# THE ECONOMIC AND ECOLOGICAL FEASIBILITY OF HARVESTING WILD FOREST TREE SEED OILS, WITH SPECIAL REFERENCE TO COASTAL RED- MILKWOODS

COVER PAGE

**Dr Derek Berliner**

**Eco-logic consulting**

February 2015

**PART 1: SUMMARY REPORT**

CEPF FINAL PROJECT COMPLETION REPORT FORMAT

# ECONOMIC AND ECOLOGICAL FEASABILITY OF HARVESTING WILD FOREST TREE SEED OILS WITH SPECIAL REFERENCE TO THE COASTAL RED-MILKWOODS

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## BASIC DATA

**Organization Legal Name**
Derek Berliner, (sole proprietor) Eco-logic consulting

**Project Title**
ECONOMIC AND ECOLOGICAL FEASABILITY OF HARVESTING WILD FOREST TREE SEED OILS WITH SPECIAL REFERENCE TO THE COASTAL RED- MILKOODS

**Project Dates**
29 February 2014-29 February 2015

**Date of Report**
February 2015

## OPENING REMARKS

The project site, (Mdumbi river mouth to Umtata river mouth), falls within Pondoland region of the Maputoland-Pondoland-Albany biodiversity hotspot, one of the smallest regions of floral endemism in the world. (See map in detailed report fig 1). Apart from high plant endemism, the scarp forests of the Wild Coast, have the world's highest levels of tree diversity for temperate latitude forest, and are of global biodiversity significance, (Silander, 2001, Berliner, 2009). However, these forests face escalating threats, from multiple causes, including: invasive alien plants, illegal timber and medical plant harvesting, hunting, slash and burn agriculture, livestock and climate change related impacts.

Levels of rural poverty in Pondoland are some of the highest in South Africa. Currently, communities have few incentives to apply any form of conservation in forest use, particularly where livelihoods may be effected (such as not grazing livestock in forests, or medicinal plant harvesting, bark stripping, poaching , hunting, slash and burn agriculture). Traditionally, tribal authorities have played an important role in resource management, but increasingly, both forestry officials, and tribal authorities are unable, or unwilling, to control resource exploitation, and compliance with state forest regulations are seldom enforced. In effect, there is absolutely no conservation management of the Wild coast's valuable forests, and a 'free for all' situation exists. This situation will continue to escalate unless local communities can be given a sufficiently attractive forest based alternative livelihood opportunities, and are included within a participatory forest management framework. Scarp forest are inherently ecologically sensitive, and although they do not lend themselves to conventional logging, they can still, if managed correctly, provide significant renewable harvestable resources, particularly in the form of Non Timber Forest Products, that can improve livelihood security and incentivise local conservation practises. With state forestry, and conservation authorities in the Eastern Cape, being unwilling or unable to carry out their mandates with regard to community forestry development or forest conservation, it increasingly appears that if these forest are to be saved for future generations, NGO's and the private sector will be required to take up this challenge,

Recent growth in the national and international market for natural, organic food, and natural health and cosmetic products (Vermaak *et.al,* 2011), has provided an opportunity to investigate and develop markets for sustainably harvested, wild non-timber forest products

This study looked into the feasibility of harvesting three species of wild forest tree seed oils, that have a potential commercial value. Specific focus was given to the economic and ecological feasibility of harvesting Coastal Red-milkwood seeds (*Mimusops caffra*), as a potential Non Timber Forest Product. To date, this species has never been utilised commercially, nor has any research been conducted on the nutritional, or other uses of the seed oils. In addition, two other species of wild tree were also considered for commercial seed oil harvesting. These include the Cape Chestnut, (*Calodendrum capense)*, and the Forest Mahogany, (*Trichiia dregeana*). The former species has been successfully commercialised for its seed oil in Kenya, but never in South Africa. The later species, has also never been commercially utilised, although its close relative, the Natal Mahogany (*Trichiia natalensis)*, has been used traditionally used in Mozambique to produce Trichelia oil, also known as 'Mafurra butter'. Analysis shows that the seed oil of the forest mahogany is comparable with that of the Natal Mahogany, and may even give higher yields.

This project included both field work, to determine potential oil, and fruit yields, as well as laboratory analysis to understand the nutritional composition of Coastal Red-milkwoods, and its potential uses. This is the first time that this species has been the subjected of this kind of analysis.

Coastal Red-milkwoods, (*Mimusops caffra*), are the dominant tree found in the coastal forests along the Eastern Cape, and can be considered as an iconic, flagship species for the conservation of this regions forested dune systems. They play a critical function in stabilising coastal dune ecosystems, and as such can be considered as a key stone species.

This study confirms earlier reports (Berliner, 2010, Berliner 2011a Berliner 2011b, see references in main report), that many of the dune forest patches, along the Wild Coast, dominated by *Mimusops caffra* are rapidly degrading. Population analysis of the Milkwood dune forest done in the course of this study have clearly shown the near absence of regeneration for the dune forest within the Mdumbi dunes section of the pilot study area (see section 3.1 and 4.1 of the main report). While this tree does coppice, the absence of seedling regeneration is of concern to the long term persistence of these forests. In response to this finding, this project, in conjunction with Mdumbi backpackers, initiated a seedling recovery and dune rehabilitation project. About 150 Coastal red milkwood seedlings were rescued from the forests ( 99 % are trampled or eaten by livestock) and were placed within a nursery, where they are currently being grown out and will replanted back into the forests, when they have reached about 1.5 meters high. Six months after transplantation into nursery bags, a 80 % seedling survival rate was reported.

## ACHIEVEMENT OF PROJECT PURPOSE

**Project purpose:**

To investigate the economic and ecological feasibility of utilising wild tree seed oils as a sustainably harvested non- timber forest product, that can provide alternative forest based livelihoods. This can serve as a replicable model to leverage improved conservation practises and livelihood opportunities to poor communities living in close association to the valuable forests, of the Wild Coast, South Africa.

**Planned vs. Actual Performance**

| Planed | Actual Performance |
|---|---|
| Determine the nutritional and lipid profile of Coastal Red-milkwoods (*Mimusops caffra* ) seed oil , and potential uses | • Micro and macro nutritional analysis of Coastal Red milkwoods seeds completed.<br>• Lipid profile compared to other African seed oils completed.<br>• Potential uses suggested but not tested.(possible unique properties may be discovered that relate to unique balance of lipid types in the oil). |
| Determine ecological feasibility of *M. caffra*, milkwood seed harvesting | • Wild stocks mapped by mapping Milkwood dune forest in GIS: for pilot study site.<br>• Dune forests mapped for expanded project site (including Ntsubane forest complex ,and coffee bay area).<br>• Population age structure model developed using tree diameter size measurements. Shows near absence of seedling recruitment, and abnormal dye off of mature trees.<br>• Age studies using tree rings analysis, shows great age of Milkwoods<br>• Harvesting up to 70 % of seed produced will have minor impact on recruitment rates.<br>• Potential long term seed harvesting impacts |

| | |
|---|---|
| | considered, mitigated by supplementary planting of nursery grown out saplings |
| Determine economic feasibility of Coastal Red milkwood (*M. caffra)* seed harvesting community enterprise | • Mean yield of Milkwood see oil: 10.5 litres /ha<br>• Mean yield of fresh fruit pulp: 65.3 kg/ha<br>• The mean value of six similar African oils currently sold on the internet was 189 $/litre<br>• Modelled annual income to suppliers for both milkwood seed oil and dry fruit in *pilot* site only (33 ha) : 11 516 $<br>• Modelled annual income to suppliers for both milkwood seed oil and dry fruit in expanded project area(132 ha): 58 656 $<br>• Employment potential for pilot site only : 6 jobs for 4 months of the year<br>• Employment potential for expanded project site : 74 jobs for 4 months of the year |
| Initiate a restoration project for the Mdumbi dune forests | • Awareness created amongst local population and local tourism resorts<br>• 150 Coastal red milkwood seedlings were potted by me, and are currently being raised in Mdumbi backpackers nursery. |
| Investigate if sufficient numbers of two other potential wild tree seed oils species ( Cape Chestnut, and Forest Mahogany) occur within the study site to warrant further investigation | • Populations of Forest Mahogany mapped with coordinates (about 20 trees found around Mdumbi valley)<br>• No Cape Chestnut trees were found in pilot study site (difficult to find in forest outside of flowering season) |
| Improve national, local, global awareness of the importance and state of the coastal dune forest systems of the Wild Coast.<br>Raise funds to assist in implement project findings | • Article written for MPAH, newsletter put out by SANBI *http://biodiversityadvisor.sanbi.org/wp-content/uploads/2014/10/MPAH_Newsletter_Winter2014.pdf*<br>• Presentation on project at MPAH feedback conference<br>• Face book page created: *https://www.facebook.com/wildseedoil*<br>• Slide share site created *www.slideshare.net/derekberliner/superfoods-from-the-fores*<br>• Chivandi, E, and Berliner D. D. (in prep). Red Milkwood (*Mimusops caffra*) Seed: proximate, fibre and mineral composition and the amino acid and fatty acid profile. South African Journal of Botany. |

***Successes and problems of the project in achieving objectives***

The project was successful in achieving its main objectives. The successes and problems encountered are described briefly below.

**Key successes**

- The models developed, demonstrated that a Wild tree seed oil harvesting enterprise based on Coastal red milkwood seed oil , is both economically and ecologically feasible, and could catalyse significant social and environmental benefits, in the form of job creation and improved conservation management.
- The nutritional analysis of Coastal red milkwood seeds contribute to the scientific understanding of this tree , and its potential commercial value of wild foods.
- The project highlights the need for further research into the potential of other wild tree seed oils besides milkwoods. Two species in particular, with high commercial potential, include: Forest mahogany, and Cape chestnut. These two species, unfortunate, did not occur in the pilot study site, in significant numbers to warrant harvesting, however they appear to occur in higher densities in the forest around Port St John's and the Nstubane forest, to the north of Port St John's. This requires further investigation.
- This project has improved understanding of the population dynamics, conservation status, and threats to coastal dune forests of the Wild Coast. The discovery of near absence of seedling recruitment, and high mature tree mortality, in many of the forest in the pilot study site is of some concern.
- This project initiated a dune rehabilitation project for the Mdumbi beach dunes. About 150 Coastal red milkwood seedlings were placed into nursery bags and are currently being looked after in the Mdumbi backpackers nursery. These will be replanted back into the dune forest when 1.5 meters. This project has been adopted by Mdumbi backpackers (contact person Johann Stadler. johann@mdumbi.co.za)
- The project has created awareness of the importance of forest, and forest based livelihoods, locally and nationally through social media and presentations and scientific papers (see outputs)

**Problems**

- *Timing of field work* with flowering and fruiting times of target species. Field work in Mdumbi area took place between April and September 2014. The Coastal red milkwood peak fruiting time is in midsummer. Although this did not detract from getting an estimate of fruiting yields , as fruiting density could be estimated from the fruiting buds that start towards the end of winter, *It* would of been preferable to of used actual fruit to measure variation in weights, flavour and possible uses of fruit. Fortunately I was able to arrange for the collection of 2 kg of Milkwood fruit prior to the project start date, and have these sent for laboratory analysis. The Cape Chestnut tree, is difficult to spot in the forest outside of its flowering and fruiting season (winter). This may be because there they were just not there , or because they are easily overlooked .
- *Lack of comprehensive analysis of the nutritional value of fruit pulp*, and inability to find a laboratory that could analyse seeds for anti nutritional factors. No analysis of the physical and chemical macro properties of the Milkwood seed oil. Although these were not explicitly stated as part of project outputs, and were not specifically budget for , they would have provided very useful supportive information .
- *Lack of any institutional or financial support.* The project was conceptualised and conducted by myself (an independent researcher and consultant). Although the Mdumbi backpackers have undertaken to raise the milkwood seedlings, the project had no involvement, and limited interest from the local NGO's, National and provincial forestry authorities, this despite the project being explained and discussed with regional forestry officials on a number of occasions. (Improved access to forest resource, improved forest conservation management and development of non timber forest products are central to

the operational policies of the Department of Fisheries and Forestry, the official custodian of these forest). PhytoTrade Africa, a NGO dedicated to supporting poverty alleviation by helping develop and market wild natural products from rural communities for export, were approached at various stages during the conceptualization and research phases of this project (2012, 2013, 2014), for advice and possible funding support. After two meetings , numerous e-mails, sharing of my documents and research finding, and phone calls with members of this organization (Mrs Lucy Welford, Mr Cyril Lombard), very little has transpired. According to my understanding, there is a reluctance to want to get involved with any projects in the Eastern Cape. More recently, (perhaps because of a change in the CEO of the organization), the new CEO, Mr Cyril Lombard expressed some interest in this project, and in October of 2014, while in the country, he requested a meeting with me near Durban. I made a special effort to attend this by driving the few hundred kilometres from Port St Johns. The repose of PhytoTrade Africa since this meeting, has unfortunately, been slow, and non committal.

## IV. PROJECT OUTPUTS

**Table 1 Listing of project activities and outputs (with cross references to sections in main report, for further details)**

| **AIM**: Determine the nutritional and lipid profile of Coastal Red-milkwoods (*Mimusops caffra* ) seed oil, and its potential uses. | |
|---|---|
| **Activities** | **Outputs** |
| • laboratory analysis of seed oil<br>• Identify any unique properties, compared to other African seed oils<br>• Identify potential uses | • Micro and macro nutritional analysis of Coastal Red milkwoods seeds completed.......................................................**sec. 3.7.2**<br>• Lipid profile compared to other African seed oils completed........... ..............................................**sec. 3.7.3**.<br>• Potential uses suggested but not tested.(possible unique properties may be discovered that relate to unique balance of lipid types in the oil)..............................................................**sec.. 4**<br>• Potential to use fruit pulp in a blended dry fruit product...............................................................sec...**3.6.4** |
| **Aim**: Determine ecological feasibility of milkwood (*M. caffra)* seed harvesting | |

| **Activities** | **Outputs** |
|---|---|
| • Map wild stocks of dune forest within study area<br>• Map dune forest in expanded study area<br>• Understand population age structure and recruitment rates<br>• Ecological impacts of harvesting<br>• Recommend mitigation | • Wild stocks mapped by mapping Milkwood dune forest in GIS: for pilot study site..............................................................**fig 1**<br>• Dune forests mapped for expanded project site (including Ntsubane forest complex ,and coffee bay area). .........................................................**Appendix2**<br>• Population age structure model developed using tree diameter size measurements. Shows near absence of seedling recruitment, and abnormal dye off of mature trees.......................................................**sec 2.2 & 2.3**<br>• Age studies using tree rings analysis, shows great age of some Milkwoods (1500 yrs plus)............................**sec 2.**2<br>• Harvesting up to 70 % of seed produced will have minor impact on recruitment rates.................................................................**sec 4.5**<br>• Potential long term seed harvesting impacts considered, mitigated by supplementary planting of nursery grown out saplings.................................................................**sec 3.8** |
| **Aim**: Determine economic feasibility of Coastal Red milkwood (*M. caffra)* seed harvesting community enterprise | |
| **Activities** | **Outputs** |
| • Model potential volumes of oil and fruit pulp harvestable from pilot study site, and from the expanded project harvesting area<br>• Research into feasible market price<br>• Model net economic value of oil and fruit pulp<br>• Estimate ssustainable employment creation potential (assume 50 % operational cost) | • Mean yield of Milkwood see oil: 10.5 litres /ha.........**sec 3.4**<br>• Mean yield of fresh fruit pulp: 65.3 kg/ha..................**sec 3.4**<br>• The mean value of six similar African oils currently sold on the internet was 189 $/litre...........................................**3.6.1**<br>• Modelled annual income to suppliers for both milkwood seed oil and dry fruit in *pilot* site only (33 ha) : $11 516 .........................................................................**sec 3.6**<br>• Modelled annual income to suppliers for both milkwood seed oil and dry fruit in expanded project area(132 ha): $ 58 656 ........................................................................**sec 3.6**<br>• Employment potential for pilot site only : 6 jobs for 4 months of the year...............................................................**sec 3.6**<br>• Employment potential for expanded project site : 74 jobs for 4 months of the year.............................................**sec 3.6** |
| **AIM**: Initiate a restoration project for the Mdumbi dune forests | |
| **Activities** | **Outputs** |
| • Initiate a dune restoration project | • Awareness created amongst local population and local tourism resorts...................................................... **sec 1.4**<br>• 150 Coastal red milkwood seedlings currently being raised in Mdumbi backpackers nursery, for later transplanting...**sec 3.8** |
| **Aim**: Investigate other potential wild tree seed oils species | |
| **Activities** | **Outputs** |
| • Investigate if sufficient numbers of two other potential wild tree seed oils species ( Cape Chestnut, and Forest Mahogany) occur within the | • Populations of Forest Mahogany mapped with coordinates (about 20 trees found around Mdumbi valley)..............**sec 5**<br>• No Cape Chestnut trees were found in pilot study site (difficult to find in forest outside of flowering season) |

| | |
|---|---|
| study site to warrant further investigation | |
| **AIM**: Improve national  local global awareness of the importance and state of the coastal dune forest systems of the Wild Coast, and potential NTFP. | |
| **Activities**<br><br>• Provide input into news letters<br>• Make public presentations<br>• Use social media<br>• Approach Phyto-trade for support.<br>• Publication of scientific paper documenting nutritional analysis and potential uses of Coastal Red milkwood | **Outputs**<br>• Article written for MPAH, newsletter put out by SANBI *http://biodiversityadvisor.sanbi.org/wp-content/uploads/2014/10/MPAH_Newsletter_Winter2014.pdf*<br>• Presentation on project at  MPAH feedback conference<br>• Face book page created: *https://www.facebook.com/wildseedoil*<br>• Presentation on wild tree seed oils submitted to World Forestry congress (Durban, 2015)<br>• Slide share site created *www.slideshare.net/derekberliner/superfoods-from-the-fores*<br>• Chivandi, E, and Berliner D. D. (in prep). Red Coastal Milkwood (*Mimusops caffra*) Seed: proximate, fibre and mineral composition and the amino acid and fatty acid profile. South African Journal of Botany.<br>• Berliner D.D and Chivandi., E. (in prep) Red Coastal Milkwood (*Mimusops caffra*): seed oil and fruit pulp as potential Non Timber Forest Products. Journal of economic botany |

## WAY FOWARD, ADDITIONAL RESEARCH AND RECOMMENDATIONS

This CEPF small grant research project has demonstrated that a community forest enterprise based on the commercial harvesting of wild Milkwood tree seed oils can be economically and ecologically sustainable, and can have catalytic effect in promoting social and environmental spin-offs.

It is hoped that this work will continue in order to capitalise and follow on from the investments made in this project . A follow-up project will include: setting up of piloting harvesting trials; start up funding for basic equipment (oil press); product testing; alternative product prospecting, setting up community cooperatives and training, improved understanding of needs and blockages to enable products to reach markets and developing and understanding of the market chain from producer to consumer.  A proposed conceptual diagram of the market chain is shown below.

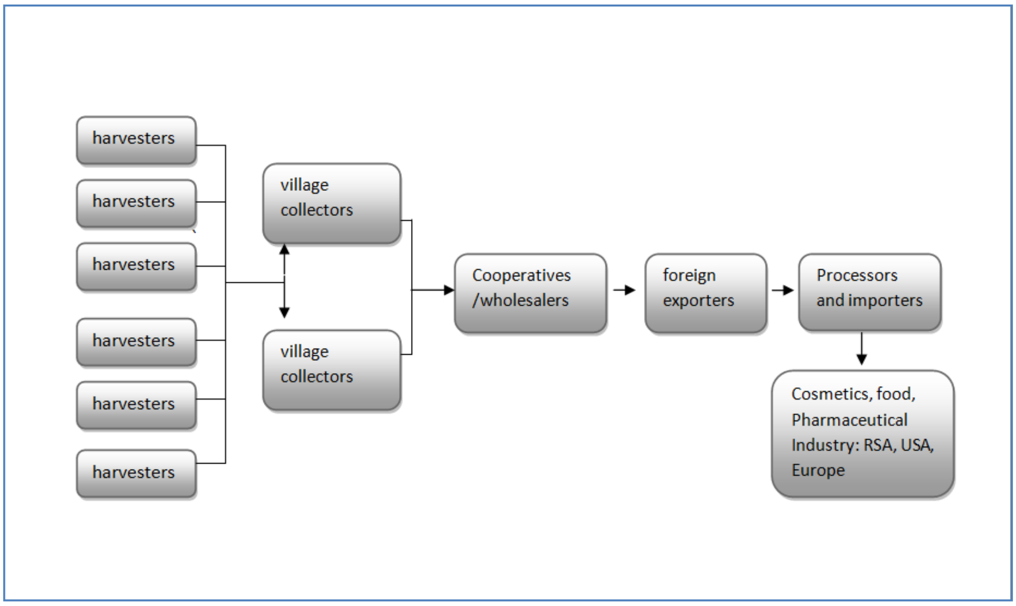


**Figure 1. Possible marketing chain for community harvested wild seed oil products**

It is understood that the development and marketing of any new product requires significant inputs and will require community structures to be fully participative in the enterprise development. In addition, work will be need to obtain the necessary harvesting and bioprospecting permits from government authorities, according to recent legislation. (NEMBA: Bioprospecting, Access & Benefit Sharing regulations).

The development of forest based alternative livelihoods programme for communal forest is urgently needed in South Africa. This approach is currently gaining momentum worldwide as it is increasingly seen as a viable option that can provide social benefits as well as contribute toward forest conservation, and carbon-stock security. What is required is sustained engagement with communities as well as basic bioprospecting research to identify potential products.

Further work to develop products for a forest based alternative livelihoods enterprises, will need to focus on those wild products that have existing markets, as well as discovering new products to capitalise on growing world demand for natural wild harvested products. For example the yungu oil of Cape chestnut and the Trichelia oil of the Natal mahogany, These oils have never been commercially harvested in South Africa, but have been elsewhere in Africa (Kenya and Mozambique, see desktop study, 'superfoods from the forest', Berliner, 2013)

In addition to these two species, there are a host of potential new and innovative wild products, that may have commercial potential, some of which I have already identified, and others still await discovery.

Guidelines developed by FAO (2011)* provide a detailed roadmap for planning a participatory Market Analysis and Development approach (MA&D) to assist local people in developing income-generating enterprises while conserving tree and forest resources. These guidelines are particularly relevant in planning a way forward for this project. In essence, three phases of enterprise development are recommended, these include :1) Identify products, markets and means of marketing; 2) prepare enterprise development plans and strategies for sustainability; 3) obtain start up funding for basic equipment, training and piloting, and developing a monitoring and evaluation of the enterprise activities.

For further details on the work done in this project, please refer to the main project document, that accompanies this report (part 2): D.D. Berliner, 2015. *Economic and Ecological Feasibility of Harvesting Wild Forest Tree Seed Oils with Special Reference to The Coastal Red Milkwoods: final report.*

* FAO, 2011. Community Forestry Field Manuals: ww.fao.org/docrep/w8210e/w8210e0b.htm

PART 11: DETAILED REPORT

**Wild Coast Tree seed oil Project :**

# ECONOMIC AND ECOLOGICAL FEASABILITY OF HARVESTING WILD FOREST TREE SEED OILS WITH SPECIAL REFERENCE TO THE COASTAL RED- MILKOODS

## Final detail report

for

Wild Land Conservation Trust

(CEPF small grant fund)

February 2015

Dr.  Derek Berliner

Eco-logic

Contents

## Executive summary

There is a pressing need for rural communities in the Wild Coast to improve sustainable, resource-based livelihoods. Given the importance of natural resources to livelihoods in the Wild Coast, for conservation projects to make any impact, they will need to be integrated with programs that improve livelihoods, and resilience to climate change. The identification and development of sustainably harvested non timber forest products (NTFP) are seen as means to improve both rural livelihoods and to incentivize improved forest conservation.

Community consent for the research was obtained and the project field work was initiated in May 2014. The pilot project study site includes the strip of coastal dune forest stretching between the Mdumbi river estuary and the Umtata mouth. The study site was divided into four sections.

The study focused on the feasibility of harvesting Coastal Red-milkwood seeds as a potential NTFP. This included both field work to determine potential oil and fruit yields, as well as laboratory analysis to understand the nutritional composition of the seeds, as well as to identify potential uses. This is the first time that this species has been subjected to this kind of analysis and there for makes a unique scientific contribution to wild products.

The field work and the models developed from the data collected, have demonstrated that a wild tree seed oil harvesting enterprise based on Coastal red milkwood seed oil, can be economically and ecologically feasible, and could catalyze significant social and environmental benefits in the form of employment and improved conservation management spin-offs for the vulnerable dune forests. The study was considered at two scales, a local pilot study site consisting of 33 ha of Milkwood forest patches, and a larger expanded project area, consisting of numerous dune forest patches covering 132 ha in total. The models developed for the pilot study area were used to extrapolate yields for the expanded project area.

Some of the immediate social benefits that could arise from this enterprise, include sustainable employment supported by the tree seed and fruit harvesting sales. For the 33 ha of the pilot site, this was calculated as 6 full time jobs for 4 months of the year, while for the expanded project site (132 ha), as 75 full time jobs for 4 months of the year. This assumed that only 50% of the revenue generated is used for wages.

Coastal Red-milkwoods, (*Mimusops caffra*), are the dominant tree found in the coastal forests along the Eastern Cape, and can be considered as an iconic, flagship species for the conservation of this regions dune systems. They play a critical function in stabilizing coastal dune ecosystems, and as such can be considered as a key stone species. It is postulated that harvesting up to 75 % of Milkwood fruit per annum, will have minor impact on recruitment rates of these trees, and any potential long term impacts can easily be mitigated by supplementary planting of nursery grown-out saplings.

The nutritional analysis done in this project of the Coastal red milkwood seeds, contributes to the scientific understanding of this tree, and its potential commercial value. The project

highlights the need for further research into the potential of other wild tree seed oils besides milkwoods. Two species in particular, with high commercial potential, include: Forest mahogany, and Cape chestnut.

This study confirms earlier reports (Berliner, 2010, Berliner 2011a Berliner 2011b) that many of the dune forest patches, along the Wild Coast , dominated by *Mimusops caffra* are undergoing ongoing degradation. A model of the systemic causes of this were first proposed by Berliner 2011 a & b) Population size class analysis of these populations, in section 1, of the study site, reveal a near absence of juvenile recruitment into the population. This was also apparent for other section of the study site (although not quantitatively assessed), where high adult tree mortalities, and poor recruitment were evident. There is concern that the Wild Coast dune forest are in decline.

In conjunction with the Mdumbi back packers, a dune forest rehabilitation initiative was started by this project. This involved 'rescuing' over 120 *M. caffra* seedlings and putting them within a nursery growing environment. The intention is to replant them back into section 1 of the study site to boost juvenile recruitment.

A spreadsheet model was developed to estimate potential fruit and seed oil yields of *M. caffra.* Oil yield varied between sections, from 6.6 to 15.3 liters per ha. The mean yield was 13.6 litters oil per ha. The total potential yield for the whole study site (area 31.6 ha), was 331.7 liters of Coastal Red-milkwood seed oil, per year. Fruit pulp (whole fruit without the seed), is a potential 'by-product' of a seed oil enterprise, and given the high volumes, could contribute significantly to the economic viability of commercialization project. Fruit pulp yield varied from 40.6 to 96.3 kg per ha of the study site. The net fruit pulp yield for the whole study site was estimated by the model as 2048 kg per year. The model uses a 75 % harvesting intensity, implying that 1/4 of the trees fruit (upper branches) are left un-harvested.

The proximate, mineral, amino acid, fibber, amino acids, lipids, fatty acids, digestibility, mineral analysis, and total energy content determinations of the shelled seed of *M. caffra* were made at the Agricultural, Research Council's Irene Research Institute. Results show *M. caffra* seeds to have protein content of around 9%, and a total oil/ fat content of 23.5 %. The protein content is comparable to that of maize, but significantly lower than most legume seeds. Arginine and Glutamic acid, were the highest concentrated amino acid, constituted approximately 13.3, and 11.3 % of the total amino acids respectively. Both are considered 'near -essential' amino acids, and that have some potential use in the nutritional supplement industry (glutamic acid is often considered as 'brain food')

While the % total fat in the seeds of Milkwoods are considerably lower (around half), that of the two Trichelia species, and Marula seed, ( these are wild tree seed oils with established markets), the quality of the oil, at least, in terms of the lipid types, are comparable. Despite this, the percentage oil content compared favourably with the oil content of such seeds as cotton (18-28%) and soya bean (11-25%) which are commercially grown for oil extraction. Coastal Red milkwoods have the distinct advantage over some of the other wild tree seed species, in that they occur in large numbers, over relatively small areas. The main lipid types are oleic acid (10.89 % of total seed weight ); palmitic acid (4.36), linoleic acid (3.28) and stearic acid (2.51 %). These lipids have a wide range of potential uses as culinary or nutritional supplements (in particular, the mono-unsaturated, oleic acid, and the poly-unsaturated, linoleic acid); in the cosmetics industry, as soaps and body butter (palmitic, stearic, and oleic acid).

Mineral analysis shows *M. caffra* seeds to be a good source of potassium (0.8%), and an exceptional source of calcium (1%), which is about 25 times the amount found in maize.

Filed work done on the two other potential tree seed oils species, Forest Mahogany and Cape Chestnut was limited by the difficulty in finding these species in the scarp forests, inland of the dune forest study area. A cluster of Forest Mahogany was found, near the Mdumbi estuary, consisting of around 15 trees, some of which are non fruit bearing males (the tree has sexes on separate trees). The Cape Chestnut remained elusive, and was not found within the study site. Unfortunately the project did not cover the late summer time period when this tree flowers and advertises it presence in the forest.

# 1 Introduction

## 1.1 Aims of the project

This CEPF small grant funded project has four main aims.

- Determine the potential uses, economic and ecological feasibility of harvesting Coastal Red-milkwoods for fruit and seed oils, including:
    - laboratory analysis of seed oil (and possibly the fruit pulp);
    - map wild stocks within study area;
    - model potential volumes and value of oil;
    - identify the potential uses from these results.

- Identify other potential sources (Cape Chestnut, and Forest Mahogany) of wild tree seed oils occurring within study area, and asses if they occur in sufficient numbers within the study site to warrant further investigation.
- Initiate a restoration project for the Mdumbi dune forests
    - start a Coastal Red-milkwood seedling regeneration project
    - improve local awareness of the importance and state of the coastal dune forest systems of the Wild Coast.

- Improve national local global awareness of the importance and state of the coastal dune forest systems of the Wild Coast, and potential NTFP
    - Provide input into news letters
    - Make public presentations
    - Use social media
    - Approach PhytoTtrade Africa for possible support.
    - Publication of scientific papers documenting nutritional analysis and potential uses of Coastal Red milkwoods

## 1.2 How this project can contributed to the implementation of the CEPF ecosystem profile.

The project site, (Mdumbi river mouth to Umtata river mouth), falls within Pondoland, one of the smallest regions of floral endemism in the world. The scarp forests of this region have the world's highest levels of tree diversity for temperate latitude forest, and are hence of global biodiversity significance (Silander, 2001, Berliner, 2009). These forests face escalating threats from multiple and synergistic causes, including: invasive alien plants, illegal timber and medical plant harvesting, slash and burn agriculture, livestock trampling and feeding, and climate change related impacts.

This project falls within Strategic Direction 3 (Maintain and restore ecosystem function and integrity in the Highland Grasslands and Pondoland corridors)

Specifically item1: Support for community stewardship initiatives that will catalyze sustainable financing from local carbon markets within Pondoland, part of the Pondoland corridor of the Maputo Pondoland- Albany Biodiversity hotspot within the Eastern Cape Province, South Africa ('The Wild Coast'),

## 1.3 Rational for project

There is a pressing need for rural communities in the Wild Coast to improve livelihood security. Given the importance of natural resources and biodiversity to livelihoods (Shackleton *et. al*, 2007); and traditional cultural practices, ( Dold & Cocks, 2012) in the Wild Coast; for biodiversity conservation to succeed, it is imperative that conservation interventions address the need for sustainable livelihoods.

Currently, communities have little incentives to apply conservation measures, particularly if they affect livelihoods (such as not grazing livestock in forests, or medicinal plant harvesting, such as bark stripping). Traditionally, tribal authorities have played an important role in resource management, but increasingly, both forestry officials and tribal authorities are unable, or unwilling, to control resource exploitation, such as bark stripping, hunting , slash and burn agriculture,  and compliance with state forest regulations are seldom not enforced. In effect there is no conservation management of wild coast valuable forests, and a free for all situation exists. This situation will continue to escalate unless local communities can be given a sufficiently attractive and viable reason to apply conservation principles (Berliner, 2010).

Growth in the national and international market for natural, organic food, and natural health and cosmetic products (Vermaak *et.al,* 2011), has provided an opportunity to investigate and develop markets for sustainable harvested non-timber forest products. Where this is closely linked to conservation and community beneficiation, fair- trade accreditation becomes possible, which can potentially increase marketability.

Wild harvested tree seed oils, have promoted sustainable livelihoods for rural communities, for many years in a number of places in Southern Africa. For example, the trade and use of Trichelia oil (also referred to as Mafurra butter is entrenched in some cultures of the provinces of Inhambane and Gaza, in Mozambique (Matakala, *et.* al, 2005)

This project provides, the first step towards a possible tree seed oil industry on the Wild Coast by doing the foundation research necessary to identify possible species, determine the quality, quantity and economic and ecological feasibility of  sustainable harvest.

## 1.4 The need for community consent and a bio prospecting permit

The Wild Coast Tree Seed oil project can be considered as a form of bio-prospecting, and as such needs to take cognisance of the National Environmental Management: Biodiversity Act, and specifically the Bio-prospecting, Access and Benefit-Sharing (BABS) regulations, of 2008. (DEA . 2008).

As this project is still in the research phase, no bio-prospecting permits are required, however, research within a communal area, requires the permission from the community, who also need to be informed about the project, its intentions and potential benefits to them .

If, or when there is any commercialization, then a bio-prospecting permit will be required from the Department of Environment Affairs, as well as a harvesting permit,

The Wild Coast Tree Seed oil project was discussed and explained to the community in two forums . On the 23 May a meeting was held at Mdumbi, in the TransCape's education centre with the board members of TransCape ( a community NPO), where I explained the project to the board. On the 27 May a meeting was held with the broader community at the TransCape eco-permaculture house, in the village of Mankose. In this meeting, the project was explained again and the need for community consent was requested. The community unanimously agreed to allow the project to continue with their blessings.

## 1.5 Description of study area

The project study site includes the strip of coastal dune forest stretching between the Mdumbi river estuary and the Umtata mouth. The greater area also includes scarp forests , and is situated within the Mankosi chieftaincy, which includes the villages of Canzibe and Tshani, and falls within the Ngqeleni administrative district. The dune forest strip was divided into four sections, as shown in the map below.


**Figure 2** The Mdumbi Study site showing four sections (white letters) for the dune forest (red line) between the Mdumbi and Mtata estuaries.

The Mdumbi estuary as well as the Umtata river mouth are considered estuaries of national importance, and are ranked as 12 th and 3 rd most important estuaries on the Wild Coast, respectively, (Turpey et al., 2007). Both estuaries, the strip of dune forest and some of the larger patches of scarp forest are considered to have high conservation value. Both estuaries , the dune forests and the larger scarp forest patches were proposed as a possible community conservation area, by the Wild Coast Project, by Berliner (2011a). (See map in appendix 1).

Many of the Coastal Red-milkwood forest of the Wild Coast are facing ongoing degradation (Berliner, 2011, 2012). Causes include interrelated factors, such as alien invasive plants, livestock (particularly, goats) and climate change related high seas and winds, (causing dune margin erosion). Like the main Mdumbi dune forest (shown below), most dune forest on the Wild Coast show degradation, with a high mortality of mature milkwoods and no or low regeneration. There is a concern that these rare and valuable forests, will not survive, once the mature trees have died off (see pictures below).

**Figure 3**. Degraded dune forest at Mdumbi mouth, Wild Coast. Note dead Coastal Red-milkwoods, This project will initiate the rehabilitation of this forest in conjunction with the locally based Mdumbi back packers. (part of section 1, shown in figure 1)

**Figure 4.** Sand dune shift gradually inundating milkwood forest near Bulungula estuary.

### 1.6 Collaboration

From the outset, it was realized that this project would require collaboration between a number of different organizations. These are discussed below.

*Field work and dune rehabilitation*: The Mdumbi back packers and there sister organization, the development NPO, TransCape, have provided essential logistic support. Accommodation has been provided for me by Mr Hyman Van Zyle, CEO of TransCape in there demonstration, off the grid permaculture/eco-house. Nursery facilities and care for the rescued Coastal red Milkwood seedlings have been provided by Mr Johann Stadler, one of the founders and co -owner of the Mdumbi backpackers, who has also taken a keen interest in the project. The Mdumbi backpackers as well as the NPO, TransCape are co-owned and managed by the Mankosi community. It is envisaged that if a commercialization of the Milkwood seeds or fruits were to occur, a community co-operative, under the management of TransCape could be set up.

*For the laboratory analysis* : The Wildlife Society of southern Africa (WESSA), East London branch (contact person Mr Mike Denison) has also shown a keen interest in the project, as it fits in with their non-timber forest products and livelihoods programme for the Wild Coast. In January of this year, before I was able to get into the field, and while the milkwoods were still in fruit, Mr. Mike Denison, of WESSA kindly assisted me by collecting two kilograms of Coastal Red-milkwood fruit from the Chinsa area. These were dried, and sent up to Dr. Elliton Chivandi from the School of Physiology, University of Witwatersrand. Dr Chivandi did the analysis of the closely related, Transvaal Milkwood, *Mimusops zeyheri* (Chivandi,*et. al,* 2010), and has expressed a desire to collaborate with this project, as it overlaps with his research interests, in animal nutrition. Dr Chivandi, used the laboratory facilities at WITS, to do proximate analysis of digestibility, energy content and amino acid essays, before sending the samples on to the agricultural Research Council (ARC) in Irene for analysis of protein, oils and fatty acids (contact person, Penny Barnes ). Dr Chivandi is also keen to collaborate in writing up the results for a scientific journal. Mineral analysis was done by the ARC, Department of Soil and Water (contact person, Mr Mike Philpot). Additional laboratory analysis to determine the presence of anti-nutritional factors, cannot be done by the laboratories mentioned above. I am currently in the process of trying to find a laboratory that does this analysis.. Analysis of the Coastal Red-milkwood fruit will also be considered, if funds permit, as this may prove to be a valuable commodity with possible commercial use.

## 2 Methods

### 2.1 Field work to assessment Coastal Red-milkwood population stability, wild stocks and potential oil/fruit yield

The coastal strip between Mdumbi and Umtata river was divided up into four sections, (based on topography, and aspect). This included the Mdumbi beach section from the Mdumbi river to the Mdumbi point. Secondly, from Mdumbi point to the Tshani river, thirdly from the Tshani river to the Anchorage hotel, and fourthly from the Anchorage hotel to the Umtata river mouth (see fig 1).

## 2.2 Population age class distribution of milkwoods

Quantitative analysis was conducted to determine the health of the population as indicated by the level of recruitment of young trees into the population. Only the most degraded of sections was analysis for thisi.e. section 1 (from the Mdumbi river to the Mdumbi point). The health of a tree species population can be measuring by considering the size class distribution of the population. For this, the diameter at approximately breast height (DBH) was measured of both living and dead trees. Because Milkwoods tend to branch quite low down, and many of the tree main stems were partially buried with sand , the measurements were mostly made just before the main branching, which was mostly lower than the standard breast high measurement of 1,5 m.

## 2.3 Assessing ages of milkwood trees

Each spring and summer, during the peak growing season a tree adds new layers of wood to its trunk. The wood formed in spring grows fast and is lighter because it consists of large cells. In winter growth is slower; the wood has smaller cells and is dark. So when the tree is cut, the layers appear as alternating rings of light and dark wood. Counting the rings enables the trees age to be estimated

A number of Milkwood trees (main trunks and/or branches) in the study site were cut, illegally, presumably for firewood. Some of these stumps were clean cut, with a chain saw, making it possible to use these cross-section for tree ageing. Because the tree is very slow growing, the tree rings of Coastal red milkwoods are very fine, and not always very clear, however using digital photographic manipulation and enlargement, it was possible to get an approximation of the tree ages from the samples

## 2.4 Assessing fruiting density

Fruiting density was approximated by counting how many terminal buds, destined to be flowers /fruit fitted into 1 $m^2$ , bamboo frame. This was used to measure total volume of fruit per tree (see figure below).

Figure 5 Approximating fruiting density and foliage volume using a meter square quadrant to count terminal buds

## 2.5 Modelling of potential oil and fruit yields

Tree volume was approximated using a 1 $m^2$ bamboo quadrant as a indicator of how many square meters of foliage were on each main stem branch. Once this technique was mastered, it was possible to approximate the total tree foliage volume relatively easily. Because fruiting quantity is closer correlated to foliage volume, than tree diameter, trees were grouped according to foliage volume classes.

Fruit yield of a tree was calculated by: foliage volume (m2) x fruiting density (fruit/m2) X weight of fruit, excluding seed (kg)

## 2.6 Assessment of wild stocks and total yield potential from study site

The following parameters were collected: main stem tree diameter at breast height (DBH), number of main forks (main stem branches), diameter of each fork, and approximated number of square meters of foliage per branch. The volume of foliage was estimated by approximating how many $m^2$ grids would be required to cover the foliage in each branch. The inherent 'architecture' of milkwood branches, and the fact that the foliage is clustered at branch ends in 'flattish planes', facilitated this method of approximation.

Absolute counts, (every individual counted and measured for main stem diameter at breast height, diameter of each main fork/branches, and foliage volume), was done for the main Mdumbi beach dune, section 1. Around 300 milkwood trees were measured in section 1. For the remainder of the sections (2, 3 and 4), an approximated counting method was developed by myself, and perfected by my field assistant (Mr. Zuko, from the community). Based on the metrics derived from analysis of section 1, a method of grouping tree sizes into three foliage size classes was developed. These were: 'small' (DBH < =60 cm); 'medium' (DBH >60, <= 120), and 'large' (DBH >120. Because statistical correlation (using MS. excel's statistical functions) showed that the main stem DBH, was only weakly correlated with tree foliage volume (R = 0.70), but that foliage volume was strongly correlated with total fork/branch diameter(R= 0.86), it was decided to base tree size classes on *foliage volume* rather than

DBH. Tree foliage volume classes included the following classes: 'small' (foliage volume <= 3 $m^2$); 'medium' (foliage volume >3, < =6 $m^2$), and 'large' (foliage volume > 6 $m^2$). This formed the basis of the rapid assessment technique developed to survey the production potential of the standing stock for the rest of the study site (section 2, 3 and 4). The method used a visual approximation of all trees falling into one of the three size classes. This was done from vantage points, from both the beach looking up, (most of the dunes forests were on a steep slope), and from the top of the dune crest, looking down. From the vantage points, the approximated number of trees falling into each of the three foliage volume size classes were estimated. This data was then transferred into the spreadsheet, to be used in a model to estimate total volume of fruit and oil from the whole study area.

## 2.7 Laboratory analysis of seeds

About 2 kg of fresh ripe *Mimusops caffra* fruits were harvested from ten randomly selected trees in February 2014, from Chinsa area (about 30 km up the coast from East London) The proximate, mineral, amino acid, fibre, amino acids, lipids, fatty acids, digestibility, mineral analysis, and total energy content determinations were made at the Agricultural, Research Council's Irene Research Institute, Republic of South Africa. Standard laboratory methods were used, these will be described in detail by Chivandi & Berliner (in prep), and Berliner & Chivandi (in prep).

## 2.8 Dune rehabilitation by growing out seedlings

The late summer/early winter rains at Mdumbi stimulated seed germination resulting in a flush of milkwood seedlings. It is clear from the absence of any Milkwood saplings (less than 1 meter high ) that these seedlings are highly unlikely to survive the winter, in particular with the ongoing trampling and browsing from livestock. Between 20 and 30 April, 20 April, 2014, about 120 seedlings were rescued from the main Mdumbi beach dune forest, and put into botting bags using a 50 % sand , 50 % compost mixture and a handful of bone meal. The seedlings are being housed in the private nursery of Mdumbi backpackers co- owner, Mr. Johan Stadler, who has taken on the project to ensure that the seedlings are looked after for the next two years or so, before they will be bigger enough to be replanted. Although they will be less vulnerable to livestock browsing at this age, it may still be necessary to provide additional protection for each plant.

## 2.9 Expanding the project production area beyond the pilot site: mapping of dune forests along coast

The economic viability of the project can be considerably increased by scaling up the area from which milkwood fruits are harvested. To do this analysis , I mapped additional Coastal Red milkwood forest patches occurring with 50 km of the pilot site. The forest were mapped using satellite imagery along with considerable ground truthing. The results of this are presented in appendix 2

## 2.10 Potential economic and social benefits of Coastal Red milkwood fruit and seeds

The following steps were followed:

- Extrapolate commercial value of oil and fruit using a mean of similar products (surrogates) as advertised on the internet
- Use fruiting density, foliage volume and  tree density by age class to determine a mean oil and fruit yield per hector of Milkwood dune forests
- Determine potential mean total oil and fruit yields for  the pilot study site (33ha) and the potential expanded project area (132 ha).
- Model potential economic value to community using a upper and lower price range (based on 1/4 of market price) for both pilot site and expanded project area
- Approximate potential employment opportunities that harvesting enterprise can provide, assuming 50 % of income to be used for wages.

# 3 Results

## 3.1 Population age class distribution of milkwoods

Section1, of the study site, the Mdumbi beach dune forest, from Mdumbi river to Mdumbi point, (about 5.3 ha ), shows a high level of dune destabilisation, dune shift and a significant number of standing dead trees. There was a total of 181 trees in which the diameter at breast height (DBH) was measured, used for an indication of tree age. A total of 27,6 % of the standing trees were dead.

The size class distribution for section 1 of the study area, shows an approximated bell shaped curve, which is a clear indication of a declining population with poor recruitment rates. Despite the presence of many seedlings (about 2 cm high), evidently these do not survive beyond the seedling stage, as there are a complete absence of any saplings or any young trees less than 1 meter high, (or any with a stem diameter smaller than 20 cm). This is of concern and indicates a 100% seedling mortality, mostly from livestock trampling and browsing,  (see figure 1 a & b, below).

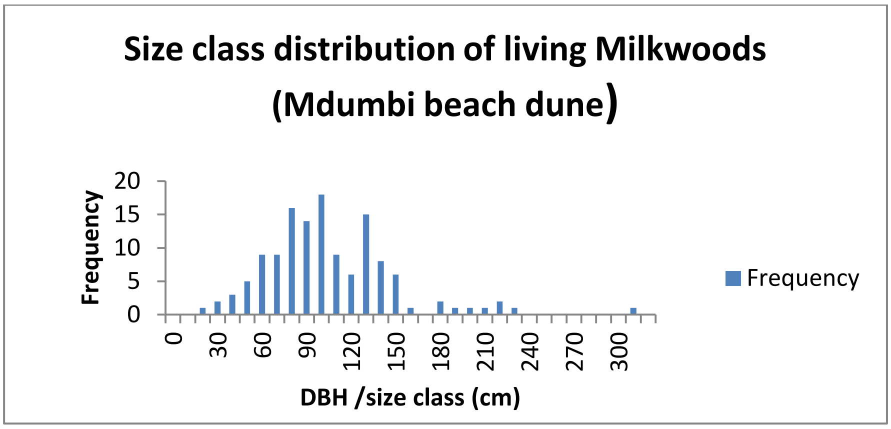


**Figure 6a.** Size class distribution of section 1 of the study site ( Mdumbi beach Coastal Red-milkwood dune forest) Size class is measure by stem diameter at breast height (DBH)

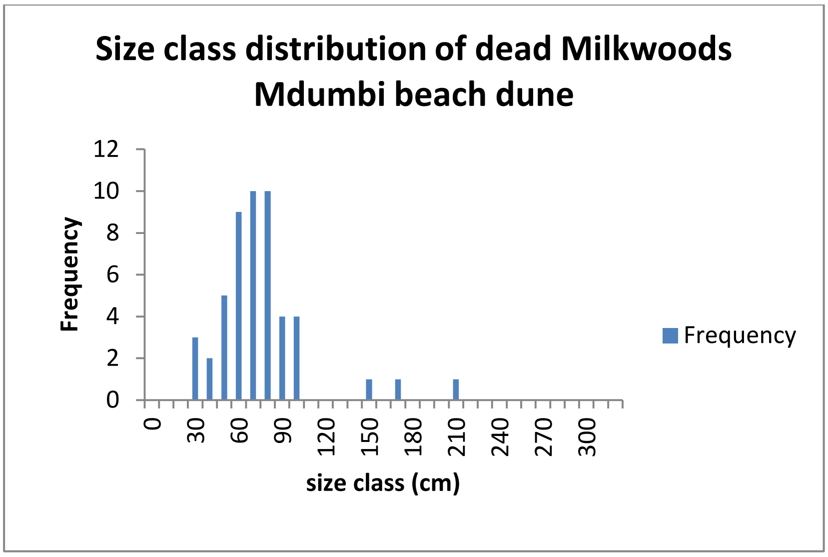


**Figure 5b.** Size class of standing dead Coastal Red Milkwoods. Shows high adult mortality. This, along with the near absence of young trees, show a declining population.

## 3.2 Assessing the age of Coastal Red milkwood trees

Although sample size was limited, a regression of tree diameter to number of rings (indicating number of years of growth) was derived. Because environmental conditions will affect the rate of tree growth, i.e. the distance between the rings, the regression will only hold for a particular species growing under the same environmental conditions.

**Table 2.** Approximate calculation of age and growth rates of Coastal Red Milkwood

| Number of tree rings (age) | Circumference of tree (cm) | growth rate in tree circumference (cm/year) | Growth rate Yrs/cm |
|---|---|---|---|
| 200 | 45 | 0.225 | 4.44 |
| 170 | 46 | 0.270 | 3.69 |
| 143 | 32 | 0.223 | 4.46 |
| Mean | | **0.239** | **4.18** |

The mean size circumference for the Mdumbi dune population was 102 cm with the largest tree being 310 cm , using the derived regression , the mean age of the Mdumbi Coastal red milkwood population is (102 X 4.18) = 426.4 years; and the oldest trees , those over 300 cm circumference are about 1295 to 1500 years

Comparison with a cross section of another Milkwood species, the White milkwood, *Sideroxylon inerme*, (different genus, but same family as the Coastal Red Milkwood) shows a similar, but slightly slower growth rate with 120 rings/years for 56 cm circumference (0,46 years for main stem to grow 1cm in circumference). See pictures below.

Figure 7. Cross section of a Coastal Red milkwood, left, and a White Milkwood, right, showing tree rings used to determine tree age.

These findings imply that Milkwoods are of considerable age and have slow growth rates. Because of this rehabilitation programs require long term planning and vision. In addition dune forest retaliation  should focus not only on supplementing regeneration (i.e. by planting of young trees grown out in nurseries), but also on avoiding further loss of mature trees, in particular the largest and oldest specimen, that may be well over 1000 years. Although the largest trees in the pilot site measured  over 300 cm in circumference, it is likely  that this could be a considerable underestimation of the actual age of the below ground growth, as milkwoods tend to re-grow (coppice) from the below ground root ball if the above ground stem is destroyed (for example by fire).

These findings cast light on the time scale over which these forests regenerate. The impact of harvesting a portion of the fruit is not likely to have  a significant impact on forest regeneration because survivable rates of seedlings are extremely low, trees live for a long time, trees coppice from old growth. In addition the harvesting impact can easily be compensated for by  planting of nursery raised saplings. The regeneration of milkwoods is often from coppicing of the underground root system. Suckers or shoots  may appear many meters from the original tree stump, but are part of the original root ball.  These root balls may be of great age.

## 3.3 Assessing fruiting density potential

Potential fruiting density was approximated by counting numbers of flowers/fruiting terminal buds in a one meter square frame. Five samples were taken randomly, from 5 different trees, and with two field workers counting independently. The mean counts between the two observers was 266 fruit per $m^2$, although, as expected there was a wide range (141 to 310). Fruiting density is influenced by many environmental conditions, such as seasonality and amount of rainfall, tree orientation to prevailing winds and sunlight. Fruiting density was a key input into the model to determine potential fruit yield per tree , as well as yield per ha of coastal red milkwoods in the study site.

**Table 3:** Estimating fruiting density of Coastal Red milkwoods. Five random samples from different trees. Counts are of numbers of fruit/flowers/terminal buds in a 1 meter square grid

| Sample | Fruit / $m^2$ |
|---|---|
| 1 | 205 |
| 2 | 331 |
| 3 | 430 |
| 4 | 141 |
| 5 | 225 |
| mean | 266.4 |

## 3.4 Modeling potential oil and fruit yield per tree

The potential quantity of oil that a tree can produce is determined by the amount of fruit it produces. This intern, is a function of the volume of foliage that the tree carries. While this will be largely determined by the size of the tree, there are other factors, in particular the branching structure of the tree, and insect infestation attacks (see picture below). To develop the model, a number of assumptions regarding fruit production, were made, these are so called 'constants' because, it is assumed that they do not vary between trees. Harvesting intensity can be set as a management option. The constants used in the model, are given in table 2 below:

**Table 4.** Constants used in model to estimate oil and fruit production from Coastal Red-milkwoods

| Item | Value |
|---|---|
| Fruiting density (fruit /$m^2$ ) | 266 |
| Dry seed wt (g) | 1 |
| % oil in seeds | 23 |
| Specific density (g/cm3) | 0.9 |
| Fruit pulp weight (ex seed) | 1.3 |
| % Harvest intensity | 75 |

The above values were used with the estimations of foliage volume to predict oil yields. The oil yield, in litters per tree, was calculated using the following formula :

Oil per tree = (m2 of foliage) x (fruiting density) x (dry seed weight) x (% oil in seed) x (specific density of oil) x (harvest intensity)

Mean oil yield per tree for the section 1, Mdumbi beach dune was: 0.33 litters per tree (assuming 75 % harvesting intensity). Note that this amount is relatively low, because the mean is of all trees, some that have been heavily damaged, or with low foliage volume relative to the tree stem diameter. The oil yield varied widely from 0.1, up to 1,3 litters per tree per fruiting season.

Once the seed has been extracted from the berry, the remaining flesh is referred to as the fruit pulp. Yield estimations of fruit pulp were calculated by :

Fruit pulp per tree = (m2 of foliage) x (fruiting density) x (fruit pulp weight) x (harvesting intensity).

The mean fruit pulp yield was 2 kg per tree but went up as high as 8 kg fruit pulp per tree (note that this is with 75% harvest intensity and excludes the weight of the seeds. The mean yield of complete fruit i.e. with seed is about 3.2 kg per tree, and about 13 kg for a largish tree.

**Figure 8.** Many of the milkwoods were infested with tent caterpillars that feed on leaves of all milkwood species. These are likely to suppress fruiting volume.

## 3.5 Assessment of wild stocks and total yield potential from pilot study site

The total fruit /seed/oil production potential from the whole study site (all 4 sections) was modelled by extrapolating foliage volumes classes developed for section 1 ,and using the approximated numbers (by view point counting) of trees falling into each of the three foliage volume class for each section.

For section 1, there was a total tree basal area of 151.32 $m^2$ within the 5.3 ha. This gives a density of 28.5 $m^2$ /ha. This basal volume of trees can produce 45.3 liters of oil, or 8.5 liters of oil per ha. Note that this section of the dune forest is the most degraded, with a high number of standing dead trees, so the oil yield per ha must be seen as a lower limit. The remaining three sections had higher standing tree volumes and hence higher yields per ha of oil. Table 2 below, shows a summary of these calculations, as extrapolated from the foliage volume size classes . The highest yield was for section 4, with 20.3 liters per ha, the mean for all three sections was 13.6 liters /ha. The total potential yield for the whole study area (31.6 ha) was 331.7 liters of Coastal Red-milkwood seed oil, per year, assuming a 75 % harvesting intensity.

**Table 5.** Oil yield per ha of Coastal Red-milkwoods for four sections of the study area (Mdumbi to Umtata rivers), as derived from foliage volume for each section, assuming a 75 % harvesting intensity. Study site section 1 size classes were derived from absolute measurements, while study site sections 2 to 4 , from visual approximations. The topographical aspect shows exposure to prevailing winds and sun (see discussion).

| Section | Aspect, facing | **Number of trees in size class** | | | Area (ha) | Foliage volume (m2) | Total Oil (l) | Yield/ha (l/ha) |
|---|---|---|---|---|---|---|---|---|
| | | **Large** | **Medium** | **Small** | | | | |
| Mdumbi river- Mdumbi point | N to NE | 43 | 48 | 37 | 5.3 | 829 | 34.8 | 6.6 |
| Mdumbi point - Tshanie river | NE-to SE | 120 | 181 | 322 | 12.4 | 3252 | 136.6 | 11.0 |
| Tshanie river- Anchorage | S | 22 | 167 | 232 | 8.8 | 1918 | 80.6 | 9.2 |
| Anchorage - Umthatha river | S | 57 | 121 | 200 | 5.1 | 1896 | 79.7 | 15.6 |
| **SUM** | | | | | **31.6** | **7895** | **331.7** | (mean: 10.5) |

After seed removal (for oil production), the remaining fruit pulp, would be an additional product that could have potential commercial value. The fruits are edible, but no record exists of using the fruit for any other products. Given the relatively high volumes of fruit that can be produced, it may have a significant economic value (between 40 and 100 kg per ha of Milkwood forest). The potential products that could be made from this, may include fruit preserve, jam or a dried fruit roll products. The fruit of the related *M. zeyheri* is high in vitamin C (60-100mg/100g), but further analysis' is still required to determine this for *M. caffra.*

**Table 6.** Fruit yield (with and without seed) for Coastal Red-milkwoods for four sections of the Pilot study area (Mdumbi to Umtata rivers), as derived from approximations of foliage volume, and fruiting intensity, for each section of the study site, assuming a 75 % harvesting intensity

| Section | Forest area(ha) | Foliage volume (m2) | Fruiting density (fruit/$m^2$) | Net fruit yield (kg) | Net Fruit pulp yield (kg) | Fruit pulp yield per ha (kg/ha) |
|---|---|---|---|---|---|---|
| 1)Mdumbi river-Mdumbi point | 5.3 | 829 | 266 | 380 | 215 | 40.6 |
| 2) Mdumbi point -Tshanie river | 12.4 | 3252 | 266 | 1492 | 843 | 68.0 |
| 3)Tshanie river-4)Anchorage hotel | 8.8 | 1918 | 266 | 880 | 497 | 56.5 |
| 4) Umtata river | 5.1 | 1896 | 266 | 870 | 492 | 96.4 |
| SUM | 31.6 | 7895 | 266 | 3623 | 2048 | (Mean: 65.3) |

Fruit pulp yield is high, with a mean of 56 kg of fruit pulp per ha. A single large tree can produce around 10 to 15 kg of fruit per year, although this may vary between trees, and years.

## 3.6 Expanding the project production area beyond the pilot site: estimating oil and fruit pulp yields

Coastal Red milkwood forest patches were mapped for about 50 km up the coast from the pilot site (see appendix 2 for maps). The table below provide summary of the total additional area and kg fruit that it could be expected to yield.

**Table 7.** Expanding the project harvest area to include three additional sections. The area of milkwood forest and extrapolated fruit yield from them, are given. * this is the original pilot site

| Section | Area (ha) | Oil yield (l) (using a mean of 10.5 l/ha) | Fruit pulp (kg) (using a mean of 65,3 kg/ha) |
|---|---|---|---|
| Port St Johns to Mboyti | 66 | 693 | 4309.8 |
| Mtakati to Mdumbi | 33 | 346.5 | 2154.9 |
| Mdumbi to Umtata mouth* | 33 | 346.5 | 2154.9 |
| Umtata mouth to Coffee bay | 13.6 | 142.8 | 888.08 |
| **Sum** | **132** | **1528.8** | **8619.6** |

## 3.6 Modeling potential economic and social benefits of Coastal Red milkwood fruit and seeds

### 3.6.1 Prices of African seed oils

The value of Milkwood seed oil is not easy to estimate, given that this is a new untested product. An indication of the potential market value of the oil was obtained by taking the mean value of six similar African oils currently sold on the internet. The results of this analysis are presented in the table below.

**Table 8.** Prices as advertised by cosmetic companies, for six different types of African wild seed oils

| Oil type | Price sold | Company | Price in $/liters |
|---|---|---|---|
| Marula oil | 28$/100ml | AAA sheabutter/Amazon.com | 280 |
| Kalahari Melon seed oil | 26$/100ml | AAA sheabutter/Amazon.com | 260 |
| Cape chestnut | R250/100ml | Essential oils South Africa. | 217 |
| Baobab oil | 20$/100ml | AAA sheabutter/Amazon.com | 200 |
| Argan oil | R220/100ml | Essential oils South Africa | 191 |
| Mafura butter | 6 UK pounds/10 g | The olive Workshop | 90 |
| Marula oil | R 100/100ml | Essential oils South Africa | 87 |
| **Mean** | | | **189** |

The overall mean market price for five different African oils is 189 US $ a liters. Although there seem to be no set ratio that determines what a commodity cost at supply to what it may be marketed for to end users, I have used a ratio of 1 : 4 e market value of the product being four time what the suppliers will be paid . For African seed oils this would be about 50 $/l. Because of the uncertainty of pricing, a price range has been used, with an upper price,(set by a 1:4 ratio) , and a lower price that can be expected as a rock bottom, market entry price (1/5 that of the upper price) . The 10 $ per liter of oil, has been used as the lower price. The tables below provides the total income expected from the sale of Milkwood oil by the supplier for both prices scenarios for the pilot site (33 ha) and a potential expanded project site, (132 ha).

### 3.6.2 Economic value of oil in pilot site only

The project pilot site from Mdumbi river mouth to Umtata river mouth consist of approximately 33 ha of near contagious Milkwoods dune forests. Using the relatively conservative yield rate of 10.5 liters of oil per ha, for a mature Milkwood forest , would produce an estimated 346.6 litters of Milkwoods seed oil per year

Table 9. Value of Milkwood seed oil to community suppliers , in pilot site (Mdumbi to Umtata mouth). Assuming an upper sale value of 50, and lower sale value of 10 $ per liter of oil

| Section | Price $ per liters of oil | Area in (ha) | Oil Yield in kg/Ha | Total Oil L | Total $ from sale of oil by community |
|---|---|---|---|---|---|
| Pilot site | Upper: 50 | 33 | 10.5 | 346.5 | **17 325.** |
| | Lower : 10 | 33 | 10.5 | 346.5 | **3 465.** |

The lower price option, is likely to be only marginal, if at all, economically viable on its own, however there are a number of options that could make this into an economically viable community based forest enterprise. These include: adding value by on site processing of the oil; selling the milkwood fruit pulp for manufacture into dried fruit rolls; and expanding the area of collection beyond the pilot site. The latter two options have been considered in the calculations below.

### 3.6.3 Utilizing the milkwood fruit pulp

*Nutritional value of Milkwood fruit pulp*

While I found the fruit of the Coastal Red-milkwood to have an unusual texture that some may have difficulty with, it is however enjoyed by people and goats alike, and does have a relatively high nutritional value. Although the fruit portion, has not been assess in the laboratory , its belongs to the family, Sapotacea, that tend to have fruits with high palatability and nutritional value. Further work is required to develop a fruit product from the Coastal red milkwoods. The company 'The good Snack Company" make a range of fruit rolls, with no additives, and that blend a number of fruits together to improve palatability. This could serve as a role model for a potential fruit product from the Wild Coast dune forest milkwoods.

*Market prices of dried fruit*

The market value of a new product such as dried milkwood fruit pulp is difficult to determine. Using current market prices of five commonly sold dried fruits and a mixed fruit assortment, the mean price per kg of dried fruit was 10.4 $ ( see table below)

Table 10 Market prices for commonly sold dried fruits

| Dried fruit type | Market price R/100g | $/kg |
|---|---|---|
| Apple | 9.99 | 8.6 |
| Mango | 22.99 | 19.8 |
| Peaches | 8.99 | 7.7 |
| Cranberries | 12.99 | 11.2 |
| Apricots | 8.99 | 7.7 |
| Mixed fruits | 8.99 | 7.7 |
| **Mean** | **12.15** | **10.4** |

### 3.6.4 The potential economic Value of dried Milkwood fruit pulp

I have used a price range with an upper price (set at about 30 % of the market price), and a lower minimal price (set at about 20 % of the market price). This gives an upper price value 3,2 $/kg dried fruit; and lower price of 2 $/kg dried fruit.

The method of estimating fruit yield is based on a model of fruiting density per square meter of foliage. Total foliage area is approximated from tree size and density. This enables an estimation of the total volume of fresh fruit per ha (65.kg). Assuming fruit has an 80 % moisture content, the mean kg dry fruit per ha will be about 13 kg/ha. The potential value to supplier will be the yield of dry fruit per ha X total area X price. ( see table below)

**Table 11. Potential value of fruit pulp in project pilot site (Mdumbi to Umtata mouth). Assuming a max price for dried fruit of 3.2 US$, and a min price of 2 US$/kg per kg dried fruit paid to community suppliers**

| Section | Price $/kg dry | Forest area(ha) | Foliage volume (m2) | Fruiting density on tree (fruit/m2) | Net fruit yield (kg) | Net Fruit pulp yield (kg) | Mean fresh Fruit pulp yield per ha (kg/ha) | Mean kg dry fruit yield per ha | Value to supplier (US $) |
|---|---|---|---|---|---|---|---|---|---|
| Pilot site | Max: 3.2 | 33 | 7895 | 266 | 3623 | 2048 | 65.3 | 13.06 | **1 379.2** |
| | Min: 2 | 33 | 7895 | 266 | 3623 | 2048 | 65.3 | 13.06 | **861.96** |

### 3.6.5 Net income from harvest of Milkwood to community in pilot site

The annual net income estimated for a Milkwood harvesting enterprise for the pilot site (Mdumbi river mouth to Umtata river mouth), from both dried fruit and seed oil is $ 18 704.2

Table 12. The annual net income estimated for a Milkwood harvesting enterprise for the pilot site (Mdumbi river mouth to Umtata river mouth), from both dried fruit and seed oil is $ 18 704.2

| Item/Pilot site only | lower prices $ | upper prices $ | Mean $ |
|---|---|---|---|
| Dried fruit | 861.96 | 1 379.2 | 1 121 |
| Seed oil | 3 465.0 | 17 325.0 | 10 395 |
| Sum | **4 326.96** | **18 704.20** | **11 516** |

Note that seed pulp is a potential additional product derived from the seeds after oil has been extruded. The use of this for animal feed will be investigated by Dr. Chivandi of from the University of Witwatersrand.

### 3.6.6 Sustainable job creation opportunities

If the upper price of oil and fruit can be obtained ( 50 $ /l oil and 3.2 $/kg dried fruit), and assuming that 50 % of the net income derived from milkwood harvesting will need to go into operational costs, this will leave 9352.1 US $, or R1047 43 per year for wages. At a daily wage rate of R145 per day (well above the R80 per day paid by government EPW programmes), this could provide about 700 person work days per year. Because the harvesting and oil extraction work load is likely to be seasonal, the 700 person work days *could provide full time employment for six staff for 4 months of the yea*r. Additional work responsibilities for these staff could include forest rehabilitation, and forest guards/rangers and collecting monitoring data on the health of the resources

### 3.6.7 Expanding the project production area beyond the pilot site: implications

The economic viability of the project could be considerable increased by scaling up the area from which milkwood fruits are harvested.

To do this analysis, I mapped additional Coastal Red milkwood forest patches occurring with 50 km of the pilot site (see appendix 2). The forest were mapped using satellite imagery along with considerable ground truthing. The table below provide summary of the total additional area and kg fruit that it could be expected to yield . The maps below the tables, show the areas

Table 13. Expanding the project harvest area to include three additional sections. The area of milkwood forest and extrapolated fruit yield from them, are given.(* this is the original pilot study site)

| Section | Area (ha) | Oil yield (l) (using a mean of 10.5 l/ha) | Fruit pulp (kg) (using a mean of 65,3 kg/ha) |
|---|---|---|---|
| Port St Johns to Mboyti | 66 | 693 | 4309.8 |
| Mtakati to Mdumbi | 33 | 346.5 | 2154.9 |
| Mdumbi to Umtata mouth* | 33 | 346.5 | 2154.9 |
| Umtata mouth to Coffee bay | 13.6 | 142.8 | 888.08 |
| **Sum** | **132** | **1528.8** | **8619.6** |

*Income estimation for suppliers from Milkwood oil and pulp harvesting for expanded project areas*

The net income that suppliers could expect from the sale of Coastal Red milkwood seed oil, and dried fruit have been extrapolated for the expanded projects areas based on the fruiting yield models derived for the pilot site. Because pricing drives the feasibility of the analysis, I have used a upper and lower price estimation to bracket the potential outcomes.

Table 14. Income to suppliers that can be expected from sale of Red Milkwood seed oil, for a upper and lower pricing scenario

| | | | Lower price | | Upper price | |
|---|---|---|---|---|---|---|
| Section | Area (ha) | Oil yeild, l (using 10,3l/ha) | Price oil $ | Total $ sale oil | Price oil $ | Total $ sale oil |
| Port St Johns to Mboyti | 66 | 693 | 20 | 13860 | 50 | 34650 |
| Mtakati to Mdumbi | 33 | 346.5 | 20 | 6930 | 50 | 17325 |
| Mdumbi to Umtata mouth (Pilot site) | 33 | 346.5 | 20 | 6930 | 50 | 17325 |
| Umtata mouth to Coffee bay | 13.6 | 142.8 | 20 | 2856 | 50 | 7140 |
| Sum | 145.6 | 1528.8 | 20 | **$30 576** | 50 | **$76 440** |

*Using a mean between upper and lower value*

Table 15. Income to suppliers that can be expected from sale of Red Milkwood dried fruit , for a upper and lower pricing scenario

| ` | | | Lower price | | Upper price | |
|---|---|---|---|---|---|---|
| Section | Area (ha) | Dry fruit pulp (kg) (using a mean of 13.6 kg/ha) | Price fruit pulp $ | Total $ sale fruit pulp | Price dry fruit $ | Total $ sale dry fruit |
| Port St Johns to Mboyti | 66 | 897.6 | 2 | 1795.2 | 3.2 | 2872.32 |
| Mtakati to Mdumbi | 33 | 448.8 | 2 | 897.6 | 3.2 | 1436.16 |
| Mdumbi to Umtata mouth (Pilot site) | 33 | 448.8 | 2 | 897.6 | 3.2 | 1436.16 |
| Umtata mouth to Coffee bay | 13.6 | 184.96 | 2 | 369.92 | 3.2 | 591.872 |
| Sum | 145.6 | 1980.16 | | **$3 960** | | **$6 337** |

Total income for both fruit pulp and seed oil production using an upper pricing scenario would be $82 777 ; and the lower pricing scenario, $34 536. The mean between the upper and lower case scenarios is $58 656.5.

### 3.6.8 Net employment creation potential from expanded area

Using an estimated $58 656.5 income to suppliers, the employment creation potential has been calculated as follows: assume a 50 % deduction of income to suppliers for operational cost, and a daily wage of R150 per day (13 $ per day); cost: total person work days potentially available are 2256 . This income could provide full time jobs for 75 people for 4 months of the year, (with $ 29 328.25 still available for operational costs).

### 3.6.9 Summary and conclusion

With the development of a new product, such as this, (Milkwood fruit pulp and seed oil), the value of the product to markets is difficult to determine. However using the models derived in the pilot study site, and a comparative analysis of similar products, (and using a mean value for upper and lower price estimates), approximations of economic and employment opportunities have been made, these are summarized in the table below.

Table 16 Summary of extrapolated economic and employment value of the harvest of Red Milkwood seed and fruit.

| Item | Value to supplier (mean between upper and lower estimates) in US $ | |
|---|---|---|
| Area harvested | Pilot site only (33ha) | Expanded project area (132 ha) |
| Milkwood seed oil (tot liters/year) | 10 395 | 53 508 |
| Milkwood dry fruit pulp (kg/year) | 1 121 | 5 148 |
| Net value US $/year | 11 516 | 58 656 |
| Job creation potential (with a 50 % of gross income to supplier used for wages) | 700 person work days (6 *jobs for 4 months of the year*) | 2256 person work days . ( 75 jobs for 4 months of the year |
| Viability | Medium | High |

## 3.7 Nutritional analysis of seeds

The results of the nutritional analysis of Milkwood seeds, are presented in the tables below. (These results will also be published in the South African Journal of Botany)

### 3.7.1 Proximate analysis ash, protein, fat and fiber

The results of the proximate analysis of the gross nutrients of *M. caffra* are given in the table, below. Included for comparison are the values for *M. zeyheri* (from Chivandi et al 2011).

**Table 17** Proximate, ash, protein, fat, and fibre composition of shelled seeds of Coastal Red-milkwood (*Mimusops caffra*) and Transvaal Red-milkwood (*M. zeyheri*). Data for the later, from Chivandi *et al* (2011). Mean of three samples, taken from ten trees randomly selected (expressed as a % of sample material).

| Component | Mean of three samples (%) | |
|---|---|---|
| | *M. caffra* | *M. zeyheri* |
| Dry matter | 89.7 | 91.1 |
| Ash | 4.2 | 2.7 |
| Protein | 9.0 | 9.3 |
| Fat (ether extraction) | 23.5 | 21.2 |
| Neutral detergent fibre | 24.3 | 33.2 |
| Acid detergent Fibre | 8.7 | 15.3 |

*M. caffra* seed's crude protein content of 9.0, is relatively low, at least, in comparison with the crude protein of content of legume seeds (major plant protein sources), but is comparable to the crude protein content of ordinary maize varieties, that according to the FAO, (1992) that range from 8% to 11%.

### 3.7.2 Amino Acids

The amino acid profile of two species of milkwood, Transvaal and Coastal red- are compared in the table below.

**Table 18.** Amino Acid profile of *M. caffra* and *M. zeyheri* for shelled seeds of these species. (Mean of three samples, expressed as g/100g of shelled seed, and as % of total protein.

| Amino Acid | *M. caffra* | | *M. zeyheri* | |
|---|---|---|---|---|
| | g/100g | % of protein | g/100g | % of protein |
| Alanine | 0.45 | 5.52 | 0.8 | 8.84 |
| Arginine | 1.09 | 13.44 | 0.79 | 8.73 |
| Aspartic acid | 0.47 | 5.81 | 0.75 | 8.29 |
| Cysteine | 0.15 | 1.85 | nd | nd |
| Glutamic acid | 0.91 | 11.29 | 1.29 | 14.25 |
| Glycine | 0.51 | 6.35 | 0.38 | 4.20 |
| Histidine | 0.26 | 3.21 | 0.37 | 4.09 |
| Hydroproline | 0.06 | 0.78 | 0.04 | 0.44 |
| Isoleucine | 0.36 | 4.45 | 0.38 | 4.20 |
| Leucine | 0.61 | 7.50 | 0.58 | 6.41 |
| Lysine | 0.38 | 4.74 | 0.64 | 7.07 |
| Methionine | 0.16 | 2.02 | 0.12 | 1.33 |
| Phenylalanine | 0.32 | 3.96 | 0.34 | 3.76 |
| Proline | 0.55 | 6.76 | 0.57 | 6.30 |
| Serine | 0.45 | 5.56 | 0.36 | 3.98 |
| Threonine | 0.44 | 5.44 | 0.44 | 4.86 |
| Tryptophan | 0.09 | 1.12 | nd | dd |
| Tyrosine | 0.27 | 3.34 | 0.71 | 7.85 |
| Valine | 0.55 | 6.84 | 0.49 | 5.41 |

Arginine and Glutamic acid, were the highest concentrated amino acid, constituted approximately 13.3, and 11.3 % of the total amino acids respectively. Interestingly, but not surprisingly, the amino acid profile of *M. caffra* is similar that of *M. zeyheri*, with Arginine and Glutamic being the dominant amino acids in both species of seed.

### 3.7.3 Lipids

The lipid profile for Coastal Red-milkwood seeds are given in the table below.

**Table 19.** Lipid profile, % of lipid type in total oil of shelled dry seeds of Coastal Red-milkwood (M. cafra). mean of three samples.

| Name | Mean % of total oil | SD(-+) |
|---|---|---|
| Oleic acid | 10.89 | 0.19 |
| Palmitic acid | 4.36 | 0.10 |
| Linoleic acid | 3.28 | 0.04 |
| Stearic acid | 2.51 | 0.03 |

| | | |
|---|---|---|
| Myristic acid | 0.93 | 0.05 |
| Lauric acid | 0.26 | 0.00 |
| Arachidic | 0.16 | 0.01 |
| Capric acid | 0.15 | 0.05 |
| Palmitoleic | 0.15 | 0.01 |
| Pentadecanoic acid | 0.10 | 0.00 |
| Eicosadienoic | 0.09 | 0.05 |
| Elaidic acid | 0.09 | 0.15 |
| Myristoleic acid | 0.08 | 0.00 |
| Lignoceric acid | 0.02 | 0.02 |
| gamma Linolenic | 0.01 | 0.02 |
| Behenic acid | 0.01 | 0.00 |
| Eicosatrienoic acid | 0.00 | 0.00 |
| Eicosadienoic acid | 0.00 | 0.00 |
| rest | 0.41 | |
| Total fat % | 23.50 | |

The lipid profile shows the presence of a wide variety (around 21) different lipid types in the oils of *M. caffra*, however, just five lipids make up around 90 % of the total oil content, with the dominant oil being oleic acid (46 % of total oil content).

In the table below, the dominant lipid types of *M. caffra*, and *M. zeyheri* are compared with four well established wild tree seed oils, that are commercially used in Southern Africa, (mostly in the cosmetics industry.)

**Table 20.** Comparison of seed oils of two species of Red-milkwood (M. caffra and M. Zeyerhi) with four wild tree seed oils, that are used commercially in Southern Africa: *Trichelia dregiana* (forest mahogany); *Scleroclaria birrea* (marula), and *Adansonia digitata* (baobab). Note: * = mono-unsaturated, ** poly-unsaturated, all rest are saturated oils. data sources: *M. cafra*, from this study, *M zeyheri*, from Chivandi et al 2011, *T. degiana*, from (xx) , all the rest from Vermaark, et al 2011.

| Lipid type | % of tot fat extract | | | | | |
|---|---|---|---|---|---|---|
| | M.caffra | *M. zeyheri* | *T. dregiana* | *T. emetica* | *S. birrea* | *A.digitata* |
| Oleic acid * | 46 | 85 | 51 | 51 | 74 | 36 |
| Linoleic acid** | 14 | | 11 | 16 | 6 | 28 |
| Linolenic** | | | 0 | 16 | 0 | 0 |
| Palmitic acid | 19 | 15 | 34 | 48 | 11 | 24 |
| Stearic acid | 11 | | 3 | 3 | 7 | 6 |
| Myristic acid | 4 | - | - | - | - | 1 |
| % total fat in seed | 24 | 21-25.6 | 55-65 | 55-65 | 58.6 | 12 |
| % Unsaturated* | 60 | 85 | 62 | 83 | 80 | 64 |

While the % total fat in the seeds of Milkwoods are considerably lower than the wild tree seed oils yields for the two Trichelia species, and Marula, (around half), the quality of the oil in terms of the lipid types, are comparable. Despite this, percentage oil content compared favourably with the oil content of such seeds as cotton (18-28%) and soya bean (11-25%), which are commercially grown for oil extraction. as well as a number of other wild tree seed oil species being considered for commercialization, in Nigeria, where yields were similar to those of M. caffra (see for example Ajiwe, et al, 2006).

Coastal Red milkwoods have the distinct advantage over some of the other wild tree seed species, in that they occur in large numbers, over relatively small areas.

### 3.7.4 Mineral analysis

The results of the mineral analysis of *M. caffra*, are presented in the table below, (where data was available), comparison are made with the *M. zeyheri*, and Maize. *M. caffra* is notable for its high calcium (ca) content relative to maize and, surprisingly, double that of *M. zeyheri* . This is likely to be due to the different soils in which they grow, dunes being high in calcium containing marine deposits.

**Table 21.** Comparison of percentages of Minerals, in *M. caffra,* with the M. zeyheri, and maize

| Element | *M. caffra* | *M. zeyheri* | Zea Maize |
|---|---|---|---|
| | % | % | % |
| P | 0.138 | 0.11037 | 0.2996 |
| K | 0.803 | | |
| Ca | 1.042 | 0.5874 | 0.0483 |
| Mg | 0.106 | 0.1023 | 0.107 |
| S | | | |
| Na | 0.026 | | |
| Fe | 0.005 | | |
| Zn | 0.003 | | |
| Mn | 0.001 | | |
| Cu | 0.001 | | |
| B | 0.002 | | |
| Al | 0.013 | | |
| Se | | | |

## 3.8 Dune rehabilitation

Concern over the degraded state of section 1, the Mdumbi main beach dune forest, was the original motivating force behind looking for non timber forest products that could be used to drive improved forest conservation. This also lead to one of the aims of the projects ie to initiate dune rehabilitation measures. This task involved a Milkwood seedling recue and replanting operation, to improve the recruitment base for the declining Coastal Red-milkwood populations. Given the slow growth rate of Milkwoods, the seedlings were established in a nursery at the very start of the project, so that their growth could be monitored over the duration of the project (1year). It is hoped that this will motivate further funding to support interventions involving dune stabilization v using supplementary planting and physical support to reduce dune shifting ,in the form of shade cloth barriers, as well as alien plant clearing .

Around 120 seedlings were 'rescued' (from livestock browsing) from the Mdumbi main dune forest and placed into nursery potting bags using a mixture of 50 % potting soil, and 50 % sand taken from the same dune, along with a handful of bone meal. After one and half months, there has been about an 85 % survival rate of the bagged seedlings. The care, and outgrowing of the milkwood trees and subsequent replanting has been adopted as an environmental responsibility project by the Mdumbi back- packers, as the dune has direct impact on the tourism value of the area.

**Figure 9.** Rescued Coastal Red-milkwood seedlings, growing out in Mdumbi backpackers nursery. The intention is to replant them back at a later stage to boost the declining populations and address the absence of seedling recruitment.

# 4 Discussion

## 4.1 Population dynamics of Coastal Red-milkwoods

*Population recruitment of section 1 forest (Mdumbi beach)*

Generally, healthy populations of forests trees will have sizes class distributions that form a typical reversed-J shaped curve (negative exponential function, i.e. many juveniles that decline exponentially with age). This general model can however be modified by various disturbances, such as logging of mature trees, or a poor seedling recruitment rate. Tree stem diameter distributions of population are commonly used to assess the disturbance effects within forests and to detect trends in regeneration (***Johnson & Davis,*** 1987). The low frequency of young age classes, in the Mdumbi beach dune, (section 1, of the study area), implies poor recruitment and environmental stresses. The size class distribution of this population (as measured by stem diameter at breast height ,or DBH), forms a bell-shaped curve, which is characteristic of a species with little recruitment (Everard *et al.* 1995).

Evidently, the problem does not reside with the poor germination rates of seeds, as the late summer/early winter rains brought on a flush of milkwood seedlings that had germinated under some of the larger Milkwoods. Unfortunately, it is almost certain that none of these seedlings will survive into the summer, due to livestock trampling and browsing. The shifting sands- due to the near absence of any protective ground cover (see model of causes of dune degradation, in appendix 2), is also a contributing factor. The complete absence of any Milkwood samplings in section 1 of the study area seems to confirm this hypothesis.

*Population age class distribution of section 2 to 4 of study area*

Because the method used to assess the standing stocks of sections 2 to 4 of the study site, was a, qualitative, visual approximation of size classes, ie no directly measure of tree DBH, it was difficult to make direct comparisons between section 1, and the other sections of the study area. However, what was clear, is that sections, 2, 3 and 4 of the study area showed considerable less dune degradation and far fewer standing dead trees, but despite there being more trees in the sub-mature class, as compared to section 1, these sections, still showed a near absence of milkwood saplings (less than a 1,5 meters high). Apart from being further away from the villages, these sections of the study area also differ in their topographical aspect, and suffer less from exposure to prevailing winds (SW and NE), while the section 1, dune is directly exposed to the storm winds, and more livestock traffic than the other sections.

*Use of M. caffra fruit pulp*

Although the fruit is widely eaten in the Wild Coast, there is no evidence of processing for storage as a dry product, however, In Botswana, *M. zeyheri* seedless fruit pulp is sun-dried and the dry residue is eaten in winter (Motlhanka et al., 2008). *M. zeyheri* fruit pulp has a high vitamin C content, 50–80 (Janick & Paull, 2008) or higher, up to 100 mg per 100 g, (Lemmens, 2005). So the pulp is a good source of vitamin C, in areas where it may be in short supply. M.zeyheri fruit pulp is also used in jams, jellies and production of fermented juices (Chivandi, et al 2011).

## 4.2 Lipids and fats

Oils can be classified in various ways. Much of the confusion about fatty acids stems from multiple systems of naming these molecules. Fatty acids can have common names, systematic names and numerical names. However, all fatty acids, (oils, or lipids) fall into one of three major categories: saturated fatty acids; monounsaturated fatty acids; polyunsaturated fatty acids. These classification are important as they relate directly to some of the oil properties, and nutritional values. In the table below, the relative % of each lipid group type for M. caffra are given.

**Table 22.** Lipid groups, expressed as a % of total oil/lipid component for *M. caffra*

| Lipid group type | Mean |
|---|---|
| Saturated | 8.71 |
| Mono-unsaturated | 11.29 |
| Poly-unsaturated | 3.37 |

| | |
|---|---|
| Transfatty acids | 0.11 |
| Cls fatty acids | 14.17 |
| Omega 3 | 0.04 |
| Omega 6 | 3.33 |
| EPA | 0.00 |
| DHA | 0.00 |
| Omega 9 | 10.98 |

Saturated fatty acids (e.g. palmitic; stearic; arachidic) most frequently occur in higher concentrations in animal foods such as butter, cheese, and fatty meats; however, there are certain exceptions to this rule, and plant-derived fats such as coconut and palm oils are also extremely high in saturated fatty acids. Saturated fats are "saturated" because the carbon atoms are completely filled with hydrogen atoms. In fatty foods, the most common saturated fatty acids are lauric acid (12:0), myristic acid (14:0), palmitic acid (16:0) and stearic acid (18:0). Excessive consumption of these three fats elevate blood concentrations of total and LDL cholesterol, but recent meta analyses (combined large population studies) demonstrate they don't increase your risk for heart disease (also see Tim Noak's  new look at the value of animal fats in human diet). These oils may have more value in the cosmetic industry than as nutritional supplements.

Mono-unsaturated fatty acids (e.g. oleic acid) most frequently occur in higher concentrations in plant foods such as olive oil, most nuts, and avocados. Although marrow from animal bones it is also a good source of mono-unsaturated fats. When contrasted to saturated fatty acids, dietary monounsaturated fatty acids lower blood cholesterol concentrations. They therefore have value in both the cosmetics industry as well as being nutritionally valuable. This is relevant to Milkwood seed oil, as the dominant oil is the monounsaturated oil, Oleic oil (as in olive oil).

Poly-unsaturated fatty acids contain two or more double bonds along their carbon backbones. Polyunsaturated fatty acids are classified into two biologically important subgroups**:** omega-6 **a**nd omega-**3** fatty acids**.** Linoleic, and linolenic acid are examples of polyunsaturated (omega 6). These are essential oils, not made by the body and a deficiency will cause various signs. The skin dries out and becomes scaly, nails crack, and hairloss as well as transepidermal water loss increases.

despite, *M. caffra* seed oils, being mostly mono-unsaturated oils, it does have a balance of all three classed of oil, although relatively low in poly-unsaturated oils (mostly omega 6), and only trace amounts of omega 3 oils. See table, below.

*M. caffra*, despite having a nutritional value comparable or better than olive oil, cannot match the nutritional value of some the commercially produced seed oils such as Chia, or flax seed, that are very high in poly-unsaturated, omega 3 oils. See table below.

**Table 23.** Comparison of lipid group categories for a number of commercially produced seed oils, with specific emphasis on nutritional value of the rare essential oils (omega 3). Seeds with a low ratio of omega 6 to omega 3 oils have high commercial value as a nutritional supplement.

| Seed type | Saturated | Mono-unsaturated | Poly-unsaturated | Omega-6 | Omega-3 | Ratio Omega 6 to 3 |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| Chia | 3.14 | 2.11 | 23.35 | 5.79 | 17.56 | 0.33 |
| Flax | 3.19 | 6.87 | 22.44 | 4.32 | 18.12 | 0.24 |
| Pumpkin | 8.51 | 14.25 | 20.88 | 20.70 | 0.18 | 115 |
| Sesame | 6.66 | 18.74 | 21.76 | 21.38 | 0.38 | 56 |
| Sunflower | 5.05 | 9.46 | 32.70 | 32.63 | 0.07 | 466 |
| Watermelon | 9.71 | 7.41 | 28.10 | 28.10 | 0.00 | nd |
| M. zeyheri | 15.25 | nd | nd | nd | nd | nd |
| M. caffra | 8.71 | 11.29 | 3.37 | 3.33 | 0.04 | nd |
| Mean | 7.53 | 10.02 | 21.80 | 16.61 | 5.19 | 127.59 |
| *M. caffra* :above mean | 'yes' | 'yes' | No | No | No | |

*M. caffra* seeds have a relatively high proportion of mono -unsaturated oils (higher than the mean of six commercially produced seed oils), due to the high oleic acid content, but lower mean for the essential omega oils. This tends to point to the potential uses of *M. caffra* oil in the cosmetics industry, or as a non essential but healthy, oil for cooking, salads etc. *M. caffra* oil could theoretically, be used as an olive oil substitute

Like Marula oil, the high proportion of mono-unsaturated fatty acids in *M. caffra*, also act as a natural antioxidants, and make the oil very stable, a useful attribute for cooking, storage and processing.

Although the brake down of the lipid types found in the *M. caffra* seed oils, show the potential for a wide variety of uses, specifically, the high amount of Oliec oil, point to culinary uses, while the high palmitic oil content point to soaps, and cosmetic products. The mixture of different oil types found in M. caffra may also give unique qualities that may be suitable as a body skin lotion . Other potential uses include uses include, resin, paint, polish, wood varnish and skin cream and solid soap, but this may require processing.

It needs to be noted that further analysis still need to be conducted to fully understand the potential uses of *M. caffra* oil. For example, the presence of any anti-nutritional-factors in the oil (tannins, saponines, etc), need to be determined before used for human consumption.

## 4.3 Protein and amino acids

*M. caffra*s seed's crude protein content of 8.99%, admittedly low in comparison with the crude protein content of legume seeds (major plant protein sources), is comparable to the crude protein content of ordinary maize varieties, that according to the Food and Agricultural Organization (FAO) (1992) range from 8% to 11%.

Milkwood seed show an interesting profile of amino acids, although not particularly high in essential amino acids it does have high levels of the semi essential amino acids, Arginine and glutamic acid. The predominant amino acid is Glutamic acid, and there are significant, although trace amounts of Methionine and cystine (0.2 g/100 g), which are arguably the most critical dietary ingredients for people lacking regular access to meat, milk, cheese, eggs, or fish, and absent in maize

Glutamic acid benefits mostly the neurological brain function and metabolism. and is being sold in the wellness industry as a 'brain food' necessary for learning, memory, and problem solving. Glutamic acid, glutamate is a non essential amino acid, but one of the most abundant neurotransmitters in the body, glutamic acid, or glutamate Essential for brain cognitive functioning. Glutamic acid is however, high in what , with 30--35% of the protein in wheat being glutamic acid.

## 4.4 Minerals

The Coastal Red-milkwood seeds are particularly high in Ca. Comparison with *M. zeh*eri is complicated by different units and moisture levels, but in general *M. caffra* have similar macro nutrients content, but a significantly higher calcium content , this can may be expected given high organic calcium in dunes soils in which they grow. *M. caffra*'s seed's calcium content is much higher than the 0.0483 % (48.3 ± 12.9 mg per 100 g) reported by the FAO (1992) for maize. While the phosphorus content of *M. caffra*'s seed (Table 1) is lower than the phosphorus content of maize at 0.2996 (299.6 ± 57.8 mg per 100g). The magnesium is relatively high for a plant source, and may be valuable nutritional.

## 4.5 Potential ecological impacts and their mitigation

The fruit of the Coastal Red-milkwood is considered tasty, and eaten by people and animals alike. The fruit forms and important food source for monkeys occurring in coastal areas , and the fallen fruits are eaten by bushpigs. Many birds eat the fruit, in particular Cape parrot, Starlings, Bulbuls, and greenbuls. The leaves are used by a number of caterpillars , in particular the Chief False Acraea butterfly (*Pseudacraea lucretia*). According to Boon (2010), all members of the genus Mimusops, are often infested with the Tent Caterpillar Moth (*Bostra carnicolor*), that spins webs over groups of leaves and causes defoliation, particularly in autumn. Although trees rapidly recover from this, the impact of this on fruit production may be significant . These impacts can be moderated by manipulating the level of harvesting intensity. It is recommended that the top third of each trees, fruit be left unused for regeneration and for fruit eating animals ( 75 % harvesting intensity)

The potential impacts of harvesting, on fruit eating animals needs to be considered within the context of communal areas, where both monkeys and bushpigs are considered pests for their crop raiding habits. The impacts on these species, at least outside of protected areas, is not a major consideration. The fallen fruit are also eaten by livestock that come into the dune forest (they are particularly relished by goats, which becomes a problem for the 'collateral damage' that they cause when in the forests- goats will eat milkwood seedlings or coppicing, having a major impact on the regeneration of milkwoods.

The environmental impact of a 75 % harvest on regeneration potential of the tree population is not likely to be significant at all, as there is currently, almost zero regeneration occurring (without any harvesting). This is due to livestock grazing and browsing in the forest and the shifting of the destabilized dunes. Fruit harvesting will reduce the number of seedlings that germinate under a tree, but it will not have any significant impact on population recruitment. In addition , if any harvesting operation is to occur, it needs to be accompanied by a dune rehabilitation program, that specifically aims to boost recruitment by enrichment planting of nursery grown milkwood sapling, of about 1,5 meters high. This will take approximately three years, if a slow growth rate of 0.5 meters a year can be attained under controlled nursery conditions.

In conclusion, it is believed that the recommended harvesting intensity of 75 % the impacts will be acceptable, particularly, within the context of communal areas. Within priority forest, designated or planned protected areas, the use of the trees fruit should be left for wildlife, and a zero harvest is advocated. It is also recommended that within any harvesting area, at least one third of the area, be left as a core 'no-take' conservation area. For this study area it is recommended that the forest patch, section 4, at the Umtata mouth be left as a 'no-take' area. This section (4) of the dune forest is also much higher in species diversity than other sections of the study area, with mixture of typical scarp and dune species.

The harvesting intensity, although essentially a management option (to reduce potential impact), is also a practical consideration, that accounts for the fact that fruit in the top third of the tree, may be less accessible for harvesting, in any case, the top third of all tree's fruit should be left for seed regeneration and for fruit eating fauna. The impact of harvesting 75 % of all fruit , on the local bird population could be an interesting postgraduate study.

# 5 Way forward

*Commercial potential*

Seed oils have been used for centuries by rural communities as food, medicine, for cosmetic applications and as fuel. Recently there has been a renewed interest in these non-timber forest products , specifically for use in the cosmetic and wellness industries formulations (Vermmark, et al 2011). The growing demand for innovative and 'natural' products provides a window of opportunity for communities with these valuable resources.

Although product development, and market potential fall outside the scope of this project, efforts will be made to seek follow up funding to expand the project further. Recently I was contacted by CEO of PhytoTrade Africa, to arrange to discuss the project. Initially, when I first approached them with the project concept, (over a year and a half ago), they were unable to assist, as they apparently, did not work in the Eastern Cape. This organizations core mission is to provide supply chain support for the development of fair trade products harvested from the wild.

*Laboratory analysis*

Additional laboratory work is still required, particularly if products are to used for human consumption. For example, the presence of any anti-nutritional factors, such as tannins, saponiens, plant sterols, need to be established. The seed pulp, after oil extraction has the potential use as a animal feed, this will also require further analysis. The fruit itself may also be a valuable product, and it would be useful to do a vitamin analysis on this. The vitamin C content of *M. zeyheri* is known to be high (2-3 times higher than oranges), but this needs to be established for *M. caffra*.

*Exploring potential products from fruit pulp*

The development of potentially marketable product from the fruits, may make the difference between a economically marginal enterprise or a viable one. The fruit pulp would be a byproduct of oil extraction, and significant volumes of fruit pulp could be produced (estimates of fruit pulp, after seed removal range from around 40 to 100 kg per ha of milkwoods). Potential fruit products include, fruit preserves, and dried fruit rolls

*Oil extraction and fruit processing methods*

Although outside the scope of this project, further work needs to be done on exploring efficient and cost effective methods of oil extraction and fruit processing. Ideally some processing should done on site, to create added value and employment, within the community. A good example to consider is the processing of Natal Mahogany, in Mozambique, to produce Trichilia oil (Mafurra butter), where the oil extraction is done on site, by crushing the seeds and boiling, with oil rising to the surface, being skimmed off the top.

*Other wild tree seed oil species to consider*

Apart from the Coastal Red-milkwood, there are two other species of tree that have established tree seed oil markets, these include the Cape Chestnut (yengu oil), and the Forest Mahogany Although the later species has not been commercially exploited before , its close relative, the Natal Mahogany, has been used in Mozambique for many years to produce Trichelia oil, or Mafurra butter. Analysis shows that the seed oil of the forest mahogany is comparable with that of the Natal Mahogany (although it is not known if there are any differences in oil quality)

This study hopes to include a look at the potential of both Cape Chestnut and Forest Mahogany seed oil harvesting from the Wild Coast, although not in the same level of detail as the Coastal Milkwood. Quite a bit of research work already exists on these two species, where the former is commercially harvested in Kenya , and the close relative of the later , in Mozambique . Any traditional use of the seed oil of these two trees on the Wild Coast has never been recorded, according to my research.

Both species occur sporadically in scarp forest, and are typically, hard to find, particularly outside of flowering season. Recently I came across a stand of about 15 medium sized forest mahogany trees. These trees were the remnants of forest, that had been cleared for maize lands, probably well over 15 years ago. It is assumed that these trees were left un felled, as they are perceived to be magical and medicinal. Most of them had substantial amounts of bark removed (used medicinally, see picture). About one third of the Forest Mahogany were in seed. Because, Forest Mahogany each sex on separate trees, not all trees will produce seed. About 2.5 kg of seed were collected from three Forest mahogany trees, and will be used to test an extract oil (see picture). To date, no Cape Chestnut trees have been found within the study area, but it is hoped that the bright pink flowers, that start in the early summer, will help to locate these trees in the forests.

**Figure 10**. The oil rich seeds of the Forest Mahogany (*Trichelia dregiana*), found close to the study site .

**Figure 11**.The author with a Forest Mahogany (*Trichellia dregiana*) showing bark stripping for medicinal use. A group of these trees were found in a deforested valley near the Mdumbi estuary. These trees appear to be one of the few species of trees that were left standing in the scarp forest that had been cleared for maize fields.

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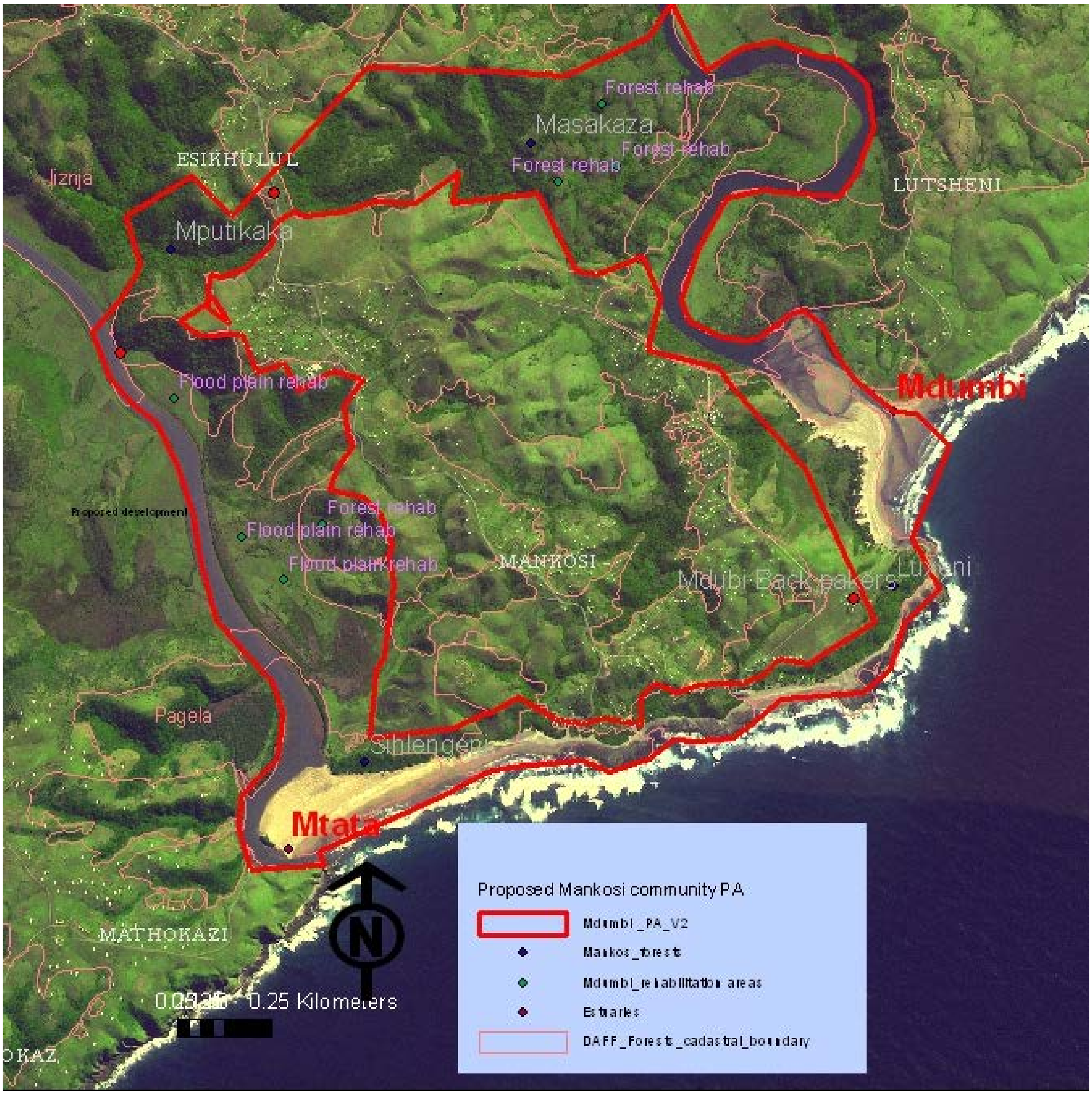
# Appendices

## Appendix 1 : Map of proposed community conservation area for Mankosi



## Appendix 2: Maps of Milkwood forest for an expanded project area

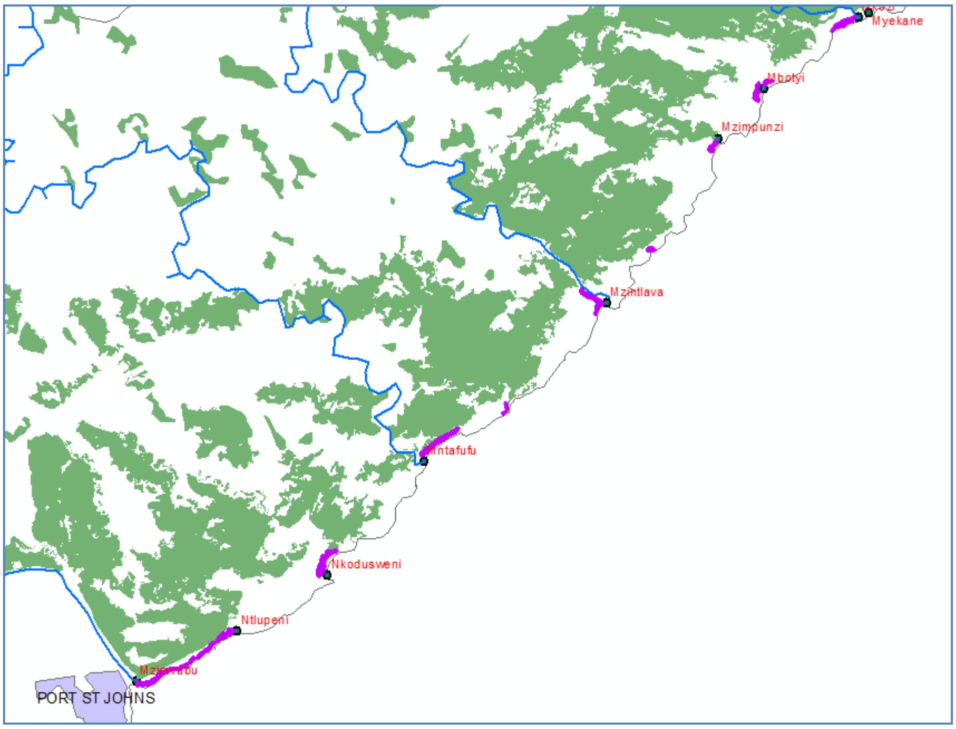



**Figure 12.** Milkwood dune forests (purple patches) of the Ntsubane forest complex (forests in green) from Port St Johns to Mboyti. (Estimated total area of Coastal dune Milkwood forest: 66 ha)

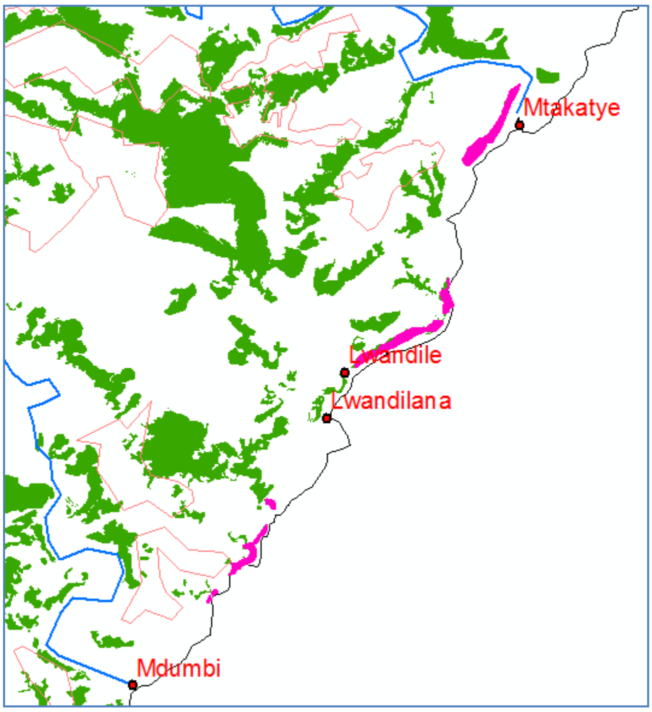



**Figure 13.** Milkwood dune forest (purple patches) between Mdumbi and Mtakatye, approximately 33 ha


**Figure 14** Milkwood dune forest between Umtata mouth and Coffee bay (purple patches), total area 13,6 ha

## Appendix 3. Model of probably causes of dune degradation for study site (from Berliner, D.D , in prep)