magaliesberg mountain range: Dry northern slopes with sparse vegetation compared to moist southern slopes with dense vegetation








The influence of **soil** on plant density may be more based on species adaption for a specific soil type. High density stand of trees may be found on both sandy and clay soils, but usually with a very strong correlation to specific species. E.g. it is well known that *Acacia* species are associated with clay soils, while *Combretum* species prefers sandy soils. In both cases, encroachment may form extremely dense stands.

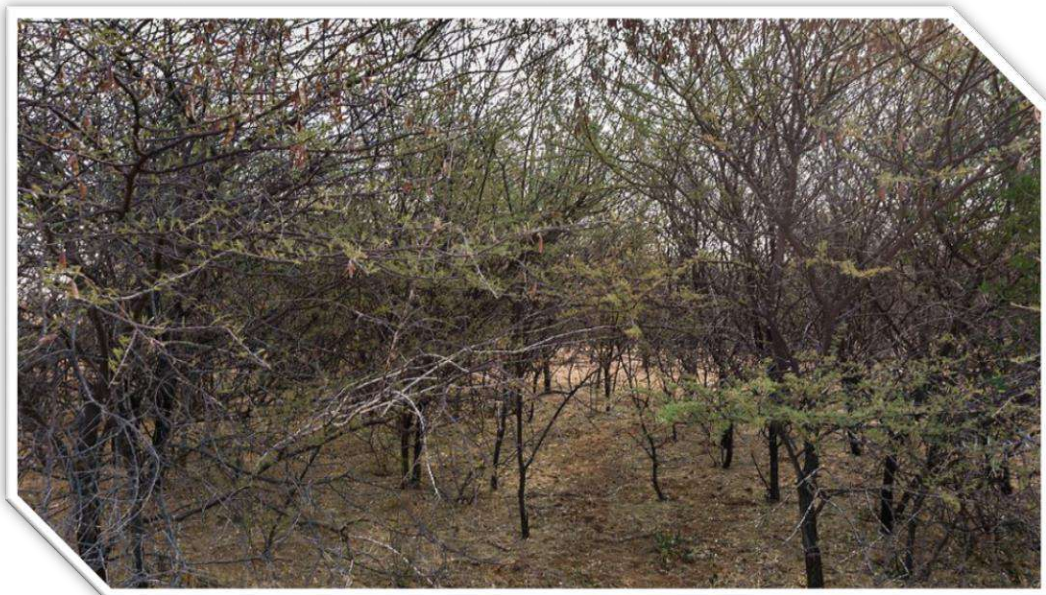


*Dense stand of *Terminalia sericea* on sandy soil*



6. Impact of Bush Encroachment

-  Bush encroachers are **fierce competitors** and in some cases will **outcompete** more valuable fodder species.
-  Large homogenous stands of plants will **lower biodiversity** in an area.
-  Some encroachment will become **too dense for animals to access** an area, especially thorny species.
-  Bush encroachment has a **negative impact on grass production** and productivity and will **lower the grazing capacity** of an area.
-  It lowers the **esthetic value** of a property.
-  It increases the **risk of uncontrolled veld fires**.
-  It disturbs the soil moisture regime of an area and **limit water availability** to other plant species.



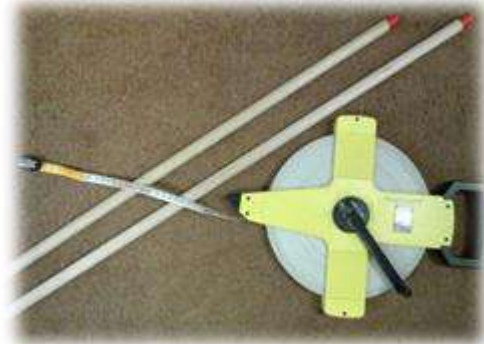
7. How to determine bush density

1. Dwarf Shrub surveys

Although there are many methods to survey woody plants, this methodology was developed to do a quick survey on only the number of plants. This is usually needed to calculate herbicide applications or labour-hours in the case of manual control. If cover is needed, the average plant diameter can also be recorded.

Equipment needed:

- ✓ 1 x 100m measuring tape OR
- ✓ 1 x 100m Nylon Ski Rope
- ✓ 2 x 1m measuring sticks
- ✓ Data sheet and pencil



How to do the plant density survey:

1. Lay out a 100m measuring tape or rope through a homogenous population of bush encroacher plants.
2. In some cases, where the stand is very dense and homogenous, a 50 m transect will be sufficient.
3. If only one person, take a 1m measuring stick and start walking along the one side of the line. Hold the measuring stick horizontally with the one end aligned with the transect line. This will mark a 1m wide belt.
4. While walking along the transect, count all plants of which the centre points are within the 1m belt.

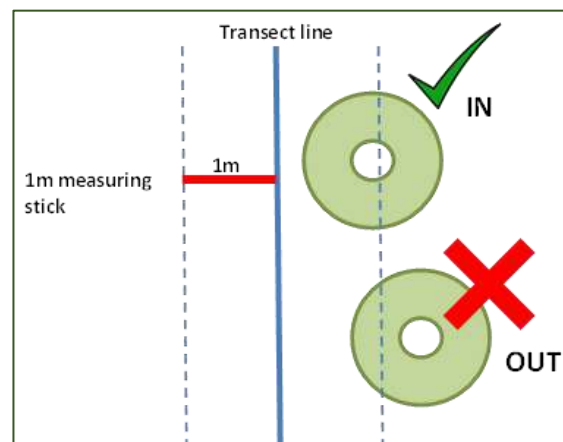
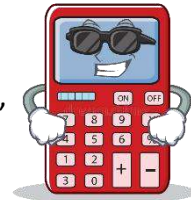


Figure 5. Counting plants in a belt transect

5. Look closely for any seedlings or young plants hidden between or under other vegetation.
6. When reaching the end of the transect line, return along the opposite side, doing exactly the same.
7. Where two persons are available to do the count, they can walk simultaneously along the line. This will half the counting time.
8. The plant counts on both sides should not differ too much – this can be used as a check for accuracy, especially where two persons did the count.

Calculating density:

1. Write down the total count for the transect (both sides), for example 400 plants.
2. This means that there are 400 plants per 200m² (100m x 2m)
3. To convert to plants per hectare: Multiply the plant count with 50, for example: 400 x 50 = 20 000 plants / ha.
4. If a 50m transect was used, multiply the count with 100 to get plants per hectare.
5. This is the **DENSITY** of encroachment.
6. Both the **AREA** of infestation (in ha) and the **DENSITY** (plant/ha) must be provided when applying for herbicide assistance or calculating the amount of herbicide needed for control.



2. Tree & shrub surveys

When thinning stands of trees it is important to know the **density of a stand** as well as the **crown diameter**. The crown diameter will influence the canopy cover of trees, which will influence the undergrowth and grass sward beneath the canopy. The smaller the crown diameter (i.e. very young plants), the higher is the number of individuals per area.

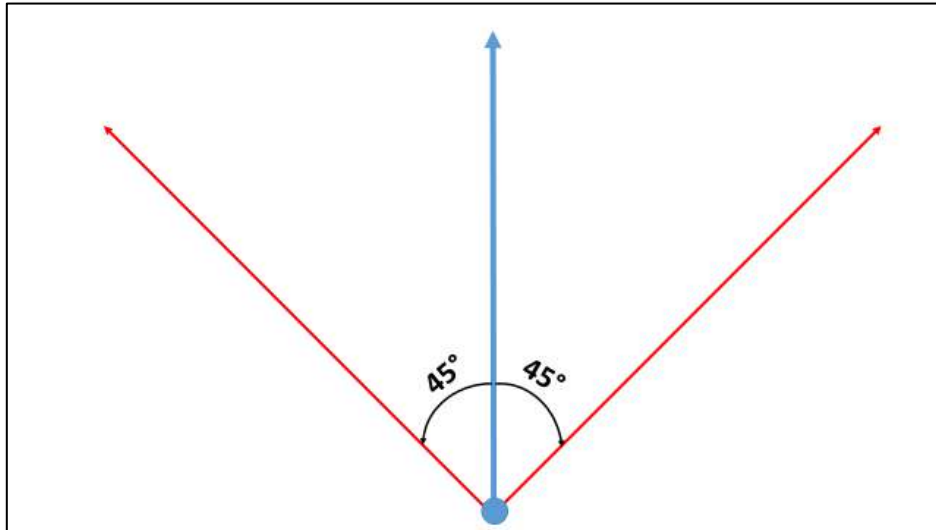
The method described in this manual was chosen because it is a very easy method to execute in the veld and need very little equipment. The method is called the “Wandering quarter” method, and was developed by A.J. Catana in 1963 to estimate population density.

CATANA A.J. 1963. The wandering quarter method of estimating population density. *Ecology*. Vol.44(2), p349-360.

Wandering quarter method

For this method, you will need a 90° angle – template:

This template is very easy to draw and you can draw one on a sheet of paper or cardboard.



In this template, the centre line will be indicating the general direction of the transect to be surveyed, and the 90° angle will indicate the range wherein the nearest tree will be selected.

Survey:

Equipment needed:

- ✓ 90° Angle Template
- ✓ A 2m measuring pole, marked at half-meter intervals
- ✓ A measuring tape (5 to 10m preferably)
- ✓ Survey form

Method:

1. Select a **starting point** for the transect. This can be a GPS coordinate, a tree, fence post etc.
2. From this point, select a **general bearing for the transect** (you may use some evident feature on the horizon as a beacon or uses a compass bearing on a GPS).
3. Stand at the starting point, **orientating the centre line** of the template in the direction of the transect.
4. Within the 90° angle, **choose the nearest living tree**.
5. **Identify the species** and fill in on survey form.

5. Measure the **distance from the starting point to the selected tree** (fill in on survey form).
6. Measure the **height of the tree** (Fill in on survey form).
7. Measure the **crown diameter** of the tree **parallel** to the general direction of the transect. (fill in on survey form).
8. From this tree, once again point the template in the transect direction and select the nearest living tree in the 90° angle.
9. **Repeat these steps** until you have collected **enough data to represent** the character of the vegetation that you are surveying, Preferably not less than 30 trees.

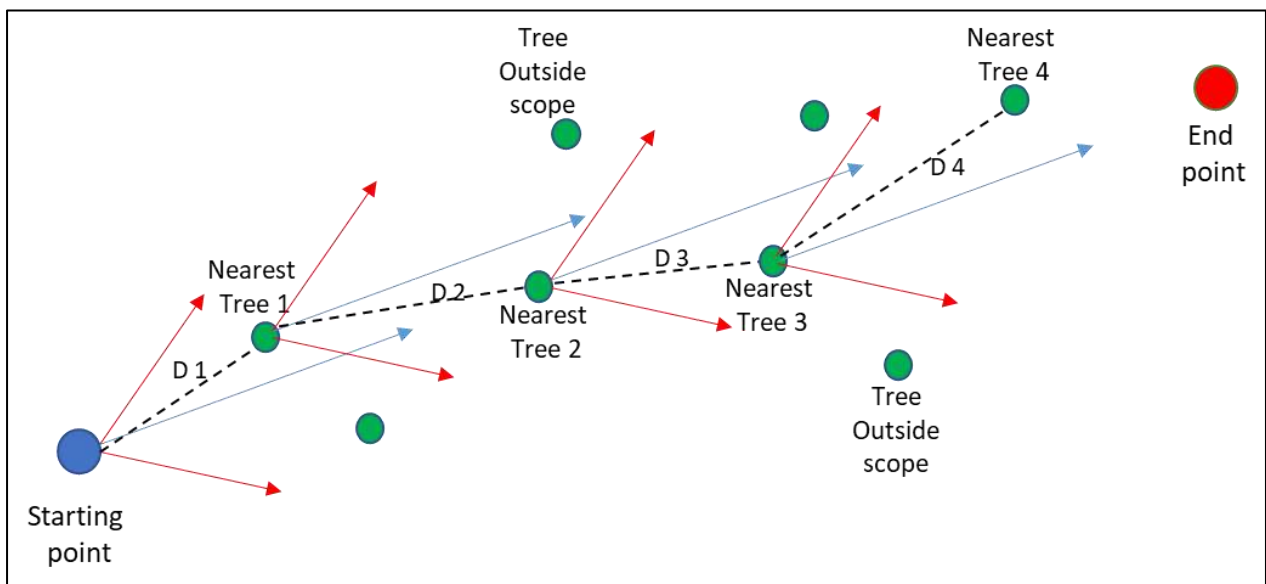


Figure 6. Diagram illustrates the execution of the wandering quarter method; D=distance between trees.

Calculations:

An excel spreadsheet can be used to automate the required calculations. The following calculations are important to provide the relevant information:

1. Mean distance (m) = $\frac{\text{Total distance (between trees)}}{\text{Number of observations}}$
2. Tree density (trees/ha) = $\frac{10\,000}{(\text{Mean distance})^2}$

8. Management and Control of Bush Encroachment

1. Prioritize control actions

When various populations of encroacher plants are scattered across the landscape, it is very important to prioritize the order of control actions. This is especially important in the case of alien plants that encroached into new areas at a rapid rate. The emphasis must be on first controlling small new emerging populations before too much harm to the environment is done. After this, large and dense populations can be tackled, where rehabilitation will also be necessary after control.

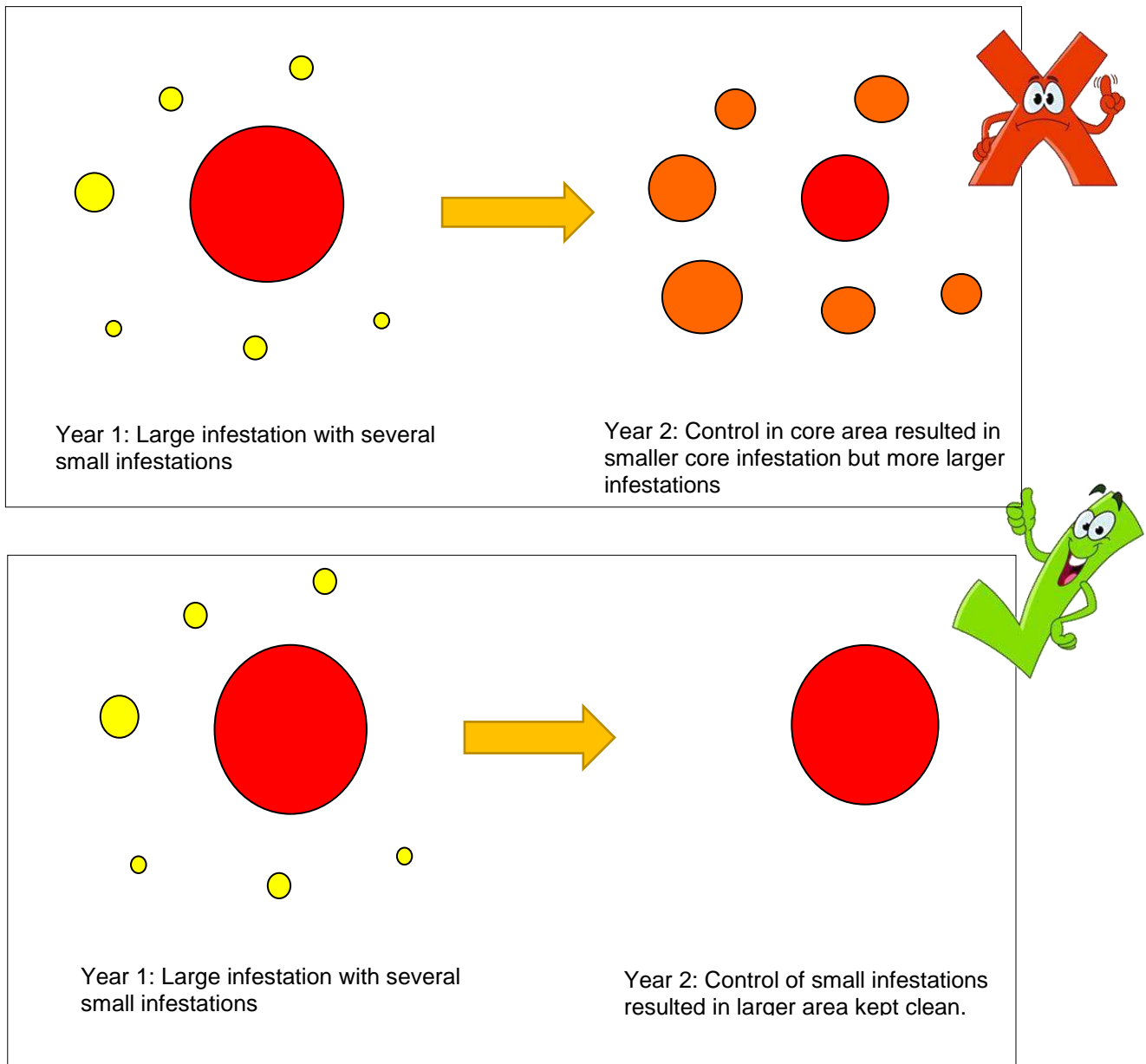


Figure 6. Priorities for the control of invasive communities

In the case of indigenous encroachers, priorities are determined by the need of the landowner. Areas needed for livestock grazing, areas that pose a risk as fire or security hazards, areas along visitor roads or encroachments near critical water sources are some examples that may be earmarked as priority areas.

The following processes for management of undesirable plant communities, either encroachers or alien invasive, are described in Sheley *et al* (1996).

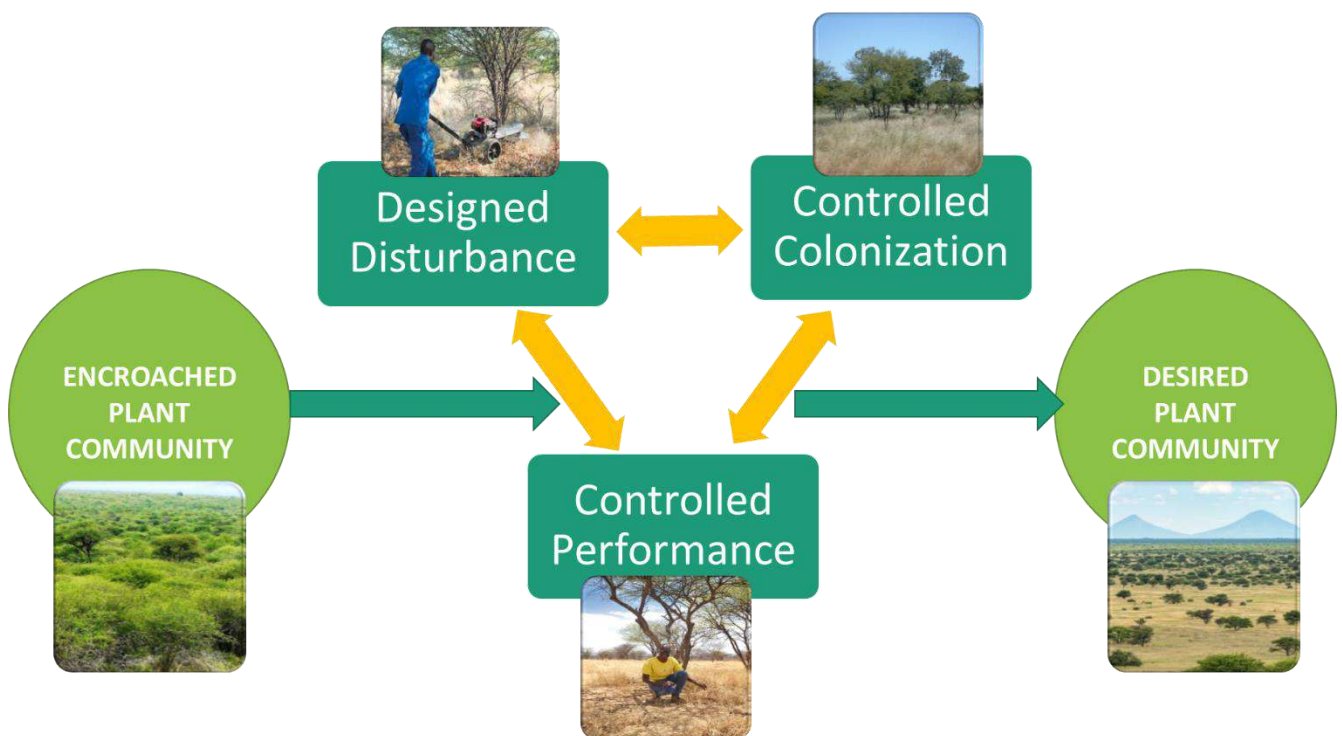











Figure 7. Processes in the management of invasive plants



2. Main principles of bush control

-  Concentrate bush control on species and individuals that are obviously part of encroacher growth and **leave the others alone**.
-  **Leave a mix of trees and bushes on the land:** 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 and imitates the heterogeneity (patchiness) of natural landscapes.
-  **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.
-  Especially in areas denuded of vegetation, cut-down **material must be left to cover the soil** and create a safe habitat for species to establish.
-  **Do not unnecessarily move or transport cut-down material** around, especially if they going to shed and disperse seeds.
-  **If herbicides are being used, foliar (leaf spray) and stem-applied herbicides are recommended.** Pellets should not be used unless they can be placed in such a manner that they do not get washed along the surface by rain and end up in non-target areas.
-  If thinning is required in densely encroached **river margins**, 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*, an exotic species that invades riverbeds, 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 immediately.

3. Mechanical control

Mechanical control can be divided into 3 categories:

i) Manual

Methods & Equipment: Removal of plants through manual labour can be done by using axes, pangas, spades, hoes, handsaws or equipment specially designed to uproot smaller shrubs. Large plants like trees are usually cut down (stumped) in order to apply herbicides on the stumps. Smaller plants like dwarf shrubs can be totally uprooted and need no further treatment.

Cost implications: Manual labour can be very expensive. To remove vegetation by hand is a long and tedious job that will require many person-hours to clear an area (0.05 – 0.2 ha/person/day). The smaller the plants and the less dense the stands, the more economic and efficient it will be to control bush encroachers by hand. For large and dense stands, rather use mechanized options or herbicides.

The pros may provide jobs to many people and the advantage is that very little training is needed, but good supervision is crucial.



ii) Semi-mechanised

Methods & Equipment: Manual labour is still required for these methods, but mechanical tools such as bush cutters and chain saws made the task easier and progress much faster (3 ha/day). Training is however compulsory to operate certain equipment and safety is of utmost importance.

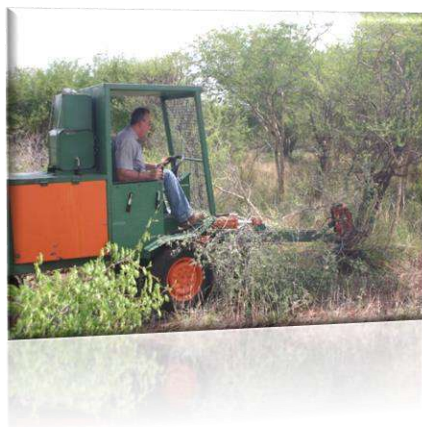
Cost implications: Maintenance of equipment and fuel costs are added to labour costs, but much more work can be done in a shorter period, that make this option more viable.



iii) Mechanical

Methods & Equipment: These methods made use of heavy mechanised cutting machinery with clippers, small bulldozer with circular saw, heavy bulldozer and bush rollers. These machines can be very effective in clearing large areas (0.5 – 4 ha/day), but is difficult to manoeuvre when selective thinning is necessary. They usually cause a lot of damage and disturbance to non-target areas and species. In some cases, the terrain may also be inaccessible e.g. steep slopes or rocky areas.

Cost implications: This kind of heavy machinery is very expensive and can only be operated by a trained operator. Only large enterprises have the budget for this kind of de-bushing, but in some cases, farmers pooled their resources to hire equipment to be used on various farms in an area. Costing for equipment is usually calculated as running cost per hour and includes fuel, maintenance and operator costs.



4. Chemical control

CAUTION:

Herbicides are hazardous material and if not handled and applied correctly can lead to:

- Poisoning and killing people
- Poisoning and killing animals
- Poisoning of water sources – stay away from wetlands, rivers, bore holes etc.
- Damage to non-target vegetation such as other woody shrubs or the grass sward
- Soil sterilization
- Very low success rate in killing target species
- Over application and under application is a waste of money!








Training

According to legislation (Act 36 from 1947) all workers applying herbicide must be trained in the safe use thereof and work under the control of a registered pest control applicator.







Mixing or spraying herbicide suspensions during very warm weather with high temperatures can be extremely dangerous. Always use masks and protective clothing when handling the herbicide, even when preparing the solution. Rather spray early in the day when temperatures are still low.





Factors that can affect the effectiveness of herbicides include:

-  Plants with **waxy or hairy leaves** may not easily adsorb the required amount chemical to kill the plant.
-  Plants are usually most susceptible to herbicides during its **active growth stage**. This is often in the seedling stage or the bud or early flowering stages.
-  Cool or extremely hot dry **temperatures** may decrease translocation of systemic herbicides.
-  Soils with **high organic matter or clay content** may require higher application rates of herbicides than sandy soils.
-  **Soil moisture** and pH can also affect persistence and effectiveness of some herbicides.

Benefits of chemical control:

-  Effective tool for new and small infestations of invasive plants.
-  Will kill target plants
-  Can have residual control effect on the seed-bank for future years depending on the chemical selected.
-  Less labour intensive than alternative mechanical methods.

Limitations of chemical control:

-  Precautions need to be taken to limit the effects on surrounding non-target plants.
-  Limited use in environmentally sensitive areas or steep slopes.
-  May have limitations of certain soil conditions or availability of water.
-  Some concerns or resistance from community groups.

Selection of herbicide should depend on your target species, other crops or plants on site, environmental considerations, and meeting your management objectives. (Source: Coastline ISC)

Chemical control can be divided into 3 categories:

i) Application by hand

Methods & Equipment: Herbicides are usually applied by hand on cut stumps or as foliar spray on shrubs and dwarf shrubs by means of a knapsack- or backpack sprayer. Pellets are placed by hand by using a spoon or application funnel-pipe. This process can be very labour intensive and time consuming. Teams need to be trained by official and recognized herbicide training companies and safety is of utmost importance.

Cost implications: Herbicide application is usually an expensive exercise and in many cases once or twice the value of the land is spend on bush control. Labour and safety gear also contribute to costs. Equipment is relatively cheap and easy to maintain. Training and supervision is of utmost importance.



ii) Application by mechanical equipment

Methods & Equipment: There are many mechanical equipment available on the market to apply herbicides. Maybe the most common one is a tractor with a boom-sprayer. Although such equipment can spray large areas in very little time, there are a few limitations:

- 🌳 Application is non-selective, and work best on homogenous stands of dwarf shrubs
- 🌳 Sprayer nozzles need to be calibrated correctly to prevent under- or over application
- 🌳 Areas need to be accessible with a relatively flat slope and little obstacles.

Cost implications: Although some equipment can be expensive, most farmers can construct their own patents by modifying some of the equipment used in cultivation practices on the farm. The running cost of the tractor and driver needs to be taken into account.



iii) Aerial application

Methods & Equipment: Aerial application of herbicides is a very suitable and effective method for controlling large areas of very dense bush encroachment. The method is however non-selective and would be most suitable for homogenous stands of bush that needs to be eradicated completely. Drones can also be used to control small areas of inaccessible invasive plants.

Cost implications: Aerial applications are very expensive and in many cases farmers forms a consortium that divides cost between all the parties involved. If large areas needs to be controlled in a short period of time, this is still one of the most cost efficient methods.



5. Biological control

Methods & Equipment: Biological control is only applicable to alien invasive species. Biological control is the use of living organisms such as insects, mites or fungal pathogens to control invasive populations. It levels the playing field by reintroducing some of the natural enemies that help control the invasive species in its native range. The aim is not to eradicate the invasive plant, but to bring its density below an appropriate ecological or economic threshold. Biocontrol is an environmentally friendly, cost-effective and sustainable way of managing invasive species and has been used effectively for more than 100 years (CABI.org)

For biological control to be effective, the population of target plants must be large enough to sustain the control agent's life cycle.

Biological control agents can be obtained from the ARC-Plant Health & Protection at the Roodeplaats Research farm. Some of the plants that have biological control agents available are:

- 🌳 Black wattle - *Acacia mearnsii*: a fungus used to prevent re-growth of black wattle stumps
- 🌳 Lantana - *Lantana camara*: a flower gall mite, a petiole-galling weevil and a root-feeding flea beetle.

Cost implications: Biological control is not very expensive, but cannot be used on indigenous species. To multiply the required control agent may take some time. Control is not absolute and can take many years to make a significant impact.



6. Fire as management tool

In South Africa, fire has always been one of the most effective tools to control bush encroachment.

IMPORTANT:

- 🔥 ***Before any controlled burning, it is mandatory for the land user to apply for a burning permit at the Department of Agriculture, Land Reform & Rural Development. (Regulation 12 of the Conservation of Agricultural Resources Act, 43 of 1983).***
- 🔥 ***It is also mandatory to get permission from the local Fire Protection Agency (FPA).***

- 🔥 *It is also mandatory to inform all adjacent landowners of your intent to burn veld, including the proposed date and time.*
- 🔥 *Burning will only be allowed on days with a safe “fire index”, as issued by the SA Weather Services.*
- 🔥 *Adequate firebreaks need to be in place, to safeguard the landowner against legal action.*

Methods & Equipment: Burning to control bush takes a lot of planning and inputs. A trained team of fire fighters is of utmost important. Equipment such as vehicles, water tanks, sprayers and other equipment must be inspected beforehand and need to be in perfect working condition. Availability of water sources is crucial.

When burning for the purpose of bush control, a very hot fire (also called a head fire) is needed. Ensure that environmental conditions such as temperature, wind and humidity will be suitable for producing a hot fire. Trollope (1980) recommend the following burning parameters as the most effective for controlling bush encroachment:

- 🔥 A high intensity fire ($>2\ 000\ \text{KJ s}^{-1}\ \text{m}^1$) is required. This can be achieved with a fuel load of 2 - 4 tons dry matter per hectare.
- 🔥 A relative humidity of below 30%
- 🔥 Air temperature should be above 25°C
- 🔥 Burn with the wind (head fire), but the wind speed should not exceed 20 km/hour
- 🔥 Time of burning is also important and the best time is during spring when the woody plants have already started to grow but the grasses are still dormant.
- 🔥 The frequency of burning is not fixed. In wetter savanna areas a fire every 3 to 4 years may be sufficient, while in drier areas it should be undertaken as opportunity arises depending on the rainfall and the presence of woody seedlings that need to be controlled.

Sufficient back-burns are necessary to contain and stop head fires. Ensure that all fire breaks are cut and cleared in order to allow vehicle movement. 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.

Remember: *The ONLY purpose of a firebreak is to allow access to an area for firefighters and NOT to prevent a fire from spreading.*

Cost implications: Firefighting teams and equipment can be expensive but in comparison with damages and loss of life that may be caused by runaway fires, the expense is always worthwhile.



7. Browsers as management tool

Methods & Equipment: The impact of browsers can be a very effective tool to manage bush encroachment. On game farms, large herbivores such as elephant and rhino will open up dense bush, making it more accessible for other browsers such as kudu. On the farm, goats are used to keep bush under control. By browsing on young trees and shrubs, goats prevent young trees to reach maturity and by continuous removal of growing points and flowers, they prevent the trees from develop and disperse seed. Over time, this depletes the seed bank and prevents future germination during favourable conditions. Browsing pressure by goats is best used as an aftercare method to prevent re-encroachment from seed or coppice.

Cost implications: If a landowner already has goats on the farm, the cost implications will be very little, if not, he will have to buy or borrow animals from nearby neighbours. This method is however not a quick fix and will also not totally eradicate bush, but can be very effective as a long-term preventative measure.




9. Rehabilitation of cleared areas


By implementing good rangeland management principles, the land user will enable sustainable utilization of his rangeland and avoid the danger of man-made bush encroachment to return. It can still happen due to natural drivers, but it will be much less frequent and probably more manageable.


The biggest threat after clearing is bare and unprotected soil. The main focus must be on re-vegetating or cover the area as quickly as possible. Just by following a few simple principles of rangeland management, this goal can already be achieved.


Some principles of sustainable management that will assist in rangeland recovery after de-bushing:


-  ***Know the resource base:*** Know the perennial species of grass that naturally dominate in the area and 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. Use indicator species to realise if rangeland is degrading, stable or improving.

 **Manage grasses for effective recovery and rest:** This is the most important principle of adaptive grazing management. Perennial and preferred species of grass are usually grazed first and most intensively. They need to recover from previous grazing completely until they have set seed before being grazed again.


 If the seed bank is too depleted already due to erosion, some local grass species can be introduced through **re-seeding**. Shallow depressions can be created across the landscape. These depressions will collect runoff water and can be used as seedling nurseries from where grasses can establish and repopulate the area. Depressions can be covered with branches to protect the seedlings against grazers.


 **Manage for effective utilisation of grasses and shrubs:** Grazing should stimulate grass production and not inhibit it. Grazing domestic livestock like cattle and some sheep breeds do not browse much. The browse component of a savanna rangeland is under-utilised while the herbaceous (grassy) component usually is over-utilised. **Browser-based livestock enterprises such as goats are encouraged.**

 **Enhance soil condition:** For grasses to flourish, the top layer of soil has to be in good condition, allowing rainwater to infiltrate easily and binding plant nutrients so they do not leach out. This is achieved mainly by keeping the soil well covered with living plants or mulched with dead plant litter to prevent soil erosion by wind or water.

 In many cases, the finer brush, cut from trees, can be used to **cover bare areas**. This will provide a safe micro-habitat for grass seedlings to establish and survive grazing pressure. This technique is called **“brush-packing”** and can cover only bare areas or being placed in a checkerboard pattern across the landscape. On slopes, it can be placed as “wooden contours” to prevent water runoff and erosion.

 Continuous control of bush encroachment as needed.

 **Plan for droughts:** By timely reduction of the livestock in synchrony with the advancing fodder deficit, the grazing pressure on rangeland can be reduced to prevent permanent damage.

 **Additional fodder** can be cultivated to provide a **fodder bank** to be used during periods of drought.

- 🌳 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 of the transition to a bushy state, requiring management intervention.
- 🌳 **Plan land use infrastructure** to make sustainable rangeland management easier, e.g. by providing enough camps per herd of livestock to facilitate effective rotational grazing management that allows perennial indicator grasses to recover from grazing.



10. The value of excess or removed biomass

The biomass removed from the land during de-bushing can be a very valuable commodity and may even contribute to the local economy. Below are some examples of how to add value to this commodity.



1. Brush packing

The use of brush packing to cover bare areas and to prevent wind and water erosion was already discussed in the previous chapter. Brush can even be used to fill up and stabilize erosion dongas. Brush packing can also be used to stabilize and re-vegetate dune crests to reduce wind erosion.



2. Mulching

When thin branches are pulverized through a shredder, it produces a very effective mulch that can be used to cover bare areas after de-bushing. Some large de-bushing equipment can even pulverised main stems of tree, leaving a thick layer of mulch to cover the soil. Where excess material is available, it can be bagged and sold to nurseries and farmers to be used as mulching material in gardens, flower beds and even on cultivated fields where conservation agriculture is practised.



3. Animal fodder

Branches can be used in a “cut-and-carry” system to supplement animal fodder. Plant material can be pulverized and use as fodder (as is) or enriched by adding some animal nutritional additives. Most Acacia pods are very high in protein but some Acacias have high tannin content that may reduce uptake of protein. Acacias are good sources of natural prebiotics (feed good bacteria in the gut of ruminants).

Pods with seeds fed to animals may risk wider distribution of seeds and create favourable conditions for bush encroachment.






4. Firewood

One of the most obvious uses for wood from a de-bushing exercise is to use it as fuel. The wood can either be used by the community or sold for additional income. Many thorn species produce very good fuel wood and is very popular in the market. Sweet thorn (*Vachellia karroo*) and Sickle bush (*Dichrostachys cinerea*) are some of the more popular and readily available fuel-wood species.

Many of the alien tree species also produced valuable fuel wood and is often sold as fuel for wood-fuel stoves and fireplaces. *Wattle* species, *Prosopis* species and *Eucalyptus* species all produce valuable and relatively good fuel wood.



5. Charcoal

The process of charcoal making is a very old process going back centuries. Traditionally, large clay mounts were used to slowly incinerate wood to produce charcoal. In many rural areas, this technique is still used, but today there are also a lot of modernized equipment available to assist in the process of charcoal making. Charcoal is used either by the community or sold as additional income. Over the years, the demand for charcoal increased and today there are many market opportunities for local entrepreneurs. The *Wattle* species are especially suitable for this process, but any wood can be used.



6. Construction material

Branches can be used for various construction purposes. Traditional kraals for livestock were, and is still, construct with branches. Branches are also used as hut building material and even to construct some basic furniture and utensils.



7. Arts & Crafts

Woodcarving of curios articles and wooden sculptures are very popular with foreign tourists and may provide additional income that contributes to the local economy.





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