

USER MANUAL: NAMIBIA BUSH BIOMASS QUANTIFICATION TOOL

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1. Background

Bush control for rangeland restoration, with or without engaging in the wood value chain for a supplementary income or the use of bush for a drought survival feed, is increasingly practiced in Namibia. This has resulted in an increase in the wood and wood product industry in Namibia.

To assist landowners and improve the sustainability of the biomass industry, the De-bushing Advisory Services (DAS) initiated the development of a user-friendly standard model for estimating bush biomass in Namibia. The initiative was funded by the Bush Control and Biomass Utilisation project implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH in close cooperation with the Ministry of Environment, Forestry and Tourism (MEFT). It was conducted by rangeland experts, Mr. Jerome Boys of the Namibian Ministry of Agriculture, Water and Land Reform (MAWLR) and Professor Nico Smit of the University of Free State in South Africa. Its core aim was to develop an excel based model on three commonly harvested woody species (*Terminalia sericea*, *Senegalia mellifera*, *Vachellia reficiens*). This base model will have the ability to be expanded over time with the addition of regression equations for other species should the need arise.

1.1. The model

The "Namibia Bush Biomass Quantification Tool" provides the user with five (5) different field data collection options associated with different accuracy levels of the predictions, as well as different parameters that can be calculated. With the required field data, the model can estimate the following:

- ▶ ETTE / ha (total and on a species basis),
- ▶ TE / ha (total and on a species basis),
- ▶ Plants / ha (total and on a species basis),
- ▶ Wood biomass (kg DM/ha, total and on a species basis),

- ▶ Wood biomass obtainable from thinning to a specified density (kg DM/ha),
- ▶ Total bush feed biomass (kg DM/ha, total and on a species basis),
- ▶ Bush feed biomass obtainable from thinning to a specified density (kg DM/ha),
- ▶ Bush feed fluctuation over months/seasons (kg DM/ha) or (kg fresh material/ha),
- ▶ Land area (ha) needed to harvest a certain quantity of wood, and
- ▶ The TE's or ETTE's to be removed when thinning the land to a predetermined density (TE / ha or ETTE / ha).

The calculated Evapotranspiration Tree Equivalents (ETTE)¹ and/or Tree Equivalents (TE)² as indicators of bush density can be used as selective bush thinning guidelines.

This user manual will equip the user (rangeland manager/farmer or harvester) with the basic information needed to use the model and also explain how to do the appropriate field data collection.

¹ Leaf volume equivalent to a 1.5m single stemmed woody plant (volume = 500cm³)

² The equivalent of a 1.5m single stemmed woody plant

2. The Namibia Bush Biomass Quantification Tool

The user is introduced to three (3) interfaces namely:

1. General information,

- ▷ General information entry
- ▷ Belt transect dimension entry (compulsory)
- ▷ Options for field data collection and the selection thereof for data entry

2. Data input, and

- ▷ Species and plant dimension measurement(s) input after field data collection

3. Results/report.

- ▷ Results that are generated from all the inputs.

General Information

General information input. This information automatically appears on the results sheet that will be used as a print-out report.

Key: Defining what the symbols used for tree dimension measurements represents

General information on names and terms in the model

Options for the plant measurement units

The three tabs that is to be completed:

1. General information
2. Data input
3. Results/Report

Accuracy levels of using a certain measurement option: a 90% represent that the prediction will be 90% correct with 10% error

Information on the measurements that provides the user with TE or ETE

Data Input

The species names surveyed will be entered here. The options are:

1. E. senegalensis
2. S. mellifera
3. V. reflexura
4. Other (Microphyllous)
5. Other (Broad leaved)

Remember: Only one option should be chosen based on decision made on "general information" sheet where the given accuracy and accompanied measurements are.

ENTER DATA HERE

Measurements can be entered here based on the chosen option. Options range from a single measurement to two (2) and three (3) measurements

Results/Report (1)

Reminder for entering transect dimensions on General information sheet. A different message appears if entered.

Information that was entered on the General information sheet automatically appears here

Calculated transect area based on transect dimensions entered on the General information sheet

Calculated total plant densities based on measurements entered on the data input sheet

Calculated plant densities on a species basis based on measurements entered on the data input sheet

Calculated total wood biomass based on measurements entered on the data input sheet

Woody plant thinning guidelines based on Tree Equivalents (TE) and Vegetation Equivalents (ETE)

TO BE FILLED IN: Long term rainfall and parameters to be set for thinning

Results/Report (2)

Calculated wood yield obtainable from thinning set parameters. Rainfall is the biggest contributor.

Calculated bush feed biomass based on measurements entered on the data input sheet

Information on moisture content of the different plant parts used for bush feed.

Calculated bush feed yield obtainable from thinning set parameters. Rainfall is the biggest contributor.

TO BE FILLED IN:

1. Degree of harvesting plants for bush feed on the landscape:
2. All plants/clearing
3. Thinning
4. Percentage of an individual plant harvested for bush feed
5. Drop-down options are available

Bush feed biomass (BFB) Fresh gives the results based on:

1. Measurements entered into the data input sheet
2. Degree of harvesting plants on the landscape
3. Percentage of an individual plant harvested
4. Phenology of the plants over season

Phenology can be changed by the user, but with experience

Figure 2.1: Overview of the model with its different interfaces. More detail is available in the booklet.

3. The use of the model

3.1. Before field work

3.1.1. Selecting an option

While the user familiarises him/herself with the model (section 2), the selection of a specific option can be decided upon based on the objection of the user's application: The user selected option include the following:

- ▶ The required field survey measurement(s),
- ▶ The required accuracy level (%) based on the selected measurement(s) option, and
- ▶ Whether TE and/or ETTE need to be calculated.

The wood, bush feed and plants/ha can be estimated by the model from any option. Figure 3.1 provides detail on data collection options.

KEY:
 SD: Stem diameter
 CD: Canopy diameter
 TH: Tree height
 CH: Height at the point where canopy is broadest

Accuracy (r values) for the given measurements (up to...)

WOOD			Offered by Option	
	Microphyllous plants	Broad-leaved plants	TE	ETTE
TH	90%	75%	YES	NO
CD	80%	45%	NO	NO
TH & CD	90%	75%	YES	NO
TH & SD	90%	75%	YES	NO
TH & CH & CD	90%	60%	YES	YES
BUSH FEED				
TH	75%	75%	YES	NO
CD	80%	85%	NO	NO
TH & CD	85%	90%	YES	NO
TH & SD	80%	90%	YES	NO
TH & CH & CD	80%	90%	YES	YES

PLEASE CHOOSE OPTION NOW

OPTION CHOICE = All measure

- NONE
- TH
- CD
- TH & CD**
- TH & SD
- TH & CH & CD

Figure 3.1: Selecting the measurement option for field data collection.

Example:

1. Veld type to be surveyed is Thornbush veld. This means that the dominant plants will be microphyllous³ and not broad-leaved⁴ plants.
2. Tree height (TH) is the most comfortable measurement of trees and the user is satisfied with the prediction accuracy and plant data available from this measurement only (TE and plants/ha on a species basis)

With these options selected:

The user will have an accuracy of 90% and 75% for predicted wood (kg/ha) for the microphyllous and broad-leaved plants, respectively. The bush feed (kg/ha) will have a predicted accuracy of 75% for both microphyllous and broad-leaved plants. The user will also have TE/ha calculated, which can be used in the selective thinning guidelines when harvesting.

The model provides the option for estimating plants/ha only, for mature plants or saplings when only plant names are entered in the species list on the data input tab without any measurements entered.

³ Are those with small leaves with a single un-branched leaf vein.

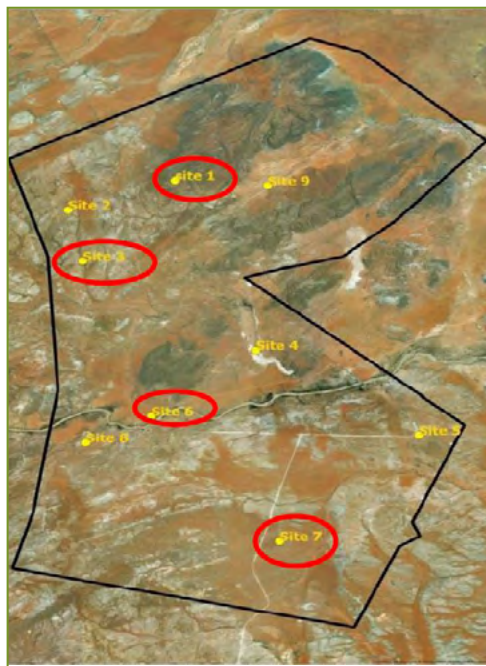
⁴ are those with leaves that have a flat, relatively broad surface.

3.1.2. Selection of survey sites

Figure 3.2 (a & b) illustrates examples on the (a) number and (b) strategic placing of sites that are representative of the larger population.



Figure 3.2a: Example of the minimum number and correct placement of survey sites to ensure representativeness of the larger population for these two specific camps.



There are nine (9) representative sites on this farm covering all geological areas with the resultant differences in vegetation types.

Depending on the user, a certain number of sites can be selected from these, but still in such a way that the entire farm is represented. Depending on the geology and vegetation of the farm, minimum of four (4) sites is recommended.

If the user decides on four (4) sites, the red circles would be the sites that best represents the farm

Figure 3.2b: Example of the minimum number and correct placement of survey sites to ensure adequate representation of the larger plant population on farm level.

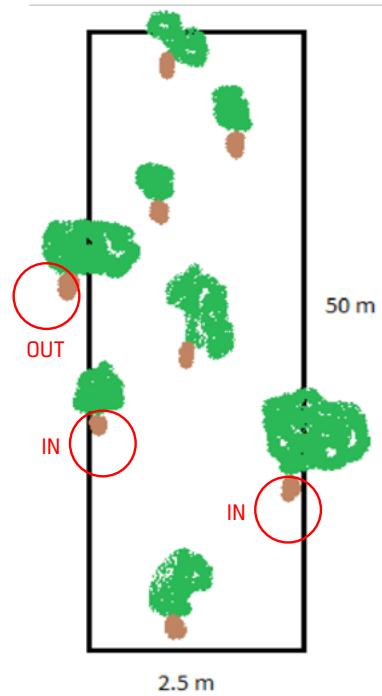
The selection of representative survey sites should preferably be done before going out to the field for data collection. Various resources such as Google earth, Google maps, GIS packages, drone images etc. can be used to identify sites that are representative of the area to be sampled. If the user does not have access to these resources, the user will have to select sites in the field that are visually representative of the larger population.

The selection and number of survey sites depends solely on the homogeneity and heterogeneity of the bigger landscape area. The more heterogeneous the area, the more survey sites need to be strategically placed for adequate representation and a more accurate estimation of the biomass of that area.

3.2. Conducting the data collection

3.2.1. Setting up a transect

Section 3.1.2 dealt with the procedure to select survey sites that are representative of the larger population. At each specific identified survey site, a standard belt transect of at least 50 x 2.5 m (125 m²) should be laid out in such a way as to best represent the woody vegetation of that site. In cases where the woody plants are patchy or the area is not very homogeneous, the length of the belt transect can be increased to either 75 m or 100 m to obtain a more accurate sampling of the vegetation. Figure 3.3 illustrates belts transects with the possibility of adjusting the transect size. The prescribed length and width is available, but other option can be selected. An alternative option for entering the area is also available, but the area should be known.



Recommended dimensions: 50m 2.5m
Transect size*: Length (m) Width (m)

Alternative area (m square) - **Fill** — Alternatively just fill area if data was collected in a different sample shape

Figure 3.3: An example of a belt transect (50-100 x 2.5 m) demarcated by a tape measure and 2.5 m measuring pole. The diagram on the right illustrates the plants to be counted as "in" when doing a survey.

3.2.2. Survey measurements

The dimensions of all rooted, live woody plants (trees and shrubs) >0.5 m in height must be measured (Figure 3.3) at each survey site within the belt transects. The different measurement options with their measurements are illustrated in Figures 3.4 -3.6. The equipment needed for a field data collection survey is:

- ▶ Measuring tape / rope of a reasonable length for marking the belt transect if belt transect will be used or pins / corner marking objects if some other form of sampling area is used,
- ▶ Measuring pole / dumpy level measuring bar for measuring the tree dimensions,
- ▶ GPS / phone that is able to locate the coordinates where the data collection is done, and
- ▶ Data collection sheet with pen / pencil.

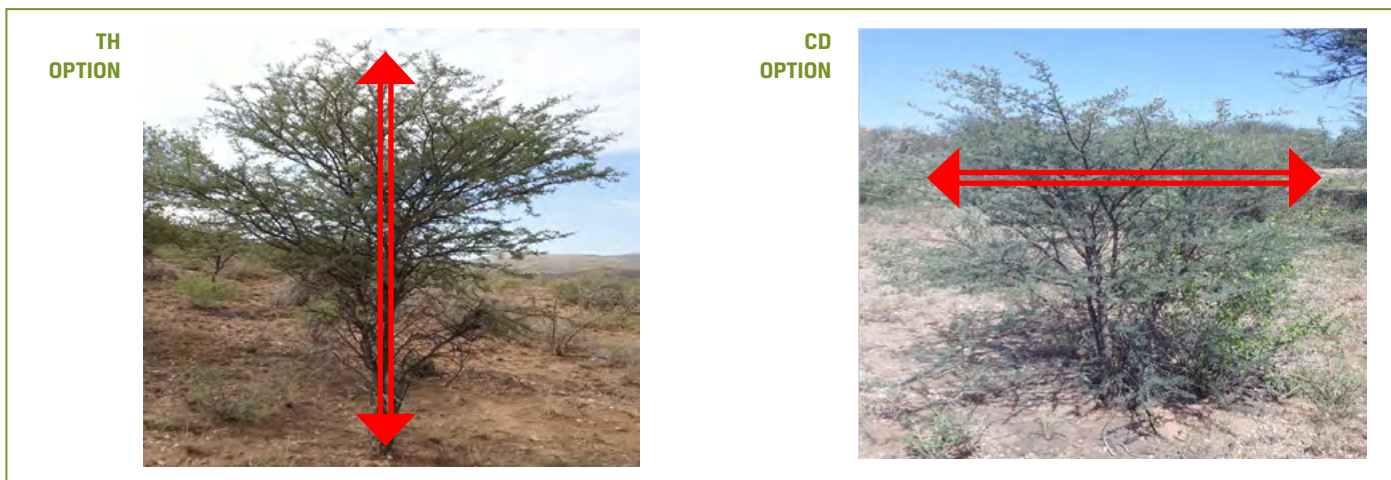


Figure 3.4: Measurement illustrations for the TH (left) and CD measurements during a survey.



Figure 3.5: Measurement illustrations for the TH & SD (left) and TH & CD measurements during a survey.

**TH & CH & CD
OPTION**

Output Required	Option on Model	Required measurements
Wood	All options	Any
Bush feed	All options	Any
Plants / ha	All options	Any
TE	TH, TH&CD, TH&SD, TH&CH&CD	TH
ETTE	TH&CH&CD	TH, CH, CD

Figure 3.6: Measurement illustrations for the TH & CD & CH (left) and CD measurements during a survey.

The measurements should be done in meters (m). Stem measurements should also be done in meters and only one average reading should be recorded if the plant is multi-stemmed. The exclusion of plants <0.5m in height does not prevent the user from counting them on a species basis and entering them into the model without measurements for a total calculated plants/ha on a species basis, which will add to the usefulness to the survey. Some important aspects to consider when doing the survey are:

- ▶ Avoid setting up a transect that includes a large tree which is not representative of the larger population
- ▶ Avoid measuring a large tree(s) in a transect that is not representative of the population and knowing that they will not be harvested

Large trees and/or protected species can be counted and entered in the model without their measurements for species composition only.

3.3. Data processing

3.3.1. Data entry into the model

General information tab

The transect dimensions (width and length) is very important on the general information entry as no data can be extrapolated without a transect area. The measurement option is also important as the data entry tab will not be active if no measurement option was selected.

General info entry

1. Click on General Information tab to start

2. Fill this information. REMEMBER: The transect length and width is compulsory

Selecting of a measurement option

KEY:

- SD: Stem diameter
- CD: Canopy diameter
- TH: Tree height
- CH: Height of tree at broadest canopy diameter

Species

1. *Terminalia sericea* (Sand geelhoud)
2. *Senegalia mellifera* (Swarthaak)
3. *Vachella reficiens* (Roorthaak)
4. Other (Microphyllous)
5. Other (Broad-leaved)

The genus', *Senegalia* and *Vachella* replaced the formerly known *Acacia* genus

Microphyllous plants: are those with small leaves with a single unbranched leaf vein.

Broad-leaved plants: are those with leaves that have a flat, relatively broad surface.

Accuracy levels for the given measurements (up to...)

	WOOD		Offered by Option	
	Microphyllous plants	Broad-leaved plants	TE	ETTE
TH	90%	75%	YES	NO
CD	80%	45%	NO	NO
TH & CD	90%	75%	YES	NO
TH & SD	90%	75%	YES	NO
TH & CH & CD	90%	60%	YES	YES
BUSH FEED				
TH	75%	75%	YES	NO
CD	80%	85%	NO	NO
TH & CD	85%	90%	YES	NO
TH & SD	80%	90%	YES	NO
TH & CH & CD	80%	90%	YES	YES

PLEASE CHOOSE OPTION NOW

OPTION CHOICE

- TH
- CD
- TH & CD
- TH & SD
- TH & CH & CD

Figure 3.7: General information entry area (left) and tree dimension measurement options with their resultant accuracies, the option of TE and/or ETT and the drop-down option to choose the selected option from (right).

Data input tab

All collected data from the field survey is entered here. The species names are available from a drop-down list. New species can be added to the tree list. It will appear on the drop-down list once added to the tree list. It is important to choose the code correctly next to the added species for the correct regression equation to be allocated to the species.

The code selection is:

- ▶ Microphyllous species = Code 1
- ▶ Broad-leaved species = Code 2

If a species is not known then either "Other (Microphyllous)" or "Other (Broad-leaved)" can be selected.

The screenshot shows the 'Data Input' screen with a table for entering data. The table has columns for 'No.', 'Species Name', and several measurement options (TH ONLY, TH (m), etc.). A dropdown menu is open for species selection, showing options like 'T. senecio', 'V. lobosana', 'S. mellifera', 'Other(Microphyllous)', and 'Other(Broad leaved)'. A 'Species list' table is also visible, showing codes for 'Microphyllous plants' (Code 1) and 'Broad leaved plants' (Code 2).

Without choosing an option and clicking on the Data Input tab, this screen appears

Choosing an option while on the General Information screen and then go to Data Input, this screen appears that shows where the data can be entered

No.	Species Name	TH ONLY	TH (m)			
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						

Free list	Species list	Code
	T. senecio	1
	V. lobosana	1
	S. mellifera	1
	Other(Microphyllous)	1
	Other(Broad leaved)	2


Figure 3.8: The data entry tab, indicating its dependence on the selected measurement option for the activation of those fields where the data needs to be entered.

3.3.2. The results/report


The report is generated from the general information and field data entries and is separated into four (4) main categories:

1. General information
2. Plant densities
3. Wood biomass
4. Bush feed biomass

RESULTS/REPORT



N-BiG
Namibia Bush Biomass Quantification Tool



Dir-bushing
Advisory Service

Please enter transect size

Length
Width

Alternative area

1. General

Date:

Farm name:

Site name/number:

Coordinates: South / Y East / X

Name of data collector:

Transect Area: m square

Figure 3.9: General information for report purposes.

2. Plant Densities

Species	Plants/ha	ETTE/ha	TE/ha
<i>T. sericea</i>	160	0	267
<i>V. reficiens</i>	0	0	0
<i>S. mellifera</i>	80	0	107
Other(Microphyllous)	0	0	0
Other(Broad-leaved)	0	0	0
Total	240		373

Figure 3.10: Plants densities (total and on a species basis).

The plants/ha is a count of all surveyed plants in the transect, extrapolated to plants/ha on a species basis. The transect area and species entry is key for the calculation plants/ha. A detailed list on extra species added during data entry is also available on a species basis for ETTE, TE, wood and bush feed on a per ha extrapolation.

The calculation of TE and ETTE-values is more complex and requires specific tree canopy measurements for their calculation. TE is calculated in the case of all measurement options where TH is the only required measurement, whereas ETTE requires the calculation of tree canopy volume which is only possible in the TH & CH & CD option. Figures 3.1 and 3.6 illustrate these options.

3. Wood biomass

Disclaimer: Taking the accuracy from estimations into account, the user is advised to consult the accuracy percentage of the option used and down-scale the biomass accordingly with a reasonable percentage to secure the risk of variations due to over and under-estimations.

This includes all stems greater than 2cm up to 18cm in diameter OPTIONAL

Total biomass (kg DM/ha): Land size (ha)

Total biomass (DM/land size): Tonnes

3.1. Woody thinning with resultant wood biomass

As a general rule of thumb: The Evapotranspiration Tree Equivalent (ETTE) should not exceed 9 - 11 times the long term average (preferably median) rainfall of an area. The Tree Equivalents (TE) should not exceed 1.5 - 3.5 times the long term average (preferably median) rainfall of an area.

PLEASE FILL	TE	ETTE
Average / Median rainfall	<input type="text" value="200"/> Set <input type="text" value="1.5"/>	<input type="text"/>
Rule of Thumb (TE) set @	<input type="text" value="1.5"/> x long term median rainfall	<input type="text"/>
Rule of Thumb (ETTE) set @	<input type="text" value="0"/> x long term median rainfall	<input type="text"/>
Wood yield available when thinning to desired TE	<input type="text" value="2.5"/>	<input type="text"/>
Wood biomass (kg/DM/ha):	<input type="text" value="0"/>	<input type="text" value="0.00"/> Tonnes

TE/ha: TE to be removed: /ha

The recommended value is indicated first and separated with 3 dots (...) from the rest

Thinning guidelines on TE's or ETTE's to be removed is calculated here

Figure 3.11: Wood biomass (total and from selective thinning)

The calculation of the estimated total wood biomass is possible with all options, but at different accuracy levels depending on the measurement option selected. In general, the more measurements per tree are taken the more accurate the estimations. The biomass wood yield that can be obtained from selective thinning is dependent on rainfall, TE and ETTE and therefore options should be selected accordingly if the users want to know how much wood will be available when thinning to a pre-determined density. The setting of the TE and ETTE options is available from a drop-down list. The model automatically detects which thinning rule to use based on the measurement option selected. The calculation of ETTE requires more tree measurements, but will render more precise predictions compared to the use of TE.

4. Bush feed Biomass

Disclaimer:

The disclaimer note under section 3 apply here as well

This includes all leaves and all stems up to 2cm in diameter

Moisture content at peak

Leaves + Stems (0 - <0.5cm)	38,9	%
Stems (>0.5 - <2cm)	28,0	%
Average	33,45	%

Total biomass (kg DM/ha): 579,83 (In full leaf)

Total biomass (kg DM/land size): 0,00 Tonnes (In full leaf)

4.1. Bush feed biomass from resultant thinning

It works on the woody thinning principle and therefore reflects the bush feed biomass available from a thinning for wood

Bush feed yield available when thinning to desired TE & ETTE

Biomass (kg/DM/ha): 0 DM/land size: 0,00 Tonnes

Figure 3.12: Bush feed biomass (total and from selective thinning)

The calculation of the estimated total bush feed biomass is also possible from all measurement options, but at different accuracy levels depending on the option selected. In general, the more measurements per tree are taken the more accurate the estimations. The thinning of bush to a certain pre-determined density with a resultant bush feed biomass is also possible as in the case of wood.

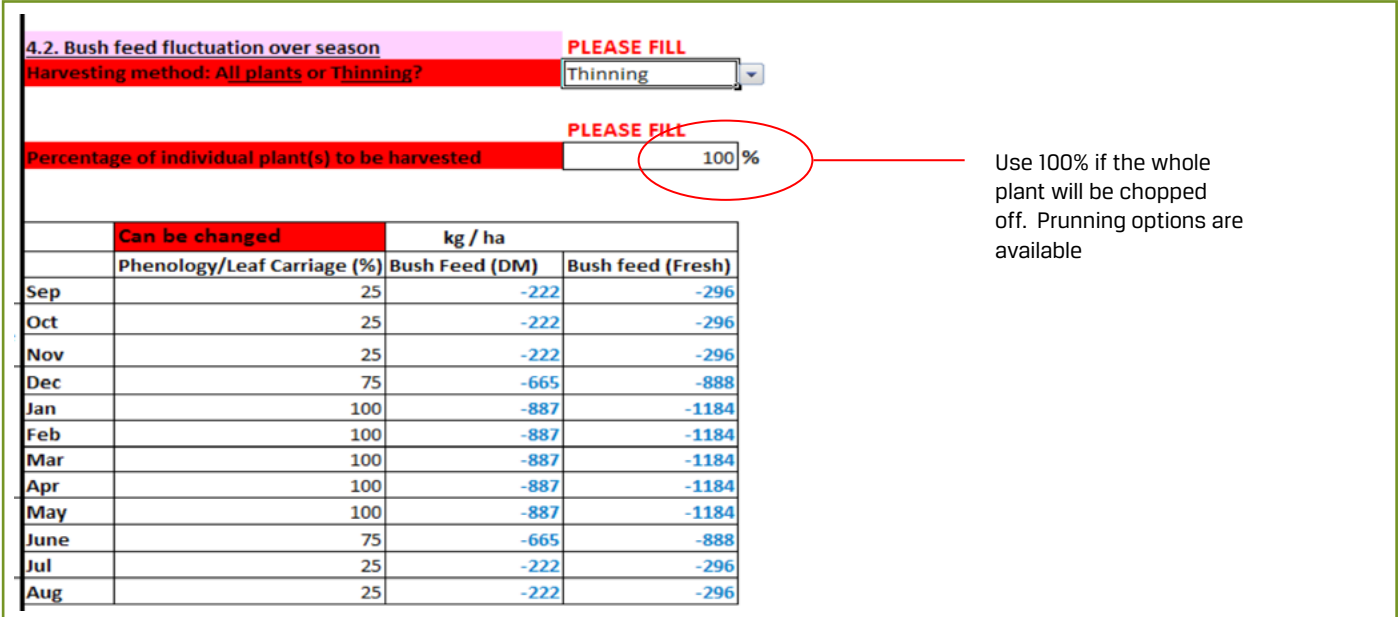


Figure 3.13: Bush feed fluctuation available through selective thinning/clearing and percentage of a plant harvested

The fluctuation of bush feed over season due to leaf phenology changes of the winter deciduous bush can also be quantified over months (Figure 3.13). This can be done for total and biomass obtained through selective thinning. An option is also available on the biomass obtainable from harvesting a certain percentage of an individual plant.

The model is supplied with leaf phenology values for each month of the year, but these leaf phenologies can be changed by the user. However, this should be done with great care as it can largely affect the biomass estimated over season.

Leaf phenology can be adjusted		kg / ha	
	Phenology / Leaf Carriage	Bush Feed (DM)	Bush feed (Fresh)
Sep	0,25	0	0
Oct	0,25	0	0
Nov	...	0	0
Dec	0,5	0	0
Jan	0,75	0	0
Feb	1	0	0
Mar	1	0	0
Apr	1	0	0
May	1	0	0
June	0,75	0	0
Jul	0,25	0	0
Aug	0,25	0	0

Figure 3.14: Option available for changing leaf phenology values for each month of the year.

A safety mechanism was brought in to separate the original leaf phenology value from the others in a drop-down list. This was done by putting the original value on top every time and separating it with three (...) from the rest in order to avoid confusion after a user has changed the leaf phenology and wants change it back to the original.

The option is also available for harvesting only a given quantity of wood and/or bush feed biomass. This requires a field data collection survey before the land area (ha) can be determined that is required for har-

vesting a given quantity of wood and/or bush feed either through clearing or thinning. Figure 3.15 illustrates the option.

5. Land (ha) required for the harvesting of a given quantity of biomass

Disclaimer: These values are calculated from available data and can only be determined after a field survey. The disclaimer note under section 3 applies here as well.

	Wood (kg) required	Ha for clearing	Ha for thinning
FILL	<input type="text"/>	0,00	<input type="text"/>
	Bush feed (kg) required		
FILL	<input type="text"/>	0,00	<input type="text"/>

Area to be filled for wood or bush feed requirement

Figure 3.15: Option for land (ha) required for harvesting only a given quantity of wood or bush feed through either clearing or thinning.

This model is particularly designed for the needs of the farmers and researchers within the wood biomass industry, specifically in Namibia, but also elsewhere. It may not precisely suite everyone's needs at the moment, but the idea was to produce this version to stimulate the need for sustainable biomass utilisation of the bush resource by means of a standardised measured quantification of the resource. The model can therefore be expanded with further specific needs that may arise in the bush biomass industry.

