**Environmental Impact Assessment on the proposed**
**330kV Power Line from Zambezi Substation to Wanela/Sesheke Border:**

# Impact on the Vegetation

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for:
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# EXECUTIVE SUMMARY

NamPower proposes to construct a 330 kV powerline between the Zambezi substation at Katima Mulilo to Zambia, crossing at Wanela/Sesheke. Construction of this powerline will require an additional 66 m next to the existing 220 kV servitude, of which the centre 12 m is to be cleared of all tall vegetation.

In order to assess the impact, a survey of the vegetation along the proposed route has been conducted. One vegetation type, the *Baikiaea plurijuga-Pterocarpus angolensis* bushlands, has been observed and is compared to a previous study done for a similar powerline to Ngoma. This vegetation type has also been rated regarding its sensitivity. Due to a relative poor species composition, with only few protected trees present, the sensitivity rating of the vegetation has dropped from an original "high " sensitivity rating for the original route to Ngoma to a "moderate" sensitivity rating for the presently proposed route to Zambia.

Four tree and shrub species were found, which are protected under the Forestry Act. A full list of species found during field work along the route is presented in Appendix 1.

Three major impacts were identified:

a) Destruction of high-value timber species: This concerns the species *Baikiaea plurijuga* (Zambesi teak), which is regarded as near-threatened due to overexploitation. Large trees of these species are to be reported to the District Office of the Directorate of Forestry for removal. Such trees are to be felled, not bulldozed out, in order to keep the trunks intact and allow these to be utilised further.

b) Clearing of vegetation and exposure of soils: The Kalahari soils are known to be extremely nutrient-poor. This situation is aggravated by the fact that nitrogen is fixed by cyanobacteria in the soil surface into forms which are available for plants as nutrients. Exposure of the soil surface to heat (by e.g. removing shading plants) will however result in these fixed nitrogen nutrients to decompose to ammonia, which is gaseous and escapes into the atmosphere. Clearing of the soil surface will thus lead to the reduction in soil fertility and production potential, and will likely also expose the soil surface to wind erosion. As mitigation, bulldozing of the vegetation should be avoided as far as possible, in order to preserve the nitrogen-fixing biological soil crust.

c) Regrowth and coppice control: Several species found along the powerline route are known to coppice strongly. Bulldozing the vegetation will also lead

to disturbances, which allow aggressive encroacher species like *Dichrostachys cinerea* and *Rotheca uncinata* to establish. Several methods of herbicidal treatments, both based on different application methods as well as different active ingredients, are available. Soil application is not recommended, as the reaction is slow, dependant on the clay content of the soil, and the herbicides are likely to leach through water movement (and thus affect non-target trees). Because of similar reasons, aerial application of herbicides (whether as foliar application or as ground application) is also not recommended. Foliar application should be limited to control the regrowth of specific high coppice shrub stands. In general, the treatment of stumps after felling is recommended. Herbicide products with active ingredients Picloram and Triclopyr or Tebuthiuron are recommended. Regrowth can effectively be controlled by annually mowing the grass along the clearing after the growing season.

The following general recommendations are made to limit the impact on the vegetation:

- Trees are to be felled along the cutline, not bulldozed. Timber species are to be reported to the District Forestry Office, who will remove the wood for sawmilling. Other species, especially *Colophospermum mopane*, provide building materials for the local populations.

- Bulldozing is to be limited to the 3 m strip needed for the access- and construction path. The remainder of the clearing is also to be cleared by felling, either with axes, chain saws or brush cutters.

- All stumps are to be treated with a suitable herbicide. Possible choices are preparations with either a Picloram / Triclopyr mixture, or with Tebuthiuron.

- Herbicides may not be applied onto the soil surface (as root treatment), neither as selective hand-treatment, nor as aerial treatment. Herbicides are also not to be applied as aerial foliage treatment for clearing purposes.

- In order to keep the clearing cleared of tall vegetation (shrubs, trees), regular (annual) mowing after the rainy season (May / June) is recommended. This will keep the grass short, thus creating an effective fire break, but will also cut short any woody coppicing and prevent these from growing tall.

- Depending on the density, any tall regrowth is to be removed by felling and stump treatment with herbicides. Foliar application of herbicides should be limited to short regrowth (below 2 m height) during the active growing season. No aerial application of herbicides is permitted, due to the highly unselective treatment such aerial application represents.

# 1 INTRODUCTION

## 1.1 BACKGROUND

Enviro Dynamics cc has been appointed by NamPower to conduct the Environmental Impact Assessment (EIA) for the proposed construction of a 330kV power line from the Zambezi Substaion at Katima Mulilo Power Station to the Wanela/Sesheke border with Zambia. This powerline will be next to the existing powerline, over a stretch of ca 3.6 km. For the powerline, a 30 m servitude will be reserved, of which 12 m, directly under the powerline, will be cleared of all woody vegetation. The construction will thus have a mayor impact on the vegetation.

The cleared area below the powerline will need to be kept clear of regrowth, in order to protect the infrastructure from damages by vegetation. Depending on the method applied to clear the vegetation, this will potentially also impact on adjacent vegetation in future.

The vegetation of the Zambezi Region forms part of the Forest Savanna and Woodland (northern Kalahari) (Giess, 1998). In this, a number of vegetation units are recognised by the "Environmental profile and atlas of the Caprivi" (Mendelsohn & Roberts, 1997). According to their map, the proposed powerline will cross onlt the Teak woodland and Teak shrubland. The authors, however, give little information on the composition of these vegetation units, making this description not very suitable for determining the vulnerability, and the potential impact, the proposed powerline has on the vegetation.

A recent study on the vegetation of the Sachinga Livestock Development Centre provides some information on especially the northern Teak woodlands and Teak Shrublands (Lushetile, 2009).

## 1.2 METHODOLOGY

A field survey was conducted on 18 July 2013. During this survey, six points located as close as possible to the proposed powerline route were surveyed. These points were placed at regular intervals every 500 m between the Katima Mulilo Power Station and the Zambia border, to the west of the existing powerline.

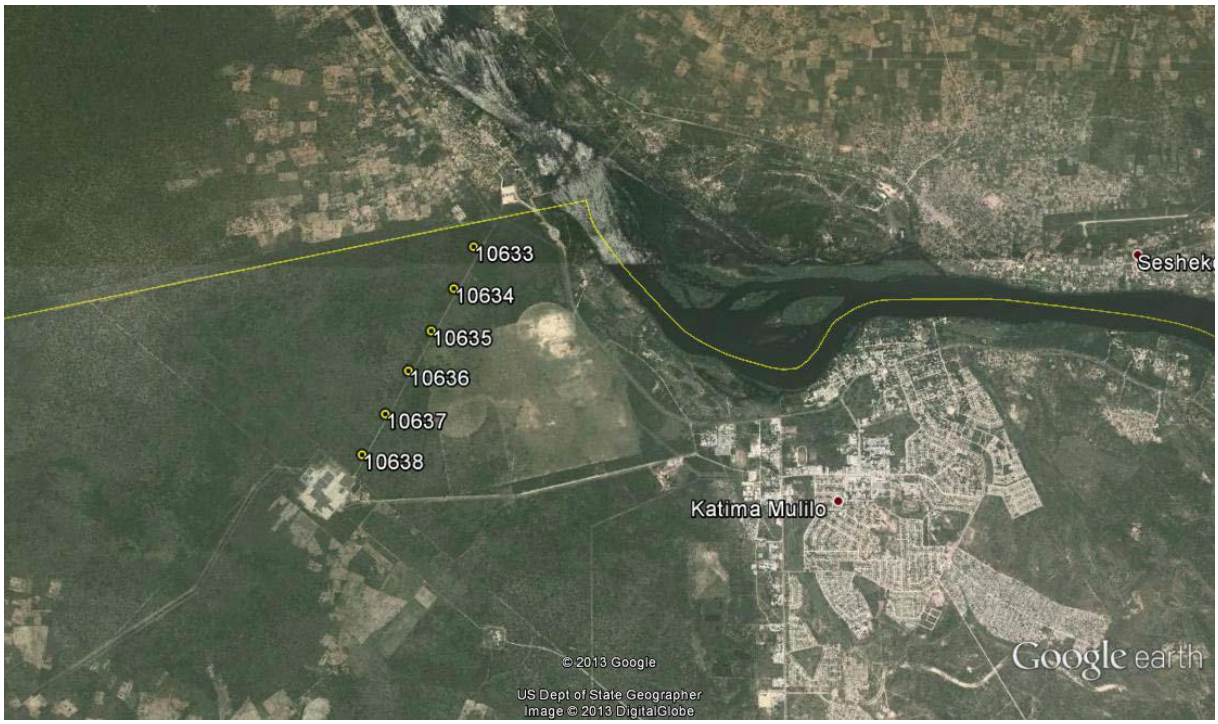

Figure 1: Location of the sample sites along the existing powerline to Zambia. Background image: Google Earth.

At each sample point, a list of species occurring was established, following the methodology used for the Vegetation Survey of Namibia project (Strohbach, 2001). This method has been proven to give a good insight on the floristic biodiversity as well as vegetation types of the study area (Strohbach & Strohbach, 2004; Strohbach & Petersen, 2007; Strohbach, 2013). In addition to the list of species, the estimated abundance of these species, as well as general site- and habitat descriptors have been recorded. These include: position, altitude (both determined with a GPS), landscape, slope range, lithology of the soil, erosion and disturbances.

The data were data-based in TurboVeg (Hennekens & Schaminée, 2001). The plot data is presented in Appendix 2. This was compared to a similar study done in 2011 in similar (same) vegetation (Strohbach, 2011). Te vulnerability of the vegetation was asessed based on a recently published method (Strohbach, 2012), which in turn is based on the presence of (i) protected, (ii) threatened, as per Red Data List and (iii) restricted range endemic species or exotic species, using available literature (Loots, 2005; Mannheimer & Curtis, 2009; Klaassen & Kwembeya, 2013). The number of species, as well as the estimated number of species (based on the Jackknife procedure, Heltshe & Forrester, 1983; Palmer, 1990), was also taken into consideration. In addition, various habitat factors were considered. The calculations were done in a compatible way to those presented by Strohbach (2011) for the previous study.

### 1.3 ASSUMPTIONS AND LIMITATIONS

A major limitation to this study was the fact that the field work could only be conducted during the dry season in mid July 2013. This resulted in the majority of herbaceous species, including grasses, not being identifiable. The assumption was however made that the major impact of the proposed powerline will be on woody species (trees and shrubs), as well as species directly relying on these for habitat, thus allowing the herbaceous layer to be mostly ignored.

# 2 LEGAL AND REGULATORY ENVIRONMENT

Plant species are protected under two separate legal instruments, being the Forestry Act (Act 12 of 2001) as well as the Nature Conservation Ordinance (Ordinance 4 of 1975).

Under the Forestry Act, a number of tree species are confirmed as declared protected species. These have been declared under the Forestry Ordinance of 1952 as well as Proclamation 486 of 1972 of the SWA Administration. Special permission is required by the Directorate of Forestry to remove these species. In addition to these specially protected species, permission is also needed from the Directorate of Forestry for general clearing of woody plants, as well as the transport of any such wood or wood products from the site / property it has been cleared from.

During the previous study (Strohbach, 2011), the District Forestry Office in Katima Mulilo, indicated that the Directorate of Forestry would not oppose a formal request for such a clearing permit, under the condition that:

(a) the cleared wood is left on site, in order for the local population to be able to use it for timber and/or firewood purposes.

(b) any sizable trees (diameter of more than 15 cm) of timber species found along the cutline are to be reported to the Forestry Office, who will cut these trees and remove them for cutting in the sawmill. These species include:

- *Baikiaea plurijuga* (Zambezi teak)
- *Pterocarpus angolensis* (African teak / kiaat)
- *Afzelia quanzensis* (Pod mahogany)
- *Dialium engleranum* (Kalahari podberry)
- *Guibourtia coleosperma* (False mopane / rosewood)

- *Burkea africana* (Burkea)

A full list of species found, as well as their protection status, has been attached in Appendix 1.

# 3 AFFECTED ENVIRONMENT

In Figure 1, an overview of the affected vegetation units as described in the "Environmental profile and atlas of Caprivi", is given. Also indicated on the map are the various vegetation sample points, indicating the classification results.

Figure 1: Map of the vegetation units effected by the proposed 330 kV powerline between Katima Mulilo and Ngoma. Also indicated are the vegetation sample sites. The vegetation units have been taken from Mendelsohn & Roberts (1997).

From the map it is clear that the vegetation units identified during the field survey do not correlate exactly with the vegetation units map:

- The Teak woodlands, Teak shrublands and *Burkea*-kiaat-false mopane woodlands have a very similar vegetation, described here as the *Baikiaea plurijuga – Pterocarpus angolensis* bushlands.

An overview of the characteristics contributing towards the sensitivity rating is given in Table 1, and a full list of species found is presented in Appendix 1.

## 3.1 THE *Baikiaea plurijuga – Pterocarpus angolensis* BUSHLANDS:

These bushlands are characterised by *Acacia fleckii, Acrotome inflata, Baikiaea plurijuga, Baphia massaiensis* subsp. *obovata* var. *obovata, Bauhinia petersiana* subsp. *macrantha, Dactyloctenium giganteum, Digitaria seriata, Eragrostis jeffreysii, Guibourtia coleosperma, Jacquemontia tamnifolia, Rhus tenuinervis, Schinziophyton rautanenii, Sesbania* sp. and *Strychnos pungens*. These are constantly accompanied by: *Acacia erioloba, Burkea africana, Combretum collinum, Grewia retinervis, Hibiscus* sp., *Ochna pulchra, Pogonarthria fleckii, Terminalia sericea* and *Vernonia poskeana* (Strohbach, 2011).

These bushlands occur on the deep sandy soils. Here a large number of timber tree species occur, including *Pterocarpus angolensis, Guibourtia coleosperma, Baikiaea plurijuga* and *Burkea africana* (Figure 2). Compare to observations done in 2011, however, the vegetation was far less diverse, with many of the prominent timber species lacking (e.g. no *Pterocarpus angolensis* or, *Guibourtia coleosperma*), and

looked more disturbed, with a very dense shrub layer typical of frequent fires. This reduced the sensitivity rating of this particular vegetation type drastically to being only moderately sensitive, compared to the high sensitivity rating given to the same vegetation type in 2011 (Table 1). The fact that the powerline affects only 3.6 km of Namibian vegetation also considerably reduces the impact it has on our vegetation.

Clearing of these *Baikiaea plurijuga – Pterocarpus angolensis* bushlands will result in extensive bare patches, which will be recolonized only slowly with annual grasses like *Aristida stipitata,* as well as the low shrub *Rotheca uncinata*. Depending on the clearing technique, extensive coppicing of *Combretum collinum* and *Bauhinia petersiana* can be expected. These cleared patches will be encroached by *Dichrostachys cinerea* shrubs as well (Figure 3). *Rotheca uncinata* is a weedy species, typically encroaching disturbed areas, and can be expected to encroach into all cleared areas along the powerline route (Figure 4).

Figure 2: *Baikiaea plurijuga – Pterocarpus angolensis* bushlands as seen along the existing powerline towards Zambia.

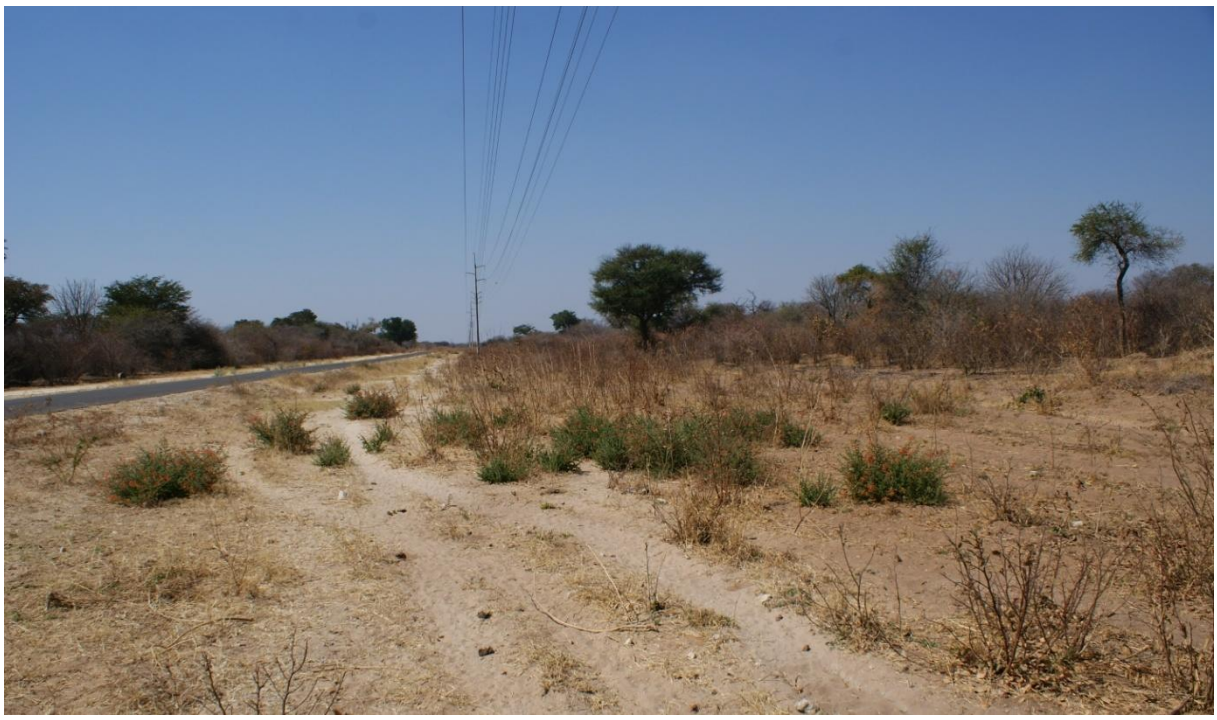

Figure 3: *Baikiaea plurijuga – Pterocarpus angolensis* bushlands after being cleared, under the powerline towards Katima Mulilo. Note the relative low regrowth of shrubs.

Figure 4: *Rotheca uncinata*, a weedy, thorny dwarfshrub, can be expected to encroach all cleared areas under the powerline.

Table 1: Biodiversity and ecosystem characteristics as related to the calculation of the community sensitivity.

| | *Baikiaea plurijuga - Pterocarpus angolensis* |
|---|---|
| No of sample plots | 6 |
| **Biodiversity:** | |
| No of species | 45 |
| Estimated no of species[1] | 63 |
| Representing Namibian species (%) | 1.41% |
| Species density (per 1000 $m^2$) | 22.3 |
| No of endemic species | 0 |
| No of RDL species | 1 |
| No of protected species | 4 |
| **Biodiversity rating:** | **137.0** |
| **Ecosystem sensitivity**: | |
| Topographic position | sand plain |
| Topographic rating | 5 |
| Slope class | 1 |
| Maximum slope (%) | 5 |
| Slope factor (X) | 2.07 |
| Average annual rainfall | 700 |
| Average annual rainfall energy | 13192.2 |
| Erosivity factor (K) | 118.26 |
| Vegetation cover (%) | 62.77 |
| Protection Factor (C) | 0.02 |
| Erosion Hazard (X*K*C) | 5.67 |
| Erosion Hazard class | 1 |
| **Habitat sensitivity rating:** | **60** |
| **Ecosystem sensitivity rating:** | **197.0** |
| **Ecosystem sensitivity score:** | **Moderate** |

[1] Based on the Jackknife procedure (Heltshe & Forrester, 1983; Palmer, 1990)

# 4 IMPACT ASSESSMENT

## 4.1 DESTRUCTION OF HIGH-VALUE TIMBER SPECIES

***Discussion***

For the powerline, a 30 m servitude is required. A 12 m strip in the middle of this is to be cleared of tall vegetation directly under the powerline. The nature of this requirement means that several trees need to be removed, irrespective weather protected, of high value as timber species, or of other use.

The only timber species identified is *Baikiaea plurijuga* (Zambezi teak). This species is regarded as near-threatened due to over-exploitation in Namibia (Loots, 2005).

***Impact summary***

| Criteria | Construction phase* |
|---|---|
| **Nature** | Destruction of timber species along the entire powerline route during construction. These include the following:<br>• *Baikiaea plurijuga* (Zambezi teak) |
| **Extent** | Site specific, along the clearing along the entire route |
| **Duration** | Permanent |
| **Intensity** | Magnitude: destructive<br>Degree: medium |
| **Probability** | Definite |
| **Significance** | Before mitigation: Medium After mitigation: Low |
| **Degree of Confidence in Predictions** | High |

* No impact during operations phase.

***Mitigation***

If removed properly (felled rather than bulldozed), the wood can be used for timber or construction purposes. It is thus recommended that such trees are felled in close collaboration with the Directorate of Forestry. DoF requested that they remove all high-value timber to the sawmills, whilst other wood, including mopane, is to be left along the clearing for the local population to collect and utilize.

## 4.2 CLEARING OF VEGETATION AND EXPOSURE OF SOILS

***Discussion***

The sandy soils of the Kalahari (including those in Caprivi) are extreme nutrient-poor (Wang et al., 2007). Nitrogen and phosphates are generally regarded as the growth-limiting plant nutrients. Where phosphates occur only in a mineral form in especially deeper soil layers, nitrogen is fixed by cyanobacteria in the soil crust as nitrate ($NO_3$) or an ammonium compound ($NH_4^+$). Both are suitable for uptake by plants, but both are susceptible to degradation. Nitrates generally degrade to nitrites ($NO_2$), a stable gas which escapes into the atmosphere. Heating the soil surface (by e.g. the sun) results in the degrading of ammonia compounds into ammonium ($NH_3$), which is also gaseous and escapes into the atmosphere (Schlesinger et al., 1990; Schlesinger & Peterjohn, 1991).

Clearing of the vegetation will result in less shade on the soil, and thus the heating of the soil surface. This in turn will result in an extreme loss of available nitrogen to plants (Schlesinger et al., 1990), and in this way significantly lowering the productivity of the soils. Bulldozing will have the added effect that the biological soil crust containing the nitrogen-fixing cyanobacteria will be destroyed (Belnap, 2002; Dougill & Thomas, 2004; Berkeley et al., 2005).

The clearing of the soil surface will also have the effect that this will be exposed to erosion. Due to the flat topography, and the relative coarseness of the soil texture (predominantly sand), water erosion is unlikely to be a problem. Wind erosion might, however, become a serious problem, as predicted for the entire Kalahari basin as far north as southern Angola, over the next 50 years (Thomas et al., 2005).

On the positive side, the clearing under the powerline can function as an additional fire break for an area already prone to very frequent fires (Mendelsohn & Roberts, 1997; Le Roux, 2011), if cleared regularly.

***Impact summary***

| Criteria | Construction phase* |
|---|---|
| **Nature** | Clearing of vegetation will result in loss of soil fertility and productivity, as well as increased wind erosion. |
| **Extent** | Site specific, along the clearing along the entire route |
| **Duration** | Long |
| **Intensity** | Magnitude: destructive<br>Degree: medium |
| **Probability** | Highly probable |
| **Significance** | Before mitigation: Low After mitigation: Low |
| **Degree of Confidence in Predictions** | High |

* No impact during operations phase.

***Mitigation***

Clearing of the vegetation should be limited to the actual area needed for construction, in order not to disturb the nitrogen-fixing biological soil crust. Other than this, no other mitigation measures are known of.

## 4.3 REGROWTH AND COPPICE CONTROL

***Discussion***

Several species in the area are known to coppice strongly. Especially *Dichrostachys cinerea* and *Combretum collinum* are known for their coppicing ability (Strohbach, 1998, 2000). *Dichrostachys cinerea* is also known as the most aggressive encroaching species in Namibia, encroaching especially in disturbed areas (Bester, 1998; De Klerk, 2004). *Rotheca uncinata* is less well-known as encroacher (mainly because of it's relative low growth, and often not persisting shoots), but has been observed to encroach extensively in disturbed areas like road verges and old fields (own observations, Figure 4).

Bush clearing follows two broad methods: mechanical clearing or clearing with herbicides. Mechanical clearing either involves the felling of trees and shrubs, using hand tools (bush picks and/or axes) or powertools like chainsaws, brush cutters, etc.; or can also be done by bulldozing ("blading"). The advantage is immediate removal of the woody plants. With hand tools, the wood can be utilised as timber or building wood, with bulldozing such trunks are often broken or splintered, and can only be used as firewood. With bulldozing, the soil is also greatly disturbed, and enables aggressive encroachers like *Dichrostachys cinerea* to establish (Smit et al., 1999). This has also been observed along existing powerlines near Katima Mulilo.

Herbicide treatment can be applied in three ways:

- Herbicides can be applied to the soil, either by hand near the base of the tree, or by aerial broadcasting. Disadvantage of this method is (a) the herbicides will only react once the soil is wet after the first rains, (b) herbicides can be taken up by nearby trees, whose roots get into contact with contaminated soils[2]. This problem is especially pronounced with aerial broadcasting. (c) In certain soil types, especially heavier (clay) soils, more herbicides are needed than in sandy soils. In soils with a clay content of more than 35 %, soil application is virtually ineffective. (d) The herbicides can wash downstream into other habitats, especially with flowing water (Smit et al., 1999; De Klerk, 2004). As large parts of the Caprivi environment form part of extensive floodplain systems, this is a likely result. Soil application of herbicides is thus **NOT** recommended.

[2] Tree roots can extend far beyond the reach of their crown. Roots of specific trees have been observed up to 100 m away from the tree (*Sclerocarya birrea*) (own observation).

- Herbicides can be applied to the foliage, either as hand spraying or as aerial spraying. Hand application is labor intensive, whilst aerial application can potentially harm adjacent vegetation, depending on the accuracy of delivery the herbicide (which in turn is wind-dependant, in addition to pilot error).
- Herbicides can be applied in conjunction with felling. In this case, the felled trunks are treated with herbicides onto the cut of the trunk, or the adjacant bark. A red dye can be added to the herbicide mixture (either with water or diesel as carrying agent, depending on the type of herbicide used), enabling the accurate identification of treated and untreated stumps.

Depending on the type of herbicide used, these are reported to be mildly toxic to humans and animals, but virtually non-toxic to birds, fish and bees. Firewood with remains of herbicides is said to be totally safe to be used (De Klerk, 2004). In all cases, caution needs to be taken not to spill any herbicides.

Both herbicidal and felling treatments are most effective if applied during the active growing season. This is because (a) the plant's resources are in the leaves and stems, not stored underground in roots, and (b) the active metabolism ensures a fast uptake of herbicides, thus preventing the potential degeneration of active ingredients due to heat and water.

In all cases, regrowth (either as coppice, most likely however as newly established plants, has to be expected. In order to prevent such regrowth to become an impenetrable thicket, regular aftercare treatments are needed (Bester, 1985a, 1985b; De Klerk, 2004).

***Impact summary***

| Criteria | CONSTRUCTION | OPERATION |
|---|---|---|
| **Nature** | Bulldozing of the cutline will damage or destroy wood which could be used as timber or construction wood, and will make it possible for aggressively encroaching species to easily establish.<br><br>Injudicious application of herbicides will destroy nearby plants, which are not targeted, either through direct contact, or through herbicides distributed by water and/or in the soil. | Injudicious application of herbicides will destroy nearby plants, which are not targeted, either through direct contact, or through herbicides distributed by water and/or in the soil. |

| | | |
|---|---|---|
| **Extent** | Site specific and local | Site specific and local |
| **Duration** | Long | Long |
| **Intensity** | Magnitude: destructive<br>Degree: medium | Magnitude: destructive<br>Degree: medium |
| **Probability** | Highly probable | Highly probable |
| **Significance** | Before mitigation: High<br>After mitigation: Low | Before mitigation: High<br>After mitigation: Low |
| **Degree of Confidence in Predictions** | High | High |

***Mitigation***

a) Any large trees are to be felled using chain saws or other appropriate mechanical devices.

b) Bulldozing is to be limited to the absolute minimum, along the access route.

c) Stump treatment with herbicides is strongly recommended. Either herbicides with Picloram and Triclopyr, mixed with diesel as carrying agent (e.g. Tordon Super), or with Tebuthiuron, mixed with water (e.g. Access) can be used.

d) Regrowth can be prevented by either regularly mowing the cutline below the powerline (and in this way also creating an effective fire break), or by treating excessive regrowth on a five-year cycle with foliar sprays. The felling and stump treatment of such regrowth can also be considered.

# 5 CONCLUSIONS AND RECOMMENDATIONS

The impact on the vegetation will be of a highly destructive, very permanent nature during construction. The operational phase will have only limited impacts on the vegetation, but regrowth of the vegetation could, if not controlled, impact on the powerline operation. The control of such regrowth could be very easy, with limited impacts, if done regularly, but could also become very costly, with potentially great impacts on the environment, if left unchecked.

In most cases, no other mitigation measures can be applied than limiting the damage done. In order to achieve this, the following recommendations are made:

- Trees are to be felled along the cutline, not bulldozed. Timber species are to be reported to the District Forestry Office, who will remove the wood for sawmilling. Other species provide building materials and fire wood for the local populations.
- Bulldozing is to be limited to the 3 m strip needed for the access- and construction path. The remainder of the clearing is also to be cleared by felling, either with axes, chain saws or brush cutters.
- All stumps are to be treated with a suitable herbicide. Possible choices are preparations with either a Picloram / Triclopyr mixture, or with Tebuthiuron.
- Herbicides may not be applied onto the soil surface (as root treatment), neither as selective hand-treatment, nor as aerial treatment. Herbicides are also not to be applied as aerial foliage treatment for clearing purposes.
- In order to keep the clearing cleared of tall vegetation (shrubs, trees), regular (annual) mowing after the rainy season (May / June) is recommended. This will keep the grass short, thus creating an effective fire break, but will also cut short any woody coppicing and prevent these from growing tall.
- Depending on the density, any tall regrowth is to be removed by felling and stump treatment with herbicides. Foliar application of herbicides should be limited to short regrowth (below 2 m height) during the active growing season. No aerial application of herbicides is permitted, due to the highly unselective treatment such aerial application represents.

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# 7 APPENDIX 1: ANNOTATED SPECIES LIST FOR THE STUDY AREA

Note: Abundance ratings follow those of Strohbach & Strohbach (2004).

| Species | Protection status | Conser-vation status | Abundance |
|---|---|---|---|
| **Annual grasses:** | | | |
| *Eragrostis porosa* (L.) P.Beauv. | | | common |
| *Dactyloctenium giganteum* Fisher & Schweick. | | | common |
| *Pogonarthria fleckii* (Hack.) Hack. | | | common |
| *Tricholaena monachne* (Trin.) Stapf & C.E.Hubb. | | | occasional |
| **Perennial grasses:** | | | |
| *Digitaria seriata* Stapf | | | common |
| *Eragrostis rigidior* Pilg. | | | occasional |
| *Panicum kalaharense* Mez | | | occasional |
| *Panicum maximum* Jacq. | | | rare |
| *Pogonarthria squarrosa* (Roem. & Schult.) Pilg. | | | occasional |
| *Schmidtia pappophoroides* Steud. | | | occasional |
| *Sporobolus fimbriatus* (Trin.) Nees | | | rare |
| **Herbs:** | | | |
| *Baissea wulfhorstii* Schinz | | | occasional |
| *Bidens biternata* (Lour.) Merr. & Sherff | | | occasional |
| *Bidens schimperi* Sch.Bip. ex Walp. | | | rare |
| *Hemizygia bracteosa* (Benth.) Briq. | | | common |
| *Hibiscus mastersianus* Hiern | | | common |
| *Jacquemontia tamnifolia* (L.) Griseb. | | | occasional |
| *Vernonia poskeana* Vatke & Hildebr. | | | common |
| *Xenostegia tridentata* (L.) D.F.Austin & Staples | | | rare |
| **Dwarf shrubs (below 1 m):** | | | |
| *Clerodendrum dekindtii* Gürke | | | rare |
| *Rotheca uncinata* (Schinz) P.P.J.Herman & Retief | | | occasional |
| **Shrubs (between 1 and 5 m):** | | | |
| *Acacia ataxacantha* DC. | | | widespread |
| *Acacia fleckii* Schinz | | | occasional |
| *Baphia massaiensis* Taub. subsp. *obovata* (Schinz) Brummitt | | | common |
| *Bauhinia petersiana* Bolle subsp. *macrantha* (Oliv.) Brummitt & J.H.Ross | | | common |
| *Boscia albitrunca* (Burch.) Gilg & Gilg-Ben. | Forestry Act | | rare |
| *Combretum elaeagnoides* | | | occasional |

| Species | Protection status | Conser-vation status | Abundance |
|---|---|---|---|
| Klotzsch | | | |
| *Combretum engleri* Schinz | | | occasional |
| *Croton gratissimus* Burch. | | | occasional |
| *Dichrostachys cinerea* (L.) Wight & Arn. | | | common |
| *Grewia flavescens* Juss. | | | occasional |
| *Steganotaenia araliacea* Hochst. | | | rare |
| **Trees (higher than 5 m):** | | | |
| *Acacia erioloba* E.Mey. | Forestry Act | | common |
| *Acacia fleckii* Schinz | | | widespread |
| *Baikiaea plurijuga* Harms | Forestry Act | near threatened | widespread |
| *Combretum collinum* Fresen. | | | common |
| *Commiphora tenuipetiolata* Engl. | | | occasional |
| *Philenoptera nelsii* (Schinz) Schrire | Forestry Act | | occasional |
| *Schinziophyton rautanenii* (Schinz) Radcl.-Sm. | Forestry Act | | widespread |
| *Terminalia sericea* Burch. ex DC. | | | widespread |

# 8 APPENDIX 2: PLOT DATA COLLECTED DURING THE SURVEY

=> Relevé number: 10633

| | |
|---|---|
| Cover abundance scale | : Percentage (%) |
| Author code | : Strohbach, Ben J. |
| Date (year/month/day) | : 2013/07/18 |
| Relev, area (m2) | : 1000.00 |
| Altitude (m) | : 962 |
| Cover tree layer (%) | : 15 |
| Cover shrub layer (%) | : 25 |
| Cover herb layer (%) | : 25 |
| Height (highest) trees (m) | : 20 |
| Height lowest trees (m) | : 4 |
| Height (highest) shrubs (m) | : 5.0 |
| Height lowest shrubs (m) | : 1.0 |
| Aver. height (high) herbs (cm) | : 120 |
| Aver. height lowest herbs (cm) | : 20 |
| Latitude (degr./min/sec) | : 17-28-45 |
| Longitude (degr./min/sec) | : 24-14-18 |
| Biome/Veg. type | : Forest savanna and woodland |
| Stratigraphy | : Kalahari |
| Cover: Gravel | : None |
| Cover: Small stones | : None |
| Cover: Medium stones | : None |
| Cover: Large stones | : None |
| Rock | : None |
| Landscape type | : Plain (<8 % slope, <100m/km relief) |
| Local topography | : Sand drift plain (covered by >50% sand) |
| Slope class | : Undulating, 3-6° (5-10%) |
| Growing period zone | : More than 120 days |
| Lithology | : Eolian |
| Erosion | : None |
| Surface crusting | : none |
| Soil depth | : 180 |
| Disturbance | : Bush encroachment |
| Region | : Caprivi |
| District | : Katima Mulilo |
| Gps_set | : WGS84 |
| Gps_acc | : 7 |

Plot 2013/101: Along Katima-Zambia line, ca 1 km before border. Photos DSC08458-DSC08462

| | | | |
|---|---|---|---|
| Acacia ataxacantha-s1 | 2 | Dichrostachys cinerea-s1 | 5 |
| Acacia erioloba-t1 | 2 | Digitaria seriata-hl | 5 |
| Acacia fleckii-s1 | 2 | Eragrostis rigidior-hl | 1 |
| Baikiaea plurijuga-t1 | 2 | Grewia flavescens-s1 | 2 |
| Baissea wulfhorstii-hl | 5 | Hemizygia bracteosa-hl | 2 |
| Baphia massaiensis s. obovata v. obovata | 10 | Hibiscus mastersianus-hl | 2 |
| Bauhinia petersiana s. macrantha-s1 | 5 | Jacquemontia tamnifolia-hl | 1 |
| Bidens pilosa-hl | 5 | Lonchocarpus nelsii-t2 | 2 |
| Boscia albitrunca-s2 | .1 | Markhamia zanzibarica-t3 | 1 |
| Clerodendrum uncinatum-hl | 1 | Panicum maximum-hl | 1 |
| Combretum collinum-t2 | 1 | Pogonarthria fleckii-hl | 2 |
| Commiphora tenuipetiolata-t2 | 2 | Schinziophyton rautanenii-t1 | 5 |
| Dactyloctenium giganteum-hl | 1 | Vernonia poskeana-hl | 2 |

=> Relevé number: 10634

| | |
|---|---|
| Cover abundance scale | : Presence/Absence |
| Author code | : Strohbach, Ben J. |
| Date (year/month/day) | : 2013/07/18 |
| Relev, area (m2) | : 1000.00 |
| Altitude (m) | : 962 |
| Latitude (degr./min/sec) | : 17-29-00 |
| Longitude (degr./min/sec) | : 24-14-11 |
| Biome/Veg. type | : Forest savanna and woodland |
| Stratigraphy | : Kalahari |
| Cover: Gravel | : None |
| Cover: Small stones | : None |
| Cover: Medium stones | : None |
| Cover: Large stones | : None |
| Rock | : None |
| Landscape type | : Plain (<8 % slope, <100m/km relief) |
| Local topography | : Sand drift plain (covered by >50% sand) |
| Slope class | : Undulating, 3-6° (5-10%) |
| Growing period zone | : More than 120 days |
| Lithology | : Eolian |
| Erosion | : None |
| Surface crusting | : none |
| Soil depth | : 180 |
| Disturbance | : Bush encroachment |
| Region | : Caprivi |
| District | : Katima Mulilo |
| Gps_set | : WGS84 |
| Gps_acc | : 7 |

Plot 2013/102: Along Katima-Zambia line, ca 500 m southwards towards station from previous.
Photos DSC08463-DSC08467

| | | | |
|---|---|---|---|
| Acacia ataxacantha | x | Digitaria seriata | x |
| Acacia erioloba | x | Eragrostis porosa | x |
| Acacia fleckii | x | Grewia flavescens | x |
| Baikiaea plurijuga | x | Hemizygia bracteosa | x |
| Baissea wulfhorstii | x | Hibiscus mastersianus | x |
| Baphia massaiensis s. obovata v. obovata | x | Loeseneriella africana | x |
| Bauhinia petersiana s. macrantha | x | Lonchocarpus nelsii | x |
| Bidens pilosa | x | Markhamia zanzibarica | x |
| Chamaecrista absus | x | Pogonarthria fleckii | x |
| Commiphora tenuipetiolata | x | Terminalia sericea | x |
| Dichrostachys cinerea | x | Vernonia poskeana | x |

=> Relevé number: 10635

| | |
|---|---|
| Cover abundance scale | : Presence/Absence |
| Author code | : Strohbach, Ben J. |
| Date (year/month/day) | : 2013/07/18 |
| Relev, area (m2) | : 1000.00 |
| Altitude (m) | : 961 |
| Latitude (degr./min/sec) | : 17-29-15 |
| Longitude (degr./min/sec) | : 24-14-03 |
| Biome/Veg. type | : Forest savanna and woodland |
| Stratigraphy | : Kalahari |
| Cover: Gravel | : None |
| Cover: Small stones | : None |
| Cover: Medium stones | : None |
| Cover: Large stones | : None |
| Rock | : None |
| Landscape type | : Plain (<8 % slope, <100m/km relief) |
| Local topography | : Sand drift plain (covered by >50% sand) |
| Slope class | : Gently undulating, 1-3° (2-5%) |
| Growing period zone | : More than 120 days |
| Lithology | : Eolian |
| Erosion | : None |
| Surface crusting | : none |
| Soil depth | : 180 |
| Disturbance | : Bush encroachment |
| Region | : Caprivi |
| District | : Katima Mulilo |
| Gps_set | : WGS84 |
| Gps_acc | : 8 |

Plot 2013/103: Along Katima-Zambia line, ca 500 m southwards towards station from previous.
Photos DSC08468-DSC08471

| | | | |
|---|---|---|---|
| Acacia ataxacantha | x | Dichrostachys cinerea | x |
| Acacia erioloba | x | Digitaria seriata | x |
| Acacia fleckii | x | Eragrostis rigidior | x |
| Baikiaea plurijuga | x | Hemizygia bracteosa | x |
| Baphia massaiensis s. obovata v. obovata | x | Lonchocarpus nelsii | x |
| Bauhinia petersiana s. macrantha | x | Markhamia zanzibarica | x |
| Bidens schimperi | x | Panicum kalaharense | x |
| Clerodendrum dekindtii | x | Pogonarthria squarrosa | x |
| Combretum collinum | x | Schinziophyton rautanenii | x |
| Combretum elaeagnoides | x | Sporobolus fimbriatus | x |
| Dactyloctenium giganteum | x | Vernonia poskeana | x |

=> Relevé number: 10636

| | |
|---|---|
| Cover abundance scale | : Presence/Absence |
| Author code | : Strohbach, Ben J. |
| Date (year/month/day) | : 2013/07/18 |
| Relev, area (m2) | : 1000.00 |
| Altitude (m) | : 965 |
| Latitude (degr./min/sec) | : 17-29-29 |
| Longitude (degr./min/sec) | : 24-13-55 |
| Biome/Veg. type | : Forest savanna and woodland |
| Stratigraphy | : Kalahari |
| Cover: Gravel | : None |
| Cover: Small stones | : None |
| Cover: Medium stones | : None |
| Cover: Large stones | : None |
| Rock | : None |
| Landscape type | : Plain (<8 % slope, <100m/km relief) |
| Local topography | : Sand drift plain (covered by >50% sand) |
| Slope class | : Gently undulating, 1-3° (2-5%) |
| Growing period zone | : More than 120 days |
| Lithology | : Eolian |
| Erosion | : None |
| Surface crusting | : none |
| Soil depth | : 180 |
| Disturbance | : Bush encroachment |
| Region | : Caprivi |
| District | : Katima Mulilo |
| Gps_set | : WGS84 |
| Gps_acc | : 8 |

Plot 2013/104: Along Katima-Zambia line, ca 500 m southwards towards station from previous.
Photos DSC08472-DSC08482

| | | | |
|---|---|---|---|
| Acacia erioloba | x | Eragrostis porosa | x |
| Baikiaea plurijuga | x | Hemizygia bracteosa | x |
| Baissea wulfhorstii | x | Hibiscus mastersianus | x |
| Baphia massaiensis s. obovata v. obovata | x | Jacquemontia tamnifolia | x |
| Bidens pilosa | x | Lonchocarpus nelsii | x |
| Combretum elaeagnoides | x | Markhamia zanzibarica | x |
| Corchorus tridens | x | Panicum kalaharense | x |
| Croton gratissimus | x | Schinziophyton rautanenii | x |
| Dactyloctenium giganteum | x | Vernonia poskeana | x |
| Digitaria seriata | x | | |

=> Relevé number: 10637

| | |
|---|---|
| Cover abundance scale | : Presence/Absence |
| Author code | : Strohbach, Ben J. |
| Date (year/month/day) | : 2013/07/18 |
| Relev, area (m2) | : 1000.00 |
| Altitude (m) | : 963 |
| Latitude (degr./min/sec) | : 17-29-44 |
| Longitude (degr./min/sec) | : 24-13-47 |
| Biome/Veg. type | : Forest savanna and woodland |
| Stratigraphy | : Kalahari |
| Cover: Gravel | : None |
| Cover: Small stones | : None |
| Cover: Medium stones | : None |
| Cover: Large stones | : None |
| Rock | : None |
| Landscape type | : Plain (<8 % slope, <100m/km relief) |
| Local topography | : Sand drift plain (covered by >50% sand) |
| Slope class | : Gently undulating, 1-3° (2-5%) |
| Growing period zone | : More than 120 days |
| Lithology | : Eolian |
| Erosion | : None |
| Surface crusting | : none |
| Soil depth | : 180 |
| Disturbance | : Fire |
| Region | : Caprivi |
| District | : Katima Mulilo |
| Gps_set | : WGS84 |
| Gps_acc | : 6 |

Plot 2013/105: Along Katima-Zambia line, ca 500 m southwards towards station from previous.
Photos DSC08486-DSC08490

| | | | |
|---|---|---|---|
| Acacia ataxacantha | x | Dichrostachys cinerea | x |
| Acacia fleckii | x | Digitaria seriata | x |
| Baikiaea plurijuga | x | Hemizygia bracteosa | x |
| Baissea wulfhorstii | x | Jacquemontia tamnifolia | x |
| Baphia massaiensis s. obovata v. obovata | x | Markhamia zanzibarica | x |
| Bauhinia petersiana s. macrantha | x | Pogonarthria fleckii | x |
| Bidens schimperi | x | Pogonarthria squarrosa | x |
| Brachiaria nigropedata | x | Schinziophyton rautanenii | x |
| Bulbostylis hispidula | x | Schmidtia pappophoroides | x |
| Clerodendrum uncinatum | x | Terminalia sericea | x |
| Combretum engleri | x | Tricholaena monachne | x |
| Croton gratissimus | x | Vernonia poskeana | x |
| Dactyloctenium giganteum | x | | |

=> Relevé number: 10638

| | |
|---|---|
| Cover abundance scale | : Presence/Absence |
| Author code | : Strohbach, Ben J. |
| Date (year/month/day) | : 2013/07/18 |
| Relev, area (m2) | : 1000.00 |
| Altitude (m) | : 965 |
| Latitude (degr./min/sec) | : 17-29-58 |
| Longitude (degr./min/sec) | : 24-13-39 |
| Biome/Veg. type | : Forest savanna and woodland |
| Stratigraphy | : Kalahari |
| Cover: Gravel | : None |
| Cover: Small stones | : None |
| Cover: Medium stones | : None |
| Cover: Large stones | : None |
| Rock | : None |
| Landscape type | : Plain (<8 % slope, <100m/km relief) |
| Local topography | : Sand drift plain (covered by >50% sand) |
| Slope class | : Gently undulating, 1-3° (2-5%) |
| Growing period zone | : More than 120 days |
| Lithology | : Eolian |
| Erosion | : None |
| Surface crusting | : none |
| Soil depth | : 180 |
| Disturbance | : Fire |
| Region | : Caprivi |
| District | : Katima Mulilo |
| Gps_set | : WGS84 |
| Gps_acc | : 5 |

Plot 2013/106: Along Katima-Zambia line, ca 500 m southwards towards station from previous. Between last two pylons before power station. Photos DSC08491-DSC08496

| | | | |
|---|---|---|---|
| Acacia ataxacantha | x | Eragrostis porosa | x |
| Acacia fleckii | x | Hemizygia bracteosa | x |
| Baikiaea plurijuga | x | Jacquemontia tamnifolia | x |
| Baphia massaiensis s. obovata v. obovata | x | Lonchocarpus nelsii | x |
| Bauhinia petersiana s. macrantha | x | Markhamia zanzibarica | x |
| Bidens schimperi | x | Panicum kalaharense | x |
| Combretum engleri | x | Pogonarthria squarrosa | x |
| Dactyloctenium giganteum | x | Steganotaenia araliacea | x |
| Dichrostachys cinerea | x | Terminalia sericea | x |
| Digitaria seriata | x | Xenostegia tridentata s. angustifolia | x |