RESPONSE OF DIFFERENT SPECIES TO BARK HARVESTING FOR TRADITIONAL MEDICINE IN SOUTHERN AFRICA

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Abstract

Bark removal for traditional medicine has a wide range of effects ranging from coppicing to dying of trees. Sustainable bark use requires information on the recovery responses and rates of individual species with different intensities of bark removal in different habitats. An experiment was carried out since July 2003 in Zambia (Miombo woodland), Malawi (Miombo woodland and Afromontane forest) and South Africa (Afromontane forest) to develop an understanding of species responses to bark harvesting. A number of target species for traditional bark harvesting were selected to represent a wide range of diameter class for each species. From each tree a vertical strip of bark of 1 m long and 10 to 15 cm wide were removed in two different seasons: dry season in July to August; and rainy season in January to February. The removed bark was then used to determine the bark thickness, moisture content and bark density of individual species at time of removal. This complemented two other studies in South Africa: the CPWild studies in the southern Cape and Cape Peninsula, and a brief study in the Soutpansberg. A total of 10 forest and 11 woodland species were studied. Bark thickness, density and moisture content varied with vegetation type, season and species. Bark recovery, if it occurred, either developed along the edge of the wound (edge growth) or on the wood (sheet growth) or a combination of the two. Many species exhibited a negative response to bark removal over the experimental period. For some species the study period was too short to show a conclusive response pattern for management prescriptions. The species responses were grouped into four categories for use in management prescriptions.

1. Background

Different tree species have different types of bark. Some are thin and smooth and others are thick and rough. One perception is that natural evergreen forest species generally have smooth and relatively thin bark because conditions in the forest require less adaptation for protection of the stem against regular harmful factors. Woodland tree species by contrast generally have rough bark, often thick, to protect the trees against regular fires burning through the savannas. The question is whether an understanding of bark thickness and surface texture within a particular vegetation type can help us to characterize the recovery response of different tree species after bark damage.

Bark is used for a variety of products such as beehives, fibre, tannin, but particularly for traditional medicine. Increasing urbanization commercialized the use of bark for traditional medicine, particularly for a number of selected species (Mander, 1988; Williams, 2003). This resulted in the over-exploitation of some target species from both protected and non-protected natural forests and deciduous woodlands, posing a major challenge to resource managers to develop mechanisms for sustainable resource use and forest protection.

Field observations showed that bark harvesting has a wide range of effects. Some species recover well and fast but others recover slowly or not at all. Some species easily die and others recover by vegetative shoot regrowth. Within a species, responses can vary depending on habitat conditions and the levels of stress a tree is exposed to. The impacts on the vegetation include loss of structure, and loss of some intensely used species. Eventually it can also impact on the future business of bark users.

Sustainable bark use requires information on the growing stock and population status of targeted species, and their recovery responses and rates after bark removal (Geldenhuys & Mitchell, 2006). We can look at responses from two sides: a resource inventory; and experimental treatment of trees. Several studies of bark response to damage were done in southern Africa since about 2000. This paper outlines some of these studies in South Africa, Malawi and Zambia, and the general response patterns, as a basis for recommended improved management of bark use from trees.

2. Bark harvesting experiments

2.1 CP Wild studies in Afromontane forest

2.1.1 Survey in Umzimkulu forests

Bark use for traditional medicine was one of four main study components of the Innovation Fund Project 'Commercial Products from the Wild (Geldenhuys, 2002; www.cpwild.co.za). The studies were started in 2000 and continued until 2003 (Geldenhuys, 2004). Four forest species were selected for study: *Ocotea bullata, Curtisia dentata, Rapanea melanophloeos & Prunus africana*. At the start a rapid assessment was made in 13 forests in the Umzimkulu District of the species used, and the impact on their condition (crown condition, wound recovery and vegetative recovery (Geldenhuys, 2004). The study showed that of the 95 species recorded, 36 species were harvested, and of the 7281 stems recorded, 6.1% were harvested. The major impact was, however, on a few target species. For *O. bullata* 359 stems were recorded of which 57.4% were harvested. For the three other main species the values were: *C dentata*: 50 stems, 60.0% harvested; *P africana*: 10 stems, 70.0% harvested; *R melanophloeos*: 124 stems, 38.7% harvested. The four main tree species responded differently to bark harvesting, in terms of both bark regrowth and vegetative regrowth. The extent to which a tree was ring-barked (percent of bark removed from the circumference of the stem) had a greater effect on the decline in crown condition than the percent of total bark removed from the main stem.

2.1.2 Bark harvesting experiment in Southern Cape forests

In response to the Umzimkulu survey results, a bark harvesting experiment was implemented in the southern Cape forests (Geldenhuys, 2004; Vermeulen & Geldenhuys, 2004): in two sites (drier Groenkop forest and moister Witelsbos forest), with three species (*O. bullata* [only Witelsbos], *C. dentata* [both sites] and *R. melanophloeos* [only Groenkop]), two seasons (July [dry season] and December [rainy season] 2001), three stem diameter categories (10-19 cm, 20-39 cm and 40+ cm), 1 m long vertical strips in three widths (5 cm, 10 cm and 20 cm [15 cm on trees <20 cm DBH]). A strip was made on two sides of a tree. On the one side all the bark down to the wood was removed, and on the other side only the outer bark was removed. The bottom half of each strip was painted with tree seal. A total of 360 trees were treated. Assessments were done every 6 months.

2.1.3 Cape Peninsula observation of illegally harvested trees

In Newlands Forest on the Cape Peninsula, members of the Afro-Montane Information Forum (a local NGO) collected data of bark-stripped trees since 1990 when the first stripped tree was located. Since then and until 2001 about 160 found stripped trees were documented and monitored (Du Toit, 2000). In order of importance, the species recorded were (number of trees observed between brackets): *Rapanea melanophloeos* (67), *Ilex mitis* (34), *Curtisia dentata* (23), *Ocotea bullata* (13), *Olea capensis* subsp *macrocarpa* (12), *Brabejum stellatifolium* (5), *Diospyros whyteana* (2), and one tree each of *Maytenus acuminata, Cassine peragua, Cunonia capensis, Olinia ventosa* and *Apodytes dimidiata*. Officials of the Table Mountain National Park recorded the following information for each stripped tree: Tree number; Dates of first and subsequent observations; Species; DBH of each stem; Estimated debarked surface area of stem; Height of bark removal; Condition of crown; Number and condition of vegetative shoots developing; and Status of bark recovery. Du Toit (2000) assessed the response of four randomly selected trees of each of the five main targeted species that were recorded over the last three years to describe the pattern of response.

2.2 FRP-DfID bark studies in southern Africa

In response to the CP Wild studies, the Forest Research Programme of the Department for International Development of the United Kingdom (FRP-DfID) initiated Project R8305 on 'Developing biometric sampling systems and optimal harvesting methods for medicinal tree bark in southern Africa' (Wong, 2003). Output 2 of the project was concerned with 'Best practice bark harvesting techniques developed for trees with different ecophysiological profiles'. The bark harvesting study was designed to determine bark response patterns and rates in 17 tree species during the dry and rainy seasons in evergreen Afromontane forest and deciduous Miombo woodland (Geldenhuys, *et al.*, in prep). The study was done during July 2003 – March 2006 in South Africa, Malawi and Zambia. In each country, two main study areas were selected. In South Africa, the study areas were in the evergreen forests of the southern Cape and Umzimkulu District. In Malawi, the study areas were in the Zomba District (Zomba Mountain Forest Reserve, evergreen forest) and in the Machinga District (Liwonde Forest Reserve, Miombo woodland), in the Southern Region of the country. In Zambia, the study areas were in Mwekera National Forest near Kitwe, and Kaloko Trust area south of Ndola, both Miombo woodland areas. The selected species represented the two vegetation formations: sometimes a species was selected from different sites; or species groups were selected from the same genus or family. A few main target species were selected in each study area (species with enough trees to select 40 to 50 trees in similar habitat and relatively close proximity). A smaller sample of less common but useful tree species with 10 to 20 trees per species per study area was selected, when the trees were found in any of the sites, to provide for a broader comparison. The species selected were:

South Africa, Southern Cape: *Ilex mitis*, *Ocotea bullata, Prunus africana* (planted), *Rapanea melanophloeos* and *Rhus chirindensis*.
South Africa, Umzimkulu District: *Cryptocarya myrtifolia, Prunus africana* and *Zanthoxylum davyi.*
Malawi, Zomba Mountain: *Prunus africana, Rapanea melanophloeos* and *Xymalos monospora*
Malawi, Liwonde Miombo woodland: *Brachystegia bussei, Brachystegia spiciformis, Dalbergia nitidula, Julbernardia globiflora, Parinari curatellifolia, Pseudolachnostylis maprouneifolia* and *Pterocarpus angolensis*
Zambia, Mwekera Reserve and Kaloko Trust: *Brachystegia spiciformis, Dalbergia nitidula, Julbernardia paniculata, Parinari curatellifolia* and *Pseudolachnostylis maprouneifolia,*

Trees were selected to present the range of sizes of a particular species in a particular site, but where possible trees had to be 20 cm or more in DBH (stem diameter at breast height). Only completely healthy trees, and only single-stemmed trees (for *Prunus* and *Rhus* in southern Cape one stem of multi-stemmed trees were also selected), were selected for treatment. Paired samples, where possible, were used (trees of approximately similar size in close proximity to each other) to treat one tree of a pair during the dry season (July - August 2003) and the other one in the rainy season (January - February 2004). The response of a tree to harvesting of a strip of bark of 1 m long and 10 – 15 cm wide was assessed every six months by the type and rate of bark recovery, effects of fungi and insects, and by changes in the condition of the tree crown.

2.3 Market-related bark studies in Limpopo Province, South Africa

Bark was sampled from six tree species in the Limpopo Province in northern South Africa during 1998 to link bark thickness recorded during ethno-botanical surveys in the traditional medicine markets of Johannesburg with the relationship between bark thickness and stem diameter at breast height (DBH) (Williams, *et al*., in prep). Samples of bark were removed from 207 stems selected from various DBH classes. A hole-saw attached to a brace was used to cut and remove 50 mm diameter circular bark discs from each selected tree at 0.5 m, 1.0 m, 1.3 m and 1.5 m above ground level. During 2004 five of the species (*Albizia adianthifolia, Balanites maughamii, Elaeodendron transvaalense, Rhus chirindensis* and *Warburgia salutaris*) were revisited in four of the original sites to quantify the nature and extent of bark re-growth, wound recovery and trunk diameter growth over six years (Williams & Geldenhuys, 2004).

3. Results

A wide range of species were studied: 11 Afromontane forest species and 11 Miombo and other woodland species. Species varied in their response to debarking, both in terms of wound recovery and closure and susceptibility to insect and fungal attack (Du Toit, 2000; Vermeulen & Geldenhuys, 2004; Williams & Geldenhuys, 2004; Geldenhuys, *et al.*, in prep). Bark regrowth on the wound is either by edge growth (from the edge of the wound), or sheet growth (on the wood in the wound), or both. Fungal and insects infestations were prominent in some species. Insects caused either pinholes on the wood surface and in some woodland species, termite formed soil tunnels on the wood surface. Some species produced excessive gum exudates, or showed severe bark lift on the edges of the wound, or cracks in the wood on the exposed part of the wound. Several species showed one or other form of vegetative regrowth, i.e. either through stem sprouts (around the wound), coppice shoots at the base of the stem, or root suckers. The general response pattern of each species is summarized in Table 1.

Table 1. Summary of the responses of different southern African forest and woodland species to bark wounding (adapted and expanded from Geldenhuys and Mitchell, 2006)

Species	Country+	Bark recovery*	Vegetative regrowth**	Other responses
Evergreen forest species				
Cryptocarya myrtifolia	S	None or very slow EG	No to few SS	
Curtisia dentata+	S	Fair SG & EG, but slow	Good SS & CS	Some bark lift; Some Pinhole & fungi development; Wound wood cracked
Ilex mitis	S	Very good SG & poor EG	Some SS & CS	Strong bark lift; Little fungi & pinholes
Ocotea bullata	S	Very good EG & some SG	Some SS & good CS	Very little bark lift; Few pinholes, some fungi
Olea capensis macrocarpa	S	Good EG & SG	SS soon died	Wood in wound cracked on drying
Prunus africana	M, S	Very good SG & EG	Some SS, Poor to good CS	Bark lifted sometimes; Yellow/white jelly excretions; Few pinholes, some fungi
Rapanea melanophloeos	M, S	No (S) to good EG (M)	Some SS, poor CS, but die soon	Some bark lift & pulling away from wound; Very prone to pinhole damage & fungal development
Rhus chirindensis	S	Good to poor EG & SG	Some SS, good CS	Some bark lift; White sticky excretion; Some pinholes & some fungi
Warburgia salutaris	S	Good EG	Yes?	
Xymalos monospora	M	Poor SG	Some SS * CS (died later)	Some bark lift
Zanthoxylum davyi	S	Poor & slow EG	Poor SS	Some excretions; Wood cracked; Fungal development
Deciduous woodland species				
Albizia adianthifolia	S	Very good EG	None	
Balanites maughamii	S	Poor & slow EG	None	Stems fluted;
Brachystegia bussei	M	Poor & slow EG, no SG	Some CS	Severe bark lift; Excretions on wound edge; Many pinholes
Brachystegia spiciformis	M, Z	Very poor & slow (M) to good (Z) EG	None	Severe bark lift; Excretions on wound edge; Many pinholes & strong termite activity
Dalbergia nitidula	M, Z	Good (M) to Poor (Z) SG & EG	None (M), Yes (Z)	Some bark lift; Few pinholes & strong termite activity
Elaeodendron transvaalense	S	Very slow EG	None	
Julbernardia globiflora	M	None	None	Some bark lift; Excretions along wound edge; Many pinholes & high termite activity
Julbernardia paniculata	Z	Poor EG, no SG	None	Many pinholes, high termite activity and fungal development
Parinari curatellifolia	M, Z	Poor & slow (M) to good (Z) EG, no SG	None (Z) to some SS (M)	Strong bark lift; Few pinholes
Pseudolachnostylis maprouneifolia	M, Z	Good (M) to very good (Z) SG & EG	None (M) to some SS (Z)	Few pinholes
Pterocarpus angolensis	M	Good SG & EG	None	Strong bark lift; Excretions along wound edge; Few pinholes but termite activity

+ M = Malawi; S = South Africa; Z = Zambia. * EG = edge growth; SG = sheet growth.
** CS = coppice shoots; SS = stem shoots

3.1 Descriptive response of individual species

Bark descriptions are based on Palgrave (2002) and Storrs (1995). Bark recovery responses are based on Du Toit (2002), Geldenhuys (2004), Vermeulen and Geldenhuys (2004), Williams and Geldenhuys (2004) and Geldenhuys, *et al.* (in prep). Sustainable bark harvesting refers to the specific tree, i.e. the bark on the tree can or cannot recover for future harvests.

3.1.1 Evergreen forest species

Cryptocarya myrtifolia (Lauraceae): The bark is relatively smooth and thin. Generally no bark lift but it occurred in some trees. If wound recovery occurred it happened very slowly, mainly through edge growth. Sheet growth occurred when cambium was left during harvesting (but soon died). Occasionally stem shoots developed around the wound. Bark cannot be harvested sustainably.

Curtisia dentata (Cornaceae): The bark is smooth in younger trees but becomes square-fissured and is relatively thin. Wound recovery was slow and poor to medium good, mainly with edge growth (up to 4 cm thick in Newlands, in Southern Cape better with dry season treatment), and poor (Newlands) to good sheet growth (Southern Cape, better with rainy season treatment). Good coppice shoots developed, up to 2 m tall (Newlands), and also some stem shoots around the wound. Pinholes were present (even through tree seal in Newlands). Stem weakening through pinholes and wood cracks (and fungi) caused windfalls (Newlands). Bark can be harvested sustainably if the strips are narrow, but recovery is slow. Severely harvested trees can survive through fast growth of coppice shoots into substituting stems.

Ilex mitis (Aquifoliaceae): The bark is relatively smooth except in old trees, which have rougher and slightly fissured bark. Strong bark 'lift' occurred (Southern Cape, because inner part of bark rot or crumbed away). Wound recovery was very good and fast through sheet growth (but thin, and better after rainy season treatment), and some edge growth (better after dry season treatment in Southern Cape). Both coppice and stem shoots (minimal) developed, and can grow fast. Level of fungal and insect development was low. Few stem shoots but some coppice shoots developed. Bark can be harvested sustainably.

Ocotea bullata (Lauraceae): The bark is smooth and thin in young trees, but becomes rough, scaly and thick in older trees. Little bark lift occurred, and if present, it was quickly filled by edge growth. Wound recovery was relatively fast through thick edge growth (better after dry season treatment in Southern Cape), and sheet growth (better after rainy season treatment in Groenkop) developed when some cambium was left behind on the wound. Many coppice shoots developed, with occasionally stem shoots around the wound. Level of fungal (external) and insect development was low. Ring-barking caused rapid decline in crown condition, and when a tree died even the coppice shoots that were not rooted in the ground also died. Bark can be harvested sustainably if the harvested strips are narrow enough to be closed by edge growth. Severely harvested trees can survive through fast growth of coppice shoots into substituting stems, if the dying tree is cut before it dies.

Olea capensis subsp. *macrocarpa* (Oleaceae): The bark is slightly rough and thick. Wound recovery was good through edge and sheet growth. Sheet growth developed well underneath tree seal. If stripped onto the wood, the wood dried quickly and cracked. Small stem sprouts developed but died again. Bark can be harvested sustainably if done in narrow strips.

Prunus africana (Rosaceae): The bark is smooth and thin in young trees, becoming rough and thick in older trees. Bark lifted in Southern Cape and Zomba (more after dry season treatment in Southern Cape) but no to very little lift occurred in Umzimkulu. Yellow/white jelly excreted (black in Southern Cape) along wound edge. Wound recovery was often 100%, mainly through sheet growth, in illegally harvested trees. The experimental trees showed very good sheet (60% of wound covered after 12 months in Southern Cape and better after rainy season treatment) and edge growth (better after dry season treatment in Southern Cape). Level of fungal and insect development was low. Significant pinhole damage developed (Zomba). Coppice shoots can develop, particularly on stumps of cut trees, and occasionally stem shoots developed. Bark can be harvested sustainably.

Rapanea melanophloeos (Myrsinaceae): The bark is relatively smooth with conspicuous lenticels when young, but become rough and thick in older trees. Significant bark lift was small (Zomba) to significant with wound widening (Southern Cape). Woodpecker holes were observed around wounds of many trees (Southern Cape). Edge and sheet growth was none to poor in South Africa but good in Zomba. Occasionally stem shoots developed (around lower part of wound in Southern Cape) but they soon died. In Newlands the tree died with 60% and more bark removal around stem. Wounds are very susceptible to fungal and insect (severe) development. Pinholes and cracks on exposed wood, with internal fungal development, weakened the stems to cause windfalls (Newlands). Bark cannot be harvested sustainably.

Rhus chirindensis (Anacardiaceae): The bark is slightly rough but relatively thin. Bark lift was severe, especially after the rainy season treatment. White sticky excretion developed after wounding (Southern Cape). Wound recovery through edge growth was very good (Limpopo) to poor (Southern Cape, better after rainy season treatment), but sheet growth was poor (Southern Cape) (good sheet growth was observed in illegally harvested trees). Wounds were susceptible to minor insect damage but fungal development was low. Some coppice shoots and occasional stem sprouts developed. Sustainable bark harvesting is doubtful, unless bark lift could be prevented.

Warburgia salutaris (Canellaceae): The bark is relatively rough and thin. Wound recovery was good and fast through edge growth, both on trees planted in archaeological sites and in natural stands (no sheet growth was observed). Edge growth rate depended on site, position of tree in the stand, direction of wound in relation to movement of the sun, and presence of termite tunnels (beneficial to recovery). No vegetative regrowth was recorded. Bark could be harvested sustainably, if in narrow strips.

Xymalos monospora (Monimiaceae): The bark is relatively thin and flakes off in large pieces. Bark lift was small. Wound recovery was slow, mainly through poor sheet growth. Some stem sprouts and coppice shoots developed but died later. Bark cannot be harvested sustainably.

Zanthoxylum davyi (Rutaceae): The bark is smooth and thin, even in old trees (with woody, horn-like knobs developing). Bark did not lift and gum excretions developed along the bark edge. Wound recovery through edge growth was poor and slow, and no sheet growth was recorded. The wood on the wound cracked. Fungal development occurred over the entire wound. Occasional stem sprouts developed. Bark cannot be harvested sustainably.

3.1.2 <u>Deciduous woodland species</u>

Albizia adianthifolia (Fabaceae: Mimosoideae): The bark is relatively rough, forming shallow squares, but is relatively thin. Wound recovery was rapid and complete (100%) through edge growth (in the small circular holes). Some sheet growth developed in trees damaged by vehicles. Bark can be harvested sustainably if the strips are narrow.

Balanites maughamii (Balanitaceae): The bark is smooth and thin, and the stem is deeply fluted. Wound recovery through edge growth was often non-existent but if present was poor to good but slow. No vegetative shoots were recorded. Retention of some cambium after porcupine damage at the base of a few trees enabled sheet growth recovery. Tree seal had no effect on wound recovery. Bark cannot be harvested sustainably.

Brachystegia bussei (Fabaceae: Caesalpinioideae): The bark is smooth and sparsely flakes into thick, round discs. Bark lift was significant. Excretion developed from the wound edge. Wound recovery through edge growth was poor and slow, with no to little sheet growth. Pinhole damage was significant. Occasionally coppice shoots developed. Bark harvesting cannot be done sustainably.

Brachystegia spiciformis (Fabaceae: Caesalpinioideae): The bark is smooth when young, becoming rough, fissuring deeply vertically and cracking coarsely horizontally, slowly flaking in thick, irregular scales. Bark lift was significant (Liwonde). Excretions developed along the wound edge (Liwonde). Wound recovery through edge growth was very poor and slow (Malawi) to good (Zambia, beter after dry season treatment Mwekera). Pinhole damage was significant and lots of termite activity was noted. No vegetative growth was recorded. Bark cannot be harvested sustainably.

Dalbergia nitidula (Fabaceae: Papilionoideae): The trees are relatively small with very rough and fissured bark that flakes off. Bark lift was small (Liwonde). Wound recovery was good (Malawi) to poor (Zambia, better after dry season treatment), both through edge and sheet growth. Few pinholes were noted with high termite activity on the wound (Liwonde). Vegetative shoots were recorded for Zambia but not for Malawi. Bark can be harvested sustainably.

Elaeodendron transvaalense (Celastraceae): The bark is smooth and relatively thin. Wound recovery was very slow through some edge growth. This appeared to be heat stimulated (sun exposure, fire). No vegetated shoots were observed. Bark cannot be harvested sustainably.

Julbernardia globiflora (Fabaceae: Caesalpinioideae): The bark is smooth when young, becoming rough later. Bark lift was small (Liwonde). Excretions developed along the wound edge (Liwonde) No wound recovery and no vegetative regrowth were recorded. Significant to pinhole damage and high termite activity on wound were noted (Liwonde). Bark cannot be harvested sustainably.

Julbernardia paniculata (Fabaceae: Caesalpinioideae): The bark becomes rough with age. Wound recovery through edge growth was low but with no sheet growth. Significant fungal presence and pinhole damage with high termite activity were recorded (Mwekera). No vegetative regrowth was recorded. Bark can be harvested sustainably if in narrow strips.

Parinari curatellifolia (Chrysobalanaceae): The bark is relatively rough and thick. Bark lift was significant (Liwonde). Wound recovery through edge growth was poor and slow (better in Mwekera), with no sheet growth (some in Liwonde). Few pinholes occurred (Liwonde). Some vegetative shoots were recorded in Malawi but not in Zambia. Sustainable bark harvesting is doubtful.

Pseudolachnostylis maprouneifolia (Euphorbiaceae): The bark is relatively smooth but fissures and cracks into squares. Wound recovery through both edge and sheet growth was good (Malawi) to very good (Zambia). In Mwekera edge growth developed much better in dry season with no seasonal difference in sheet growth. Few pinholes occurred (Liwonde). Vegetative shoots developed in Zambia but not in Malawi. Bark can be harvested sustainably if in narrow strips.

Pterocarpus angolensis (Fabaceae: Papilionoideae): The bark is rough and fissured with a reddish sap excreting when the bark is damaged. Bark lift was significant but soon filled with edge growth. Excretions developed from the wound edge. Wound recovery was good through both edge and sheet growth. Few pinholes developed but high termite activity occurred on the wound. No vegetative shoots were recorded, although the stem, when cut, can develop coppice shoots. Bark can be harvested sustainably.

4. Discussion

The results from the different studies do provide a basis for generalised management prescriptions. The many different tree species, some within the same genus or family, from the two main vegetation formations in southern Africa, evergreen Afromontane forest and deciduous Miombo woodland, show four generalised patterns of recovery. Wounds recover through edge growth or sheet growth, or both, or they do not recover in a reasonable time. The rate of recovery is very good and fast in some species to very poor and very slow in others.

Fungal and insect infestations become important in the species that show no to slow wound recovery. The pinholes and wood cracks become entry points for fungi into the wood (J. Roux, personal communication, 2006) to weaken the stem to a point that the tree either dies or snaps. This was evident in the Newlands forest where trees were observed over a relatively lengthy period (Du Toit, 2000) and in southern Cape with smaller trees in CPWild study.

Termite tunnels on the wound are prominent in some of the woodland species but they do not pose a threat to the tree. They are superficial and may even prevent the wood from drying out.

The observations during the Umzimkulu survey showed the importance of coppice shoots in the survival of severely debarked trees (Geldenhuys, 2004). *Ocotea bullata* developed good coppice regrowth, but the coppices died if the tree died. However, if the tree was cut before it died, the coppice shoots grew fast (3 to 4.5 m in height in 18 months) and ensured the survival of the tree. Species with the ability to develop coppice regrowth have a better chance to survive than species that do not have that ability.

Species in which the wounds do not recover easily could still be harvested for their bark, but in a different approach. Such species could be considered for cutting the tree in a selection system and using all the bark on the stem and branches. For example, *Rapanea melanophloeos* often form good regeneration in dense stands on the forest margin. Selective felling of such stems for bark use could thin the stand and facilitate better growth of the remaining stems (Geldenhuys, 2004).

There are many other species that are harvested for their bark that have not been studied for better management. The different studies show that we do not have to test many trees to know how a species would respond. The Limpopo study (Williams & Geldenhuys, 2004) showed that cutting the small circular discs provides an easy method for the assessment of bark recovery. Scars can be made around the stem at different heights to test the effect of different factors. This will require fewer trees to be treated and with less damage to a specific tree. The lateral widening of the circular scar can also give some indication of the extent of stem diameter growth. Another approach would be to do specific observations during a resource inventory in terms of the edge and sheet recovery of a wound, and the development of vegetative shoots.

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