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Ecological Review: The implications of fynbos ecology for *Cyclopia* species

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EADP 696: THE DEVELOPMENT OF GUIDELINES FOR THE SUSTAINABLE HARVESTING OF WILD HONEYBUSH

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Service Provider: Caroline Gelderblom Consulting

THE IMPLICATIONS OF FYNBOS ECOLOGY FOR *CYCLOPIA* SPECIES

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1. A REVIEW OF FYNBOS AND *CYCLOPIA* SPECIES ECOLOGY

The aim of this review is to present existing ecological knowledge of fynbos and *Cyclopia* spp. (with a focus on *C. intermedia*), which is relevant to the development of guidelines for the sustainable harvesting of wild honeybush. General ecological aspects that are important to understand in this context that will be covered are ecological determinants of fynbos, biological characteristics of the Genus *Cyclopia* and *C. intermedia*, variability within this species and responses of reseeders and resprouters to fire and harvesting.

1.1 Fynbos ecology

The Fynbos biome (Figure 1) is the largest of the biomes in the Core Cape Floristic Region, covering some 90 000 km^2 (Manning and Goldblatt, 2012). All species of *Cyclopia* grow in fynbos (Schutte, 1997), the characteristic vegetation of the biome. Fynbos is associated with nutrient-poor soils, most derived from sandstones and quartzites of the ancient Table Mountain Group. However, some fynbos communities grow in coastal lowland settings on leached, aeolian sands and calcareous soils derived from calcrete and limestone. Only one commercial species of *Cyclopia* is found in lowland fynbos, namely *C. genistoides* (kustee).

Fynbos is a shrubby vegetation characterised by the presence of three plant types: proteoid shrubs, which are usually large-leaved species in the family Proteaceae that form the overstorey (tallest shrubs) in mature veld (i.e. veld with a post-fire age of at least 8 years); ericoid shrubs that have small, hard leaves and comprise several thousand species in many families (e.g. Ericaceae, Rutaceae, Rhamnaceae); and restioids, rush-like plants in the Restionaceae. Proteoids do not have a universal presence in fynbos but the other two plant types do.

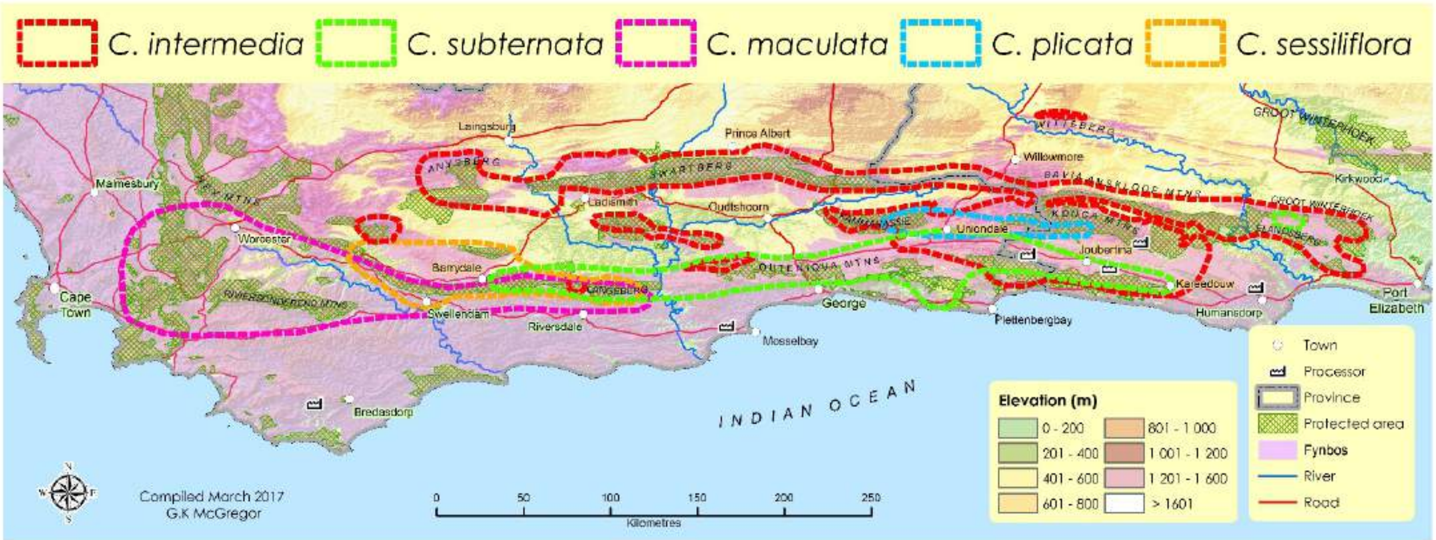

Figure 1: The fynbos biome and the distribution of the five commercially important wild harvested *Cyclopia* species. The map also shows the extent of protected areas in the study area.

The conservation status of the Fynbos biome is geographically biased (Lombard *et al*., 2003). Thus, the mountains, where most *Cyclopia* spp. grow, are generally well-conserved (see Figure 1), although important areas such as the Caledon and Bredasdorp mountains are significant gaps. On the other hand, lowland areas are massively under-represented in the protected area system (Rouget *et al*., 2014).

1.2 Rainfall

While the Fynbos biome is said to grow under a winter-rainfall regime, this is not strictly true. Only the south-west and western parts of the biome receive more than 60% of their rainfall during the winter months (Bradshaw and Cowling, 2014). East of a line from Cape Agulhas in the south to Laingsburg in the north, the biome experiences year-round rainfall, although the spring and autumn months are the most reliably wet; hence the rainfall regime is better described as bimodal. West of the Knysna/Uniondale line, the summer months are driest, while eastwards, lowest rainfall is recorded in winter. Interestingly, the majority of *Cyclopia* species grow in the bimodal rainfall region of the Fynbos biome (Figure 2).

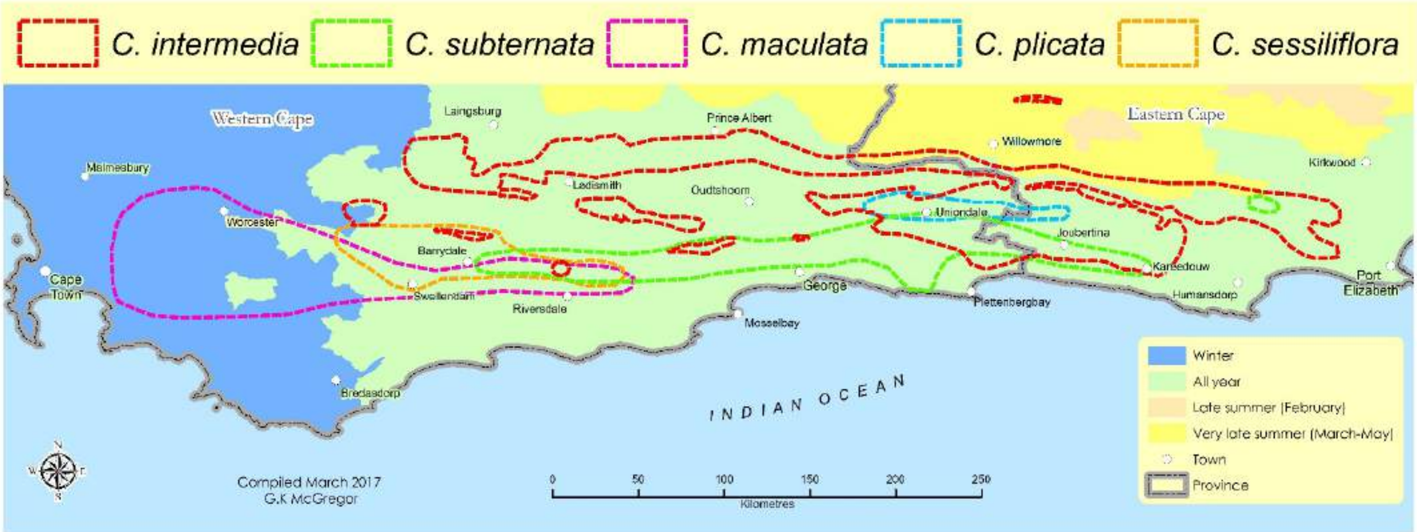

Figure 2: Rainfall seasonality across the distribution range of the five commercially important wild harvested *Cyclopia* species (based on data from Schulze, 2007).

1.3 Fire

An important feature of fynbos, and a crucial management issue, is its exposure to regular fires. Indeed, fynbos vegetation is supremely fire-adapted and has been exposed to fire since its inception more than 100 million years ago (He *et al*., 2016). Without fire, most fynbos, especially on the deeper soils of the lower mountains slopes, would be colonised by forest and thicket. Under natural circumstances (i.e. without anthropogenic influence), fire-return intervals for most fynbos vegetation are in the order of 10-50 years. The season of burn varies according to climatic regime, with the western, winter-rainfall areas predominantly experiencing fires in the dry summer and autumn months, the western, bimodal rainfall regions also experiencing mainly summer fires, while the eastern bimodal rainfall regions may experience fires at any time of the year, with a tendency for winter fires associated with hot, berg wind conditions (Kraaij and Van Wilgen, 2014). Under human influence, the fire return intervals in many parts of the Fynbos biome have become significantly shorter, owing to the massive increase in the incidence of ignitions. In some cases this is deliberate, so as to improve the grazing value of veld, for example in the eastern grassy fynbos. However, in most instances fires are accidently (or negligently) started by humans, or started by arsonists. The MODIS fire data shows fire return intervals for the study area over the past 15 years. While the data is limited by the short period of record (15 years), in the context of this study, what is remarkable is the high frequency of fire in and around Kareedouw, Joubertina, parts of the Kouga mountains and the Elandsberg, all of which are wild honeybush harvesting areas.

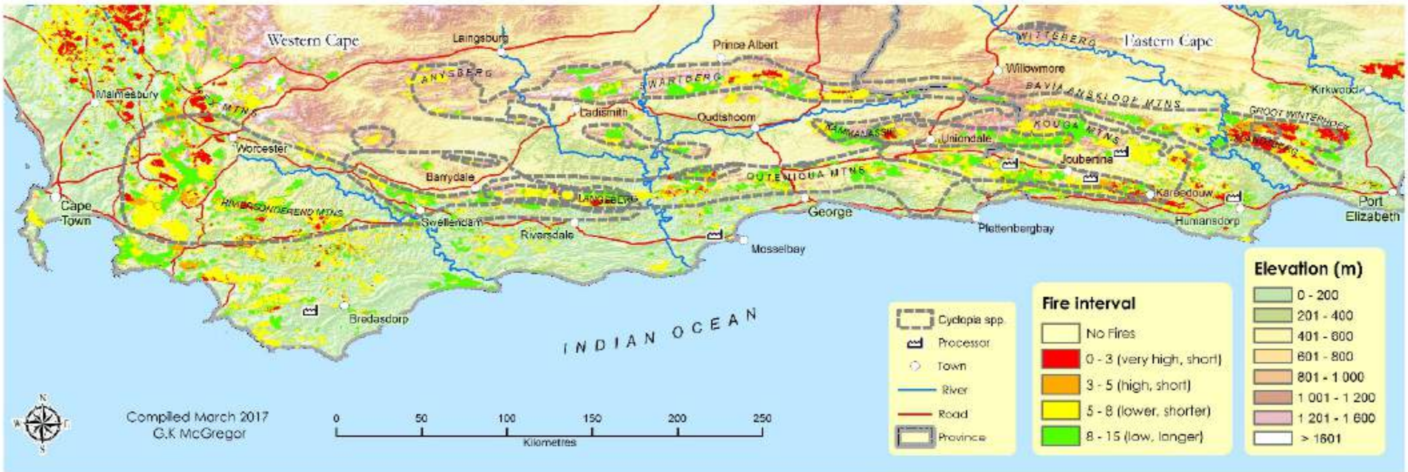

Figure 3: Fire return intervals for the study area, based on MODIS data which is only available for a 15 year period 2002 to 2016.

As indicated above, fire is a crucial management tool in fynbos, enabling managers to increase or decrease the size of species' populations, depending on the fire regime applied. Thus, in the western biome, winter fires may reduce the populations of proteoid shrubs and throughout the biome, fires applied at very short intervals (four years and less), proteoids may be eliminated entirely. Why should this happen? The answer lies in the different ways in which fynbos species regenerate after fire.

1.4 Growth form: reseeders and resprouters

For fynbos species, there are two main post-fire regeneration strategies: resprouting and reseeding (Keeley *et al*., 2012). Resprouters regenerate from dormant, fire resistant buds located on the plant's branches and stems, or below the ground, in lignotubers or rootstocks. In the case of reseeders, the plant is killed by fire (i.e. it is incapable of resprouting) and regeneration occurs via seeds which are either stored in the soil (as is the case for most ericoids) or on the plant canopy (as is the case for most proteoids). It is commonly assumed, although somewhat inaccurately, that resprouters are more resilient to fire since they regenerate vegetatively whereas reseeders are much less resilient to fire since they depend entirely on seeds for population growth and persistence (van Wilgen *et al*., 1992; Keeley *et al*., 2012). Thus, a short-interval burn, which occurs before reseeders have replenished their seed bank, will likely result in a sub-population crash. On the other hand, it is widely, though possibly erroneously, held that resprouters will not be affected. The same applies to fire season when timing of a burn is associated with conditions that are unsuitable for germination of the seeds of reseeders.

In actual fact, both reseeders and resprouters are vulnerable to post-fire population decline, although the former less so than the latter. Recent research, which has monitored populations of fynbos reseeders and resprouters over many decades, has shown that populations of resprouters have declined more significantly than reseeders in the long term (Thuiller *et al*., 2007; Slingsby *et al*., 2017). The reason for this is not entirely clear, but increased summer drought associated with climate change has been suggested as a possible influence through its impact on seedling recruitment. It is important to note that resprouters are also dependent on some seed regeneration for population maintenance as adult plants eventually die. As resprouters allocate more of their resources to lignotubers and other vegetative reproductive organs, the suggestion is that their seedlings have less resources and are consequently more vulnerable to drought (Verdaguer & Ojeda, 2002).

The important lesson here is that it is not wise to assume that resprouters will persist indefinitely in the veld. Adult plants have limited lifespans and require occasional seed regeneration to maintain populations. In terms of the honeybush industry, it is therefore essential to harvest resprouters (such as bergtee – *Cyclopia intermedia*) in such a way that they are still able to flower and set seed. It is also vital that harvesting regimes enable the plants to produce sufficient carbohydrate to replenish the buds and rootstocks that enable successful resprouting. More research is required to determine the optimum harvesting regimes for maximizing production of honeybush foliage, and minimizing negative impacts on resprouting capacity. What we do know is that resprouters have much shorter lifespans than originally thought. Consequently, it is important that harvesting regimes facilitate regeneration via seed and hence seedlings, and do not further reduce lifespans by removing too much plant material at high frequency intervals.

2. ECOLOGY OF *CYCLOPIA INTERMEDIA*

Most of the research reports and peer-reviewed literature on *Cyclopia* spp. focus on the agricultural side of cultivated production (mainly of *C. genistoides* and *C. subternata*) and on the biochemical properties of the various species used in honeybush tea production (see special issue of South African Journal of Botany 2014, vol. 110).

The research publications by Schutte (1997) and Schutte *et al*., (1995) have made a major impact on our knowledge of the genus *Cyclopia*. Also, the work of Barnado (2013) provides valuable information on aspects of the ecology of *C. intermedia* through monitoring in three sites located across the species' distribution. An understanding of the ecology of the species is fundamental to developing a sustainable harvesting approach.

2.1 Botanical description of *C. intermedia*

C. intermedia is a long-lived perennial which takes the form of an erect, robust shrub up to 2 m tall that sprouts after fire. The leaves are typically fine, arranged on the stem in a tri-foliate arrangement with leaflets that are lance-shaped to elliptic with slightly recurved margins. Flowers are about 12 mm long, bright yellow and the calyx has almost rounded lobes with a leathery texture and a golden sheen. (Extracted from Vlok and Schutte, 2010).

It is the most widespread of the species in the genus, with a distribution that ranges across the Cape Fold mountains. The most western populations occur in the Waboomsberg (north west of Barrydale), the furthest inland in the Witteberg (North of Willowmore), the most easterly in the Vanstadens mountains, west of Port Elizabeth. Other mountain areas in which *C. intermedia* occurs include the Witteberg (between Laingsberg and Touws Rivier), Anysberg, Swartberg, Touwsberg, Rooiberg, Kammanassie, Kouga, Baviaanskloof, Langeberg, Outeniqua, Tsitsikamma, Elandsberg and Langkloofberge (Schutte 1997, Manning and Goldblatt 2012, Vlok, J.H.J., 2017, pers. comm.). The distribution of the species is shown in Figure 4. This map represents the most detailed and accurate species distribution map available for the species, relying on published material, field mapping and expert input.

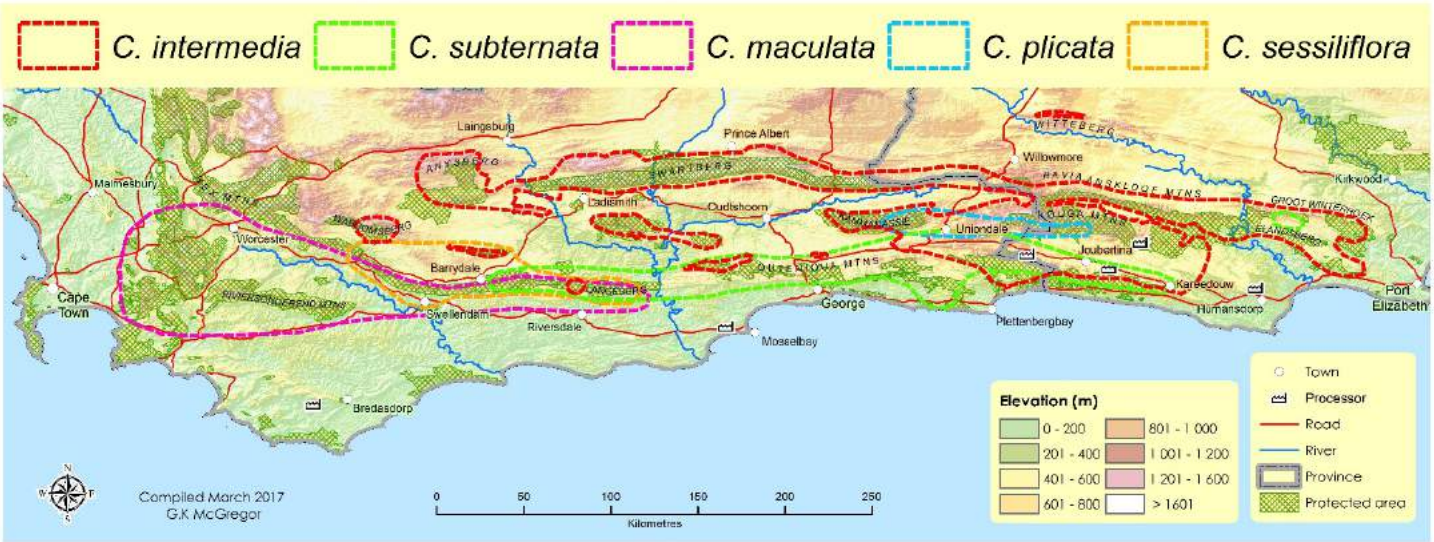

Figure 4: Distribution range of C. intermedia, based on Manning and Goldblatt 2012; Schutte, 1997; expert mapping (J. Vlok, 2017), and field data.

Morphological changes in a species occur on both spatial and temporal scales (Schutte 1995). Notes in the botanical description refer to the variation in the shape and size of the calyx lobes and bracts which is considerable. More noticeable in the field is the variation in leaf size, and plant form: specimens from high elevation sites in the Bo-Kouga and the Hartbees Rivier area (Western Baviaanskloof) which are interspersed amongst more obviously recognisable *C. intermedia* plants, have small leaves and a compact form, to the extent that the species is not immediately recognisable. In contrast specimens from the Longmore area (eastern range of distribution), have longer, broader leaves. Schutte (1995) notes that characteristics such as leaf shape, plant height and volume might be visibly different between populations of the same species, depending on the environmental conditions of the different habitats; hence the name 'intermedia'(Vlok, J.H.J., 2017, pers. com).

2.2 Conservation status of *C. intermedia*

In the case of *C. intermedia*, which is mainly a higher altitude species, much of the species distribution range falls in mountain water catchment areas and the populations are therefore well represented in formally protected areas. These formally protected areas, indicated on the map (Figure 4) include: the Baviaanskloof Nature Reserve, the Garden Route National Park, Formosa Provincial Nature Reserve, Gamkaberg Nature Reserve, Rooiberg Nature Reserve, Towerkop Nature Reserve, Anysberg Nature Reserve, and the Groot Swartberg Nature Reserve.

Using a GIS based model, and data from expert mapping, locality records and field observations, *C. intermedia* is shown to be distributed across an area of approximately 13 900 km^2 (Figure 4). Of the potential honeybush-bearing land area (based on aspect elevation, vegetation type and geology) of 2520 km^2, 1395 km^2 occurs in formally protected areas while 1125 km^2 of land is privately owned. In terms of the conservation of the species this is a fortunate situation. There has been some pressure to open protected areas to controlled harvesting, and the potential for this is presented in a report by Hobson and Joubert, 2011. However until such time as a comprehensive resource assessment exists with information on the actual impact of harvesting, this will not happen.

2.3 Phenology

Phenology, is the study of a plant's phenophases (i.e. the timing of, recurring life cycle phases, including growth, bud formation, flowering and fruiting (Pierce, 1984). The growth phenophase includes leaf growth, leaf elongation and new leaf production. The reproductive phenophases include flowering, fruiting, and seed set. In agricultural production, knowing and understanding the phenophases of a plant has a direct influence on crop management in terms of pruning, fertilising, irrigating and harvesting. To this end, Motsa *et al*., (2017) have studied the phenophases of *C. genistoides* and *C. subternata*. In dealing with a wild crop like honeybush, knowledge of the phenophases should also inform management.

Environmental conditions at a meso- and micro- scale, including elevation, aspect, rainfall and rainfall seasonality will influence the timing and duration of phenophases (Cramer *et al*., 2014). The growth strategy of a plant, reseeder versus resprouter, in the case of *Cyclopia* spp., will be reflected in their phenophases. While flowering for a resprouter like *C. intermedia* is important for seed set and potential new growth, the plants invest more energy in developing the rootstock (lignotuber) which will produce new foliage after fire (Cramer *et al.,* 2014). For a reseeder like *C. subternata*, flowering is visibly much more intense as the plant only reproduces by germination of seed after fire.

2.3.1 Phenophases of *C. intermedia*

A description of phenophase stages for *C. intermedia* from Barnado (2013) is given in Table 1. The results are based on data collected at three sites from Barrydale (Western most site), Swartberg and the Eastern Kouga (eastern most site). It was also noted that in the Eastern Cape phenophases were delayed an average of two weeks at the easternmost Kouga site, resulting in flowering only occurring in October.

Table 1: Illustration of phenophases of C. *intermedia*

Features	Season of development	Image
Flowering buds	Develop in April and May (Autumn)	 *Newly developing flowering buds*
Bud enlargement	Occurs from June to August (winter	 *Enlarged buds on a stem (Barnado, 2013).*
Flowering	Appear from September to November (Spring)	 *A three year post-harvest C. intermedia bush in flower.*
Pod development	Occurs from November (Summer)	 *Seed pods on a plant.*

Features	Season of development	Image
Seed set	Takes place in December (Summer)	 *Open pod and new growth (Barnado, 2013)*
Growth	Ensues from December to March (Summer)	 *Abundant new growth, with newest shoots (light green) at the stem tips, one year post-harvest.*

Elevation also affects flowering due to cooler temperatures. Flowers are 'expensive' in terms of a plant's water content. At Bergplaas in the eastern Baviaanskloof, in the first week of January at the highest point (1 200m), one third of the population was in flower, one third had green pods and one third had ripe pods (pers. obs.). At the same time, other sites in the Langkloof (such as Louterwater, Joubertina and north of the Krom Heights), plants had already shed their seeds. Anecdotal evidence for the Bo-Kouga suggests that on the high mountain slopes, the plants are still in flower in December (D. Hodgson, 2015, pers. comm.)

In terms of management, the popular belief that flowers are a valued part of the harvest material and are essential for the sweet aroma and flavour of honeybush has been disproven by Du Toit and Joubert (1998). They demonstrated that the presence of flowers improved the aroma and flavour of the tea, but found that it was not essential for characteristic sensory properties. They also noted that much of the flower material is in fact lost in processing because it is reduced to a fine powder which is lost in sieving. This was confirmed at this project's Louterwater workshop in January 2017 by processor participants who prefer harvest bundles with a third or less of the stems with flowers.

2.3.2 Fire and its effect on growth, flowering and seed production

The fire regime influences the resprouting potential of the lignotuber, with more vigorous resprouting occurring after fire as opposed to after harvesting (Q. Nortje, pers. comm., 2014; A. Schutte Vlok, pers. comm., 2017). Barnado (2013) showed that harvested plants tend to have more stems than plants not subjected to harvesting. This may lead to a competitive advantage because they produce more flowers and therefore more seed (if managed appropriately). Other anecdotal evidence (Louterwater Workshop, January 2017) comes from farmers who assert that flower (and therefore, seed production) is greatest in the two to three years after a fire, or after harvesting; thereafter it declines rapidly. Quinton Nortje, a wild honeybush farmer of many years' experience has noted that post-fire growth, flowering, and therefore seed production is greater than post-harvest. This is most likely the effect of fertilisation of the soil by ash (pers. comm., 2014).

2.4 Plant maturity

In horticultural terms, plant maturity refers to the stage at which the plant or plant part, has reached the optimum phase required for utilisation and commercial use. It is an indication that the general plant has grown sufficiently in order to produce fruit and other commodities used in the agricultural sector. In *C. intermedia*, reaching a stage of maturity is important for several reasons:

- Maturity affects tea production as older stems give a more desirable flavour; green stems are unsuitable for tea production;
- Maturity affects the seed set for reproduction; the more flowering seasons a plant experiences, the greater the seed store in the soil, and the greater the opportunity for germination and establishment of seedlings;
- Allowing the plant to mature before cropping allows time for the build-up of reserves in the rootstock for resprouting after harvest (or fire).
- A healthy lignotuber depends on production and translocation of 'food' (the products of photosynthesis) manufactured in the green parts of the plant. Harvest intervals must allow for the replenishment of reserves, used to produce new growth after harvesting (or fire).

3. REFERENCES

Barnado, N. 2013. *Sustainable harvesting of wild populations of* Cyclopia intermedia *in Kouga, Eastern Cape, South Africa*. Port Elizabeth: Nelson Mandela Metropolitan University (M.Sc. Dissertation) [pdf].

Bergh, N., Verboom, G.A., Rouget, and Cowling, R. M. 2014. In: *Fynbos: Ecology, Evolution, and Conservation of a Megadiverse Region*. Allsop, N., Colville, J.F. and Verboom, G.A. (eds). Oxford University Press, United Kingdom. pp 93-118.

Bradshaw, P. L. and Cowling, R. M. 2014. Landscapes, rock types, and climate of the Greater Cape Floristic Region. In: *Fynbos: Ecology, Evolution, and Conservation of a Megadiverse Region*. Allsop, N., Colville, J.F. and Verboom, G.A. (eds). Oxford University Press, United Kingdom. pp 26-46.

Cramer, M.D., West, A.G., Power, S. C., Skelton, R. and Stock, W.D. 2014. In: *Fynbos: Ecology, Evolution, and Conservation of a Megadiverse Region.* Allsop, N., Colville, J.F. and Verboom, G.A. (eds). Oxford University Press, United Kingdom. pp 248-272.

Du Toit, J., and Joubert, E. 1998. Effect of drying conditions on the quality of honeybush tea (*Cyclopia*). *Journal of Food Processing and Preservation* 22; 493–507.

He, T., Lamont, B.B. and Manning, J. 2016. A Cretaceous origin for fire adaptations in the Cape flora. *Scientific Reports*, 6, 34880.

Joubert, E., Joubert, M.E., Bester, C., De Beer, D. and De Lange, J.H. 2011. Honeybush (*Cyclopia* spp.): From local cottage industry to global markets—The catalytic and supporting role of research. *South African Journal of Botany*, 77(4): 887-907.

Hobson, S. and Joubert, M. 2011. Eastern Cape honeybush tea project: Industry overview, assessment and proposed interventions. Unpublished report to the Coega development Corporation.

Keeley, J. E., Bond, W. J., Bradstock, R. A., Pausas, J. G. and Rundel, P. W. 2012. *Fire Ecology, Evolution and Management in Mediterranean Climate Ecosystems*. Cambridge Univ. Press, Cambridge.

Kies, P. 1951. Revision of the genus *Cyclopia* and notes on some other sources of bush tea. *Bothalia*, 6: 161–176.

Kraaij, T. and Van Wilgen, B.W. 2014. Drivers, ecology, and management of fire. In: *Fynbos: Ecology, Evolution, and Conservation of a Megadiverse Region*. Allsop, N., Colville, J.F. and Verboom, G.A. (eds). Oxford University Press, United Kingdom. Pp 47-72.

Kraaij, T., Baard, J.A., Cowling, R.M., van Wilgen, B.W. and Das, S. 2013. Historical fire regimes in a poorly understood, fire-prone ecosystem: eastern coastal fynbos. *International Journal of Wildland Fire*, 22(3): 277-287.

Lombard, A. T., Cowling, R. M., Pressey, R. L. and Rebelo, A. G. 2003. Effectiveness of land classes as surrogates for species in conservation planning for the Cape Floristic Region. *Biological Conservation*, 112(1); 45-62.

Manning, J. C. and Goldblatt, P. 2012. *Plants of the Greater Cape Floristic Region.1: The Core Cape Region*. *Strelitzia* 29, South African National Biodiversity Institute, Pretoria.

Mucina, L., and Rutherford, M.C. (eds). 2006. *The Vegetation of South Africa, Lesotho and Swaziland*. *Strelitzia* 19, South African National Biodiversity Institute.

Motsa, M. M., Slabbert, M. M., Bester, S. and Ngwenya, M. Z. 2017. Phenology of honeybush (*C. genistoides* and *C. subternata*) genotypes. *South African Journal of Botany*, 110: 57.

Pierce, S. M.' 1984. *A synthesis of plant phenology in the Fynbos Biome*. SA National Scientific programmes Report No. 88. CSIR, Pretoria.

Rouget, M., Barnett, M., Cowling, R. M., Cumming, T., Daniels, F., Hoffman, M. T., Manuel, J., Nel, J., Parker, A., Raimondo, D. and Rebelo, T. 2014. Conserving the Cape Floristic Region. In: *Fynbos: Ecology, Evolution, and Conservation of a Megadiverse Region*. Allsop, N., Colville, J.F. and Verboom, G.A. (eds). Oxford University Press, United Kingdom. pp 321-336.

Roy, D.P. and Boschetti, L. 2009. Southern Africa validation of the MODIS, L3JRC, and GlobCarbon burned-area products. *Geoscience and Remote Sensing, IEEE Transactions on*, 47(4): 1032-1044.

Rutherford, M.C., Powrie, L.W., Husted, L.B. and Turner, R.C. 2011. Early post-fire plant succession in Peninsula Sandstone Fynbos: The first three years after disturbance. *South African Journal of Botany*, 77(3): 665-674.

Schulze, R.E. 2007. *South African Atlas of Climatology and Agrohydrology*. Water Research Commission, Pretoria, RSA.

Schutte, A.L. 1997. Systematics of the genus *Cyclopia* Vent. (Fabaceae, Podalyrieae). *Edinburgh Journal of Botany*, 54: 125–170.

Schutte, A.L., Vlok, J.H.J. and van Wyk, B.E. 1995. Fire-survival strategy - a character of taxonomic, ecological and evolutionary importance in fynbos legumes. *Plant Systematics and Evolution*, 195: 243–259.

Slingsby, J.A., Merow, C., Aiello-Lammens, M., Allsopp, N., Hall, S., Mollmann, H. K., Turner, R., Wilson, A. M., and Silander Jr., J. A. 2017. Intensifying post-fire weather and biological invasion drive species loss in a Mediterranean-type biodiversity hotspot. *Proceedings of the National Academy of Sciences USA.* (In Press).

Thuiller, W., Slingsby, J. A., Privett, S. D. and Cowling, R. M. 2007. Stochastic species turnover and stable coexistence in a species-rich, fire-prone plant community. *PloS One*, 2(9): e938.

Van Wilgen, B. W., Bond, W. J. and Richardson, D. M. 1992. Ecosystem management. In: *The Ecology of Fynbos. Nutrients, fire and diversity*. Cowling, R. M. (ed.). Oxford, pp. 345-371.

van Wilgen B.W., Forsyth, G.G., De Klerk, H., Das, S., Khuluse S. and Schmitz P. 2010. Fire management in Mediterranean-climate shrublands: a case study from the Cape fynbos, South Africa. *Journal of Applied Ecology*, 47: 631–638.

Verdaguer, D. and Ojeda, F. 2002. Root starch storage and allocation patterns in seeder and resprouter seedlings of two Cape *Erica* (Ericaceae) species. *American Journal of Botany*, 89(8): 1189-1196.

Vlok, J.H.J. and Schutte-Vlok, A.L. 2010. *Plants of the Klein Karoo*. Umdaus Press, Hatfield.

Personal Communication

Hodgson, D., 2015. Farmer. De Hoop, November 2015.

Nortje, Q. Honeybush Farmer. Nooitgedacht, August 2014.

Schutte-Vlok, A.L., Ecologist. Kouga Wildernis, March 2017.

Vlok, J.H.J., Ecologist. Kouga Wildernis, March 2017.