

SUSTAINABLE BARK HARVESTING FOR MEDICINAL USE: MATCHING SPECIES TO PRESCRIPTIONS

W.J. Vermeulen
South African National Parks, Knysna

Abstract

Different forest and woodland species react differently to bark stripping, both in terms of wound closure and susceptibility to insect and fungal attack. Systems for the sustainable harvesting of bark for medicinal use should thus be species specific. To facilitate the development of harvest prescriptions, tree species could be grouped according to their response to bark stripping, based on experimental harvesting results or local knowledge of the species. Two broad categories could be distinguished, namely species that show no wound closure after bark stripping, and species where wound closure occur through phellogen sheet and/or edge development. The latter could be further categorised, based on the rate of wound closure and the extent of insect and fungal damage following bark stripping. Key aspects to a harvest system for strip harvesting include strip width and length, harvest rotation, minimum diameter of harvest trees, percentage of the trees in the population to be exposed to bark stripping, the number and rotation of strips on selected trees, as well as the optimum season for bark stripping. For species that show no wound closure through edge or sheet development, strip harvesting is not a long-term management option. For these species a full-tree harvest system needs to be developed to supply in the demand for bark. Full-tree harvesting would entail the felling of mature trees and the harvesting of all utilisable bark, or the stripping of as much as possible bark off the standing tree if it cannot be felled. In essence, sustainable bark harvesting through full-tree harvesting would entail the development of a timber yield regulation system for the target species.

In areas of high population densities or where natural forest and woodlands have a limited distribution, the demand for bark could exceed volumes that could be supplied through strip or full-tree harvesting. To address over-exploitation and to meet the demand for bark, various management options could be considered. This could include forest conservation and expansion activities, as well as the development of alternative resources.

1. Introduction

Tree bark is a commonly used traditional medicine in South Africa (Grace, 2002; Grace *et al.*, 2002) and beyond (*vide* Cunningham, 1993). The growing demand for medicinal bark, commercialisation and destructive harvest techniques pose a major threat to high demand forest species. Also, a large percentage of especially rural communities still use traditional medicines, with the most valued medicines harvested from natural forest (Lawes *et al.*, 2004). In addition, thousands of people are dependent on the trade in medicinal plants to generate an income. For example, there are an estimated 28 million traditional medicine consumers in South Africa alone, using 19 500 tonnes of plant material per annum, generating an expenditure of R273 million annually (Mander, 1998). Of the important market species, bark is the plant part most commonly used (Mander, 1998), with all indications that the demand will remain high (Mander, 1998; Grace *et al.*, 2002). Considering the importance of the medicinal plant industry and the dependence of communities on traditional medicines, the uncontrolled, destructive harvesting of tree bark (*vide* Cunningham, 1993; Mander 1998; Grace 2002; Grace *et al.*, 2002) from natural forest and woodlands is a growing concern.

2. Options for sustainable bark harvesting and decision tree

Various management options exist to provide in the need for medicinal bark. These include the management of existing natural forest resources, as well as resource expansion through the development of alternatives (*vide* Diederichs *et al.*, 2003; Diederichs 2006). Harvesting from the existing resource could include strip harvesting, full-tree harvesting, the harvesting of bark as a by-product from timber harvesting, and coppice management. The development of alternatives would include the establishment of forest stands (e.g. on the forest edge or in forest gaps) and the cultivation of trees, especially for leaf harvesting. The scope of management options to ensure a sustainable supply of medicinal bark of a particular species would largely depend on the response of the target species to bark stripping.

Following experimental bark harvesting research (*vide* FRP-DFID, 2003, Syampungani, 2005) conducted on a wide range of forest (*Cryptocarya myrtifolia*, *Ilex mitis*, *Ocotea bullata*, *Prunus africana*, *Rapanea melanophloeos*, *Rhus chirindensis*, *Xymalos monospora*, *Zanthoxylum davyi*) and woodland species (*Brachystegia bussei*, *B. spiciformis*, *Dalbergia nitidula*, *Julbernardia globiflora*, *Parinari curatellifolia*, *Pseudolachnostylis maprouneifolia*, *Pterocarpus angolensis*) in southern Africa, a decision tree was developed to aid forest managers with the selection of the most appropriate harvest system for a particular species. The system involves the grouping of species based on their response to bark stripping, incorporating ability and rate of bark regrowth through phellogen edge and/or sheet growth, susceptibility to fungal and insect attack (Appendix 1), as well as other variables such as bark lift from the remaining wood, excretions on the wound surface, etc.

The first step in the choice of a harvest system is to categorise the target species according to their response to bark stripping, based on experimental harvesting or local knowledge of the species. Depending on whether trees recover after bark stripping, a species could be allocated to one of two harvest options (Appendix 1):

A Strip harvesting: Wound closure after bark stripping through sheet and/or edge growth.

B Full-tree harvesting: No wound closure after bark stripping.

Depending on the extent and rate of wound closure through edge and/or sheet growth, species that qualify for strip harvesting could be further categorised to ease the development of harvest prescriptions (Appendix 1):

- 1: Poor rate of wound closure through sheet and/or edge growth (e.g. wound of 5 cm wide not closed within 36 months)
- 2: Fair rate of wound closure through sheet/and or edge growth (e.g. wound of 5 cm wide closed between 24 and 36 months)
- 3: Good rate of wound closure through sheet and/or edge growth (e.g. wound of 5 cm wide closed within 24 months)

Harvest options and prescriptions for sustainable bark harvesting are also affected by the extent of damage through insect and/or fungal attack to the exposed wound after bark stripping. A species could be allocated to one of three classes:

- 1: Major damage through insect and/or fungal attack after bark stripping
- 2: Minor damage through insect and/or fungal attack after bark stripping
- 3: No or negligible damage through insect and/or fungal attack after bark stripping

The different groupings can be defined more clearly as results of experimental harvesting become available.

Not all species that show bark regrowth have the potential to supply a sustainable flow of bark through strip harvesting. Rate of wound closure and extent of damage through insect or fungal attack would be the final determinant of whether strip harvesting is a viable option for a particular species. To identify species with true potential for strip harvesting a combined assessment of rate of wound closure and susceptibility to fungal and/or insect attack is required (Table 1). Based on this combined assessment, a species would either be a clear candidate for strip harvesting or have marginal scope for strip harvesting. For example, a species with a poor rate of wound closure would not qualify for strip harvesting if it suffers major damage through fungal or insect attack after bark stripping, while a species with a poor rate of wound closure but is not susceptible to fungal or insect damage would have marginal scope for strip harvesting. Those species with fair or good wound closure, and that suffer minor or no insect/fungal damage are most likely to sustain strip harvesting (Table 1). Regarding species with marginal scope for strip harvesting, other factors such as bark-lift from the remaining wood, presence of agony shoots, etc. would be the final determinant of whether bark supply could be sustained through strip harvesting.

For those species that do not recover through sheet or edge growth a full-tree harvesting system needs to be developed to supply in the demand for bark.

3. Strip harvesting

Key aspects to a harvest system for strip harvesting include strip width and length, harvest rotation, minimum diameter of harvest trees, percentage of the trees in the population to be exposed to bark stripping, and the number and rotation of strips on selected trees. A decision on harvest prescriptions should be taken after assessing all the variables. There is, however, no fixed rule for the development of such prescriptions. The combined assessment of wound closure and susceptibility to fungal and/or insect attack could guide the formulation of harvest prescriptions for those species that do qualify for strip harvesting (Table 2).

Table 1. Guide for the selection of trees for strip harvesting, based on rate of wound closure and susceptibility to fungal/insect attack

		Fungal and/or insect attack		
		1 Major	2 Minor	3 None or negligible
Wound closure	None	Full tree harvesting	Full tree harvesting	Full tree harvesting
	1 Poor	Full tree harvesting	Full tree harvesting	Marginal scope for strip harvesting ¹
	2 Fair	Full tree harvesting	Marginal scope for strip harvesting ¹	Strip harvesting
	3 Good	Marginal scope for strip harvesting ¹	Strip harvesting	Strip harvesting

¹Consider factors such as bark lift, drying out of bark around the wound edge, thickness of bark regrowth, presence of cracks and excretions on wound surface, etc. for a final decision

Table 2. Recommended strip width and percentage of healthy trees for selection for strip harvesting, based on rate of wound closure and susceptibility to insect/fungal attack of the target species

		Fungal and/or insect attack		
		1 Major	2 Minor	3 None or negligible
Wound closure	1 Poor			5 cm strip 33% of population
	2 Fair		5 cm strip 33% of population	5 – 10 cm strip 50% of population
	3 Good	5 cm strip 33% of population	5 – 10 cm strip 50% of population	10 cm strip 66 % of population
		<ul style="list-style-type: none"> Harvest rotation should allow for wound closure Strip width for sheet growth could be proportional to tree diameter 		

3.1 Strip width and harvest rotation

The faster the rate of wound closure through sheet and/or edge growth, the shorter the harvest rotation or wider the strip width that could be used. With the formulation of harvest prescriptions, though, there is a trade-off between rotation and strip width. The shorter the rotation, the smaller the strip width, and *vice versa*. This is especially the case where wound closure takes place exclusively through edge growth. In addition, the harvest rotation would also be affected by the extent and rate of fungal and/or insect attack. For example, even though the rate of wound closure could be fast, harvesting could still be restricted to a short rotation or small strip width to limit the impact of fungal or insect attack.

Based on experimental research conducted to date, a strip width of 5 to 10 cm seems to be the most likely for the species that recover through sheet or edge growth. Table 2 could be used to guide the selection of strip width for particular species. Where wound closure takes place through sheet growth, strip width could also be proportional to tree diameter. Strip length is more flexible and could be up to 2 m, depending on taper and bark thickness. Depending on the rate of wound closure and the selected strip width, the harvest rotation is likely to be two years or more. Harvesting could either be rotated between trees within a forest stand, or by dividing the stand into smaller harvest units to be worked according to a fixed schedule.

3.2 Number of strips

Various options exist in terms of the number of strips that could be harvested per tree and how it should be rotated around the stem between successive harvests. In the case of large trees and species that recover well after bark stripping, two strips per harvest (e.g. east and west) could be considered. At the next rotation (once full wound closure has taken place) the two strips could be harvested south and north on the stem, etc. In most cases, though, only one strip per harvest is recommended until supporting evidence through long-term monitoring is available that more than one strip at a time could be sustained.

3.3 Diameter of harvest trees and harvest percentage

As smaller trees are more affected by bark stripping, a minimum diameter for harvest trees should be set. Based on experimental harvesting to date, it is recommended that the minimum DBH be set arbitrarily at 20 cm. The DBH could be lowered where supporting evidence is available for a species that the harvesting of smaller trees could also be sustained, or for sub-canopy species.

As the long-term affect of strip harvesting on the survival and longevity of trees is still not known, it is advisable to also restrict strip harvesting to only a certain percentage of the healthy population of the target species. It is recommended that no more than two thirds of the healthy trees of a population be exposed to strip harvesting, and not more than a third for species that have low wound closure rate or are susceptible to fungal or insect attack. Table 2 could be used to guide decision-making on this.

3.4 Harvest season

Experimental results show that response to bark stripping (in terms of e.g. edge growth, sheet growth, susceptibility to fungal and insect attack) could be affected by season of harvesting, and this varies between species (Geldenhuys *et al.*, 2002; Vermeulen & Geldenhuys, 2004). Where possible, this should be considered with the formulation of harvest prescriptions by concentrating harvesting in the seasons that would yield the most positive response to bark stripping.

3.5 Harvest method

An instrument with a thin blade could be used to remove the vertical strip of bark. Measures should be taken to prevent the remaining bark lifting from the wood as this would negatively affect wound recovery, especially regards edge development. The harvesting tool should be inserted at an angle to ensure that the bark is only lifted at the wound side of the edge during the harvest operation. Removing narrow strips of bark, working gradually outwards until the specified strip width is reached would help to prevent bark-lift (*vide* Geldenhuys & Mitchell, 2006).

4. Full-tree harvesting (tree population management)

Full-tree harvesting applies to species that show no wound closure through edge or sheet growth after wounding, and bark supply through strip harvesting can therefore not be sustained. Full-tree harvesting would entail the felling of mature trees and the harvesting of all utilisable bark (including the branches), or the stripping of as much as possible bark off the standing tree if it cannot be felled.

In essence, sustainable bark harvesting through full-tree harvesting would involve the development of a timber yield regulation system for the target species. This would require a growing stock survey, and the gathering of information on rate of turnover (regeneration, increment, mortality, etc.) through long-term monitoring to calculate sustainable harvest levels. For a single-tree selection system, it is advisable that criteria for the selection of harvest trees (based on tree condition) also be developed. Ideally, a use or market for the timber should also be found to ensure the optimum use of the available resource.

It should be noted that full-tree harvesting need not to be confined to species that do not recover after bark stripping. Especially for commercial use where there's a demand for large volumes of medicinal bark, full-tree harvesting would be a more viable option than strip harvesting, provided that a scientifically sound timber yield regulation system is in place.

5. Alternative approaches to bark harvesting

In many areas the supply from natural resources would not be able to meet the demand for medicinal bark, especially regards certain high-demand species. Where communities are dependent on these resources, or where business opportunities exist, this would require the development and provision of alternative resources (*vide* Diederichs, 2006). This must be done in close cooperation with users, to ensure that the alternatives are acceptable. Indications are that the active compounds with healing properties are also present in the thinner bark and leaves (Drewes *et al.*, 2006). Should this be acceptable to users, this would allow more scope for the development of alternative resources. Alternative approaches to bark harvesting could include the establishment of forest stands for bark harvesting, coppice management, as well as the harvesting of medicinal bark as by-product from timber harvesting operations.

5.1 Establishment of forest stands for bark harvesting

This would include the establishment of stands of the target species in open areas, and forest expansion through the establishment of target species on the forest edge (*vide* Geldenhuys 1994). The objective would be to maintain stands of high-demand species from which bark (thin to shorten the rotation) and leaves could eventually be harvested on a sustainable basis. This could be achieved through the establishment of mixed stands of the target species in open areas in riparian zones (protected against fire), within plantation stands (which could serve as a nurse stand for forest development), in forest clearings (protected against fire and grazers), etc. Depending on species, these stands could be exposed to strip or full tree harvesting. The establishment of pure stands of indigenous species, however, could be expensive and an intensive management operation (*vide* Geldenhuys, 1975; Van Daalen, 1988; Lübbe & Geldenhuys, 1991) and for most of the target species probably not a viable option for bark supply for medicinal use.

A more viable option in the shorter term could be enrichment plantings on the forest edge, especially where the target species are already well-represented (e.g. pioneer-like species such as *Rapanea melanophloeos*) and where it borders disturbed areas (such as roads and commercial plantations) and is protected from fire (*vide* Van Daalen, 1988). This would not only provide a resource for bark harvesting, but also contributing towards consolidating the forest area and serve as buffer to outside disturbances.

5.2 Cultivation for leaf harvesting

For species with the active medicinal compound also active in the leaves, as have been found for species such as *Ocotea bullata* (Zschocke *et al.*, 2000; Drewes *et al.*, 2006), stands of the target species could be established and managed in the same manner as tea plantations, keeping the crowns and main stem cropped (Geldenhuys, 2004). This would be much less destructive than bark harvesting and stands would be in production at much earlier age, and would especially be an option for species that could be grown from cuttings or are adapted to browsing. However, indications are that cultivated plants could be poorer in total chemical components (Drewes *et al.*, 2006; *vide* George *et al.*, 2001). For example, for *R. melanophloeos* the chemical compound rapanone was isolated in large quantities from wild plants, but could not be detected from cultivated ones (Mashimbye, 1993 cited in George *et al.*, 2001). Although traditional healers will have to buy into the concept of leaf harvesting, there seems to be general acceptance of propagated medicinal plants by most healers and their clients (Spring & Diederichs, 2006).

5.3 Coppice management

Some species (e.g. *Ocotea bullata*) show active coppice growth at the base of the stem, especially after the main stem was cut or damaged, or died off naturally. This is a potential source for medicinal bark. Often these coppices are heavily browsed by forest antelope and, also through a process of self-thinning, only a few survive to become sizeable trees (Lübbe, 1989). Coppices are a potential source for medicinal bark, which could be optimised through active coppice management. Should traditional healers and other stakeholders buy into the concept of using leaves, leaves as well as bark could be produced through a system of coppice management (rotational harvesting of multi-stemmed trees) (*vide* Geldenhuys, 2004; Mander *et al.*, 2006), similar to the approach used in commercial forestry with the production of *Eucalyptus* timber (Schönau *et al.*, 1994).

The potential for bark harvesting through coppice management is probably limited considering the minimum tree size that would be required for bark harvesting. Where the active compounds associated with healing are also present in the leaves, coppice management for the harvesting of leaves is a more viable option, provided that traditional healers buy into this concept.

5.4 Integrated resource use

Where commercial timber harvesting takes place, the harvesting of non-timber forest products such as bark, should be integrated with the timber harvesting system and the forest management plan for the area. This would allow for different bark harvest options to be implemented in the same forest area, and a maximised bark yield.

Harvest options could include the following:

- Harvesting of bark from trees felled for commercial timber harvesting;
- Harvesting of bark from tree parts remaining in the forest after timber extraction;

- Harvesting of bark from species with a limited market for commercial timber, but are available for harvesting as part of an existing timber yield regulation system, e.g. *Curtisia dentata* in the southern Cape (vide Seydack *et al.*, 1995),
- Strip harvesting in timber harvest areas of species with no or little commercial timber value;
- Coppice management of felled trees (e.g. *Ocotea bullata* and *Prunus africana*).

6. Estimating sustainable yield

With the development of a bark harvest management plan, the demand for domestic use, as well as the potential for commercial harvesting, need to be considered and explored. To this end, the potential bark yield under the various bark harvest options needs to be estimated. This should include yield through strip harvesting under different harvest regimes, as well as full-tree harvesting. The potential bark yield is also critical in assessing whether the demand for bark (domestic or commercial harvesting) in a forest area could be met, and to assess the viability for commercial harvesting. This would determine whether alternative resources for bark harvesting need to be developed.

The volume of bark that could be harvested under different prescriptions and scenarios would depend on the growing stock of the target species, the rate of tree growth and bark production, bark thickness, etc. (vide Lamy, 2006).

7. Concluding remarks

The development of prescriptions and management systems for sustainable bark harvesting should be done in close cooperation with users and other relevant stakeholders. Indigenous knowledge and traditional practices should, as far as possible, be incorporated into harvest systems and accommodated in harvest prescriptions. Also, the needs for domestic use, especially in rural areas where communities are dependent of forest resources for their daily livelihood, should be accommodated first. Only once these needs have been accommodated, could resources be made accessible for commercial harvesting.

Although harvest prescriptions could be based on sound, scientific research and local knowledge of the resources, the long-term impact of strip harvesting on tree growth and the resource is not known. Also, for many species in big demand the relevant information on tree response to wounding is not available, and conservative, interim harvest prescriptions need to be implemented to control use. An adaptive management approach is therefore required for especially strip harvesting. This would entail the monitoring of tree and resource response to controlled harvesting, and the refinement of harvest prescriptions as required, to ensure optimum, sustained use of the available resource in the long-term.

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Addendum 1. Grouping of species based on response to bark stripping to aid with the selection of the most appropriate system for sustainable bark harvesting.

