HONOURS OR MASTERS

Project 1

Title: Large branchiopods of the Western Cape revisited: distribution, taxonomy and conservation status.
Field: Aquatic invertebrate biodiversity
Supervisors: Dr Nasreen Peer (Stellenbosch University), Mr Musa Mlambo (Albany Museum), Ms Nancy Job, (SANBI), Dr Theresa Sethusa (SANBI), Ms Dewidine Van Der Colff (SANBI)
University for registration: Stellenbosch University

Description:
A recent assessment of the conservation status of wetlands in Western Cape province, demonstrated that a substantial number of wetlands have had their ecological status deteriorated, and some completely destroyed. More than 15 years ago, De Roeck et al (2007) sampled 54 temporary wetlands, and reported 14 large branchiopods from the Western Cape. Since then, several changes (both taxonomically and temporary wetland condition) have taken place that necessitate revisitation of the conservation status of large branchiopods in this province. Taxonomically, i) two undescribed species have been recognized in fairy shrimps (Anostraca), ii) several species described in the neighbouring provinces, whose occurrence and distribution (for both i & ii) is not fully known, and iii) taxonomic revision of both tadpole shrimps (Notostraca) (moving from one recognised species to four) and Spinicaudata (done at both national and international levels, have completely changed the systematics and taxonomy). Further, three of the 14 recorded species in the province (De Roeck et al 2007) have never been recorded in the last 70 years, so their conservation status is uncertain, and no molecular data is available for including them in molecular phylogenetic studies. In this project extensive re-sampling of a select number of these known localities and museum collections will be re-examined to assess the true extent of a select number of species. Doing so, will not only allow us to give the true conservation status of the large branchiopod species in the province, but will also contribute in the mapping of wetlands.

Project 2

Title: Population dynamics of endemic freshwater mollusca in Western Cape.
Field: Aquatic invertebrate biodiversity, malacology
Supervisors: Prof. Anusha Rajkaran (University of the Western Cape), Dr Nelson Miranda (Nelson Mandela University), Mr Musa Mlambo (Albany Museum), Ms Nancy Job (SANBI), Dr Theresa Sethusa (SANBI), Ms Dewidine Van Der Colff (SANBI)
University for registration: University of the Western Cape

Description:
The National Biodiversity Assessment (NBA) of South Africa 2018, found that rivers and wetlands are among the most threatened ecosystems and identified a major gap in our understanding and status reporting of freshwater invertebrates and how they are impacted by environmental and anthropogenic pressures. Here we aim to update current occurrence records and ecological information about native and endemic freshwater Mollusca at strategic sites (rivers, wetlands, and stormwater ponds) in the Western Cape province. The following genera will be the focus of this project: *Bulinus*, *Tomichia*, *Burnupia*. The taxa within these genera are Data-Deficient and are endemic species in need of taxonomic revision (*Tomichia* spp., *Burnupia* spp.), as well as species of medical importance (*Bulinus* spp. are the intermediate hosts of the parasites that cause Schistosomiasis). This project will contribute to

the assessment of environmental status and pressures impacting these species, as well as provide information about their population dynamics.

MASTERS

Project 1

Title: Improving our understanding of the plant communities, habitat characteristics, and threats to Robertson Granite Renosterveld.
Field: Plant ecology
Main supervisor: Dr Ed T F. Witkowski (University of the Witwatersrand)
Co Supervisors: Ms Anisha Dayaram (SANBI) and Ms Alekzandra Szewczuk (University of the Witwatersrand)
University for registration: University of the Witwatersrand

Description:
The National Vegetation Map is the basis for the Terrestrial Ecosystem Map in many conservation planning, spatial planning and prioritization processes in South Africa. Since the publication of the first iteration of the classification and map in 2006, SANBI has focused on improving and refining parts of the map that authors of the vegetation types, and users of the map have identified as areas that need to be improved to strengthen the processes in which the map is used. As part of this work, the Robertson Granite Renosterveld (FRg3) is an understudied vegetation type that has been identified as a priority. The vegetation type was previously mapped based on prominent geological features in the mountainous region above the town of Robertson. However, the plant communities and species within the area delineated were not fully described. We wish to further our understanding of the communities, dominant and endemic species, and important habitat characteristics that define this vegetation type. This study will involve a combination of field sampling and remote sensing.
The data collected from this project will contribute to several components of the VEGMAP Project including:

1. The terrestrial ecosystem map or national vegetation map
2. The National Vegetation Database of vegetation plots
3. The VEGMAPhoto (s afr) project on iNaturalist

The prospective applicant will be based at the University of the Witwatersrand but will conduct fieldwork in the Western Cape on a combination of private and municipal lands

Project 2

Title: Improving our understanding of the plant communities, habitat characteristics, and threats to Drakensberg-Amathole Afromontane Fynbos (Gd6).
Field: Plant ecology
Main supervisor: Dr Andri Van Aardt (University of the Free State)
Co Supervisors: Ms Anisha Dayaram (SANBI)
University for registration: University of the Free State

Description:
The National Vegetation Map is the basis for the Terrestrial Ecosystem Map in many conservation planning, spatial planning and prioritization processes in South Africa. Since the publication of the first iteration of the classification and map in 2006, SANBI has focused on improving and refining parts of the map that authors of the vegetation types, and users of the map have identified as areas that need to be improved to strengthen the processes in which the map is used. As part of this work, the Drakensberg-Amathole Afromontane Fynbos vegetation type is an interesting grassland with strong fynbos elements and occurs

somewhat disjunct from the rest of the Fynbos Biome. In the 2006 version of the National Vegetation Map this vegetation type was understudied and only some portions of the full extent were captured. Furthermore, only some characteristics of the communities and a limited number of species were captured. Therefore, much work remains to further our understanding of the new patches of this vegetation type by studying the communities, dominant and endemic species, and important habitat characteristics that define this vegetation type. We may also explore the key pressures on this vegetation type. This study may involve a combination of field sampling and remote sensing.
The data collected from this project will contribute to several components of the VEGMAP Project including:

1. The terrestrial ecosystem map or national vegetation map
2. The National Vegetation Database of vegetation plots
3. The VEGMAPhoto (s afr) project on iNaturalist

The prospective applicant will be based at the University of the Free State and will conduct fieldwork in the Free State on both private lands and Nature Reserves.

Project 3

Title: Morphometric analyses and taxonomic limits within the *Brunsvigia natalensis – radulosa* species complex (Amaryllidaceae).
Field: Plant Systematics, Taxonomy
Supervisors: Prof Ramagwai Sebola (SANBI), Dr Robert Archer (SANBI), Prof Muthama Muasya (University of Cape Town),
University for registration: University of Cape Town

Description:
The genus *Brunsvigia* Heist. belongs to the family Amaryllidaceae and it is one of the eleven genera within this family that are endemic to southern Africa. *Brunsvigia* species are mostly distributed in the Western Cape's northwest region, which has the highest diversity of species, followed by the midlands of KwaZulu-Natal (Snijman, 2012). The recent comprehensive taxonomic revision of this genus led to the recognition of 18 species (Duncan et al., 2016), thus recognizing one more species since the work of Dyer (1950; 1951). The species *B. natalensis* Baker and *B. radulosa* Herb. share a striking resemblance, and are not easily distinguishable. In most instances, *B. natalensis* is usually smaller in dimensions compared to *B. radulosa*, but size alone is not a reliable variable (Dyer, 1950). *B. natalensis* and *B. radulosa* are sympatric, and the species boundaries are often arbitrary. Herbarium gatherings appear mixed, thus making identification of the species difficult. The aim of the study is to assess species limits within the *B*. *natalensis – radulosa* species complex, and revise the taxonomy of the complex. Multivariate analysis techniques will be used to analyse the pattern of morphological variation. Effort will be made to incorporate molecular data, in particular the nuclear region ITS and plastid *trn*T-*trn*L to study variation within the complex.

Project 4

Title: Conservation status of the narrow range endemic and rare dragonflies of the Cape Floristic Region
Field: Entomology and Ecology
Supervisors: Supervisors: Dr Charl Deacon (Stellenbosch University), Ms Dewidine van der Colff (SANBI), Prof Francois Roets (Stellenbosch University), & Prof Michael Samways (Stellenbosch University)

University for registration: Stellenbosch University

Description:
In the Cape Floristic Region (CFR) of South Africa, there is at least 70 dragonfly species. The focal species of this project will be the14 endemic species of the CFR. Narrow-range species rather than widespread species are at most risk from climate change, as well as from invasive alien trees. They appear largely to be habitat specialists, with predictions that the loss of certain habitats will lead to their spatial decline with increasing effects of climate change. However, little has been done in warmer parts of the world with narrow range dragonfly endemics naturally confined to specific areas, especially specific catchments, and even specific rivers. One of these areas is the CFR which has had no glaciations for > 200 my. This project will explore the survivability of the local CFR endemic dragonfly species and/or morphological forms at the fine spatial scale and will provide distribution data that will feed into the Red List assessments of the 14 focal CFR endemic species from 11 broad localities. There will also be a genetic component to the study by collecting DNA barcodes for selected taxa, particularly the distinct morphological forms of South African endemics in different parts of the country, e.g., the Cape forms of: *Pseudagrion draconis* (lacking post-ocular spots), *Pseudagrion hageni hageni* (southern red form), *Syncordulia gracilis* (different colour patterning: this is a high priority species), *Orthetrum julia capicola* (lighter form, different body patterning, different habitat preferences), and *Ellattoneura frenulata* (blue vs. black form, but still a CFR endemic). Sampling will focus within protected areas not transformed areas at low elevation which are often characterized by a homogenized and generalist fauna.

Prospective outputs:

1. Better understanding of distribution of endemic and other dragonflies in the CFR, while also determining characteristic assemblages relative to catchment/river.
2. Determining resilience to major fire events.
3. Contributing information for the updating of these species Red List assessments.

Project 5

Title: The implementation and evaluation of biodiversity informatics techniques like Optical Character Recognition tools, for text extraction, from Natural History Collections specimen labels
Field: Biodiversity Informatics
Supervisors: Ms Fatima Parker-Allie (SANBI), Dr Morne du Plessis (NICD), Dr Wayne Florence (IZIKO Museums) and Dr Adriaan Engelbrecht (UWC)
University for registration: University of the Western Cape

Description:
This project aims to strengthen the new and developing field of biodiversity informatics and is being conducted within the SANBI-GBIF framework. It brings together several elements to support this area of research including, data contained in natural history collections (time, space, taxonomy), the use of innovative technological tools like optical character recognition (OCR) and its potential to support efforts in mass digitization. As we steadily head into the advent of the Fourth Industrial Revolution, along with the rest of the world, the benefits of automation in nearly every aspect of our lives have become apparent. While specimen data capture continues to be labour intensive, new biodiversity informatics technologies allows one to, with some modification, evaluate and benchmark these technologies to assess its utility in the local NHC context. Fundamentally the project proposes to optimise the use of optical character recognition (OCR) as a method to transform digitally encoded / captured information, from images into human readable text. The importance of being able to accurately explore this

space in biodiversity informatics is that it allows for significantly higher throughput of specimen processing than through manual human translation and capture. The benefits of this work would include the ability to use biodiversity informatics techniques to increase both throughput and quality of specimen data capture, while saving time and costs, and will support efforts towards a stronger technology driven STI agenda.

Project 6

Title: Investigating the impacts and benefits of beekeeping in renosterveld
Field: Conservation Ecology
Supervisors: Dr Colleen Seymour (SANBI) and Prof Sjirk Geerts (CPUT)
University for registration: Cape Peninsula University of Technology

Description:
The Honeybee (*Apis mellifera*) is used extensively for crop pollination globally. The economic and social importance and impacts of *A. mellifera* is well known in areas beyond its native range, but less is known in regions where it occurs naturally. *Apis mellifera,* although native to South Africa, occurs at higher than natural densities because it is kept as a managed pollinator. Although managed pollinators benefit beekeepers, commercial farmers and local communities, the high densities at which these generalist pollinators can occur may lead to disruption of pollination networks, impacting specialist pollinators and the plant species they pollinate. Furthermore, the "boom and bust" dynamics associated with both the flower resource of crops and the movement of managed pollinators may also have implications for pollinator networks.

The Overberg is an important agricultural region in the Western Cape and contributes substantially to South Africa's canola (*Brassica napus*) yield. *Apis mellifera capensis* is native to this area and managed beehives are extensively used for canola pollination to the benefit of the broader community. Simultaneously, there are scattered remnants of renosterveld amongst these canola fields, often along watercourses connecting small fragments (Topp and Loos 2019). This raises the question of whether *A. mellifera* can replace lost pollinators, or whether they compete with indigenous pollinators, and what the implications for successful seed set in indigenous plant communities might be. Baseline data for wild pollinators in the fragments are known (Hauber et al. 2022).

Therefore, by considering the importance of *A. mellifera* in crop pollination, ecosystem services and the influence on biodiversity, this project aims to quantify the use and importance of beehives by local communities and commercial farmers through questionnaires and simultaneously sample pollination webs and quantify ecosystem services provided by these habitat fragments through a cost-benefit analysis. This work will contribute to SANBI's research strategy, subcomponent 5.1, by contributing to understanding models of ecosystem risk posed by various management strategies (Activity 5.1.2).

Project 7

Title: Investigate threats to ecological services within protected Strategic Water Source Areas and their impact in relation to water provision
Field: Geography and Environmental Studies
Supervisors: TBC - Mr Tsamaelo Malebu (SANBI contact person)
University for registration: Stellenbosch University

South Africa is a water-scarce country, receiving around half of the global average annual rainfall, with the variability of rainfall both in space and time. This water scarcity is being

exacerbated by escalating demand due to economic and population growth, urbanization and rising standards of living, unsustainable use and high levels of wastage and loss, and increasing pollution which renders water not fit for use. In addition, the degradation of wetlands, riparian zones, and the surrounding land and changes in rainfall patterns, and increasing temperatures due to climate change, are contributing to reduced security of supply (DWS, 2018). South Africa depends greatly on the water from its strategic water source areas (SWSAs) – those regions which supply a disproportionately high amount of the country's water in relation to their size. Numerous studies have found that the regionally SWSAs make up only 10% of the land area of South Africa, Lesotho, and eSwatini, yet they provide 50% of our runoff.

SWSAs are vital ecological infrastructure assets for continued water security and their strategic importance lies in their significant ability to provide for the country's economic, agricultural and basic human needs. Their beneficiaries allow the impacts of future development options to be assessed in a more equitable and comprehensive manner, a goal that is strongly aligned to the SDGs and associated national integrated development plans yet only 13% of South Africa's SWSAs are legally protected. The low levels of formal protection of SWSAs mean a great extent of our water source areas are highly vulnerable to land use development pressures that pose different threats to water security, these include mining; invasive alien vegetation; land degradation and soil erosion from poor farming practices, etc.

The 13% of South Africa's SWSAs that are legally protected have been declared as an environmentally sensitive area under NEMA, 107 of 1998, clause 24 (2A) and therefore, there's a need to closely look at what is highly compatible with these SWSAs and what is detrimental. This project aims to make use of GIS and Remote Sensing techniques to (1) identify and map potential threats posed by the existing land use and tenure within the Boland SWSAs; (2) provide a spatial representation of land use activities that affect water quality and quantity within the study area, a special focus to map alien invasive plant species as they use more water than natural vegetation and (3) Investigates and recommends compatible land uses in relation to what currently exists to improve water provision from SWSA.

MASTERS OR DOCTORAL

Project 1

Title: Determining and monitoring baseline taxonomic and functional diversity of above- and below ground terrestrial invertebrates
Field: Invertebrate systematics, Taxonomy
Supervisors: Dr Colleen Seymour (SANBI) and Dr Charlene Janion-Scheepers (University of Cape Town)
University for registration: University of Cape Town

Description:
Although 80% of all species on earth are terrestrial invertebrates, they are still vastly understudied (Stork et al. 2015). While 1 million species of insects have already been described, it's thought that 80% remain to be discovered (Stork 2018). In addition, recent literature suggest that global insect populations are in decline (Hallmann et al. 2017, Sánchez-Bayo & Wyckhuys 2019), with more than 60% threatened by climate change and agriculture (Outhwaite et al. 2022). However, the generality of these patterns is not clear due to insufficient data and sampling bias (Simmons et al. 20109, Thomas et al. 2019). Indeed, data are usually lacking from the Southern Hemisphere, especially from African countries. Although understanding of the insect diversity in South Africa is increasing, several major regions remain unsampled, with even baseline data lacking, particularly for belowground taxa (Janion-Scheepers et al. 2016). In addition, the shortage of trained taxonomists and curators available to identify species and describe new species hampers progress. Developments in DNA barcoding techniques have, however, sped up species discovery, allowed recognition of cryptic species, and improved knowledge of species distributions (Ratnasingham & Hebert 2013). Habitat destruction and climate change make the need to quantify species diversity an urgent priority to aid conservation decision and policy making.

This project will use a combination of traditional taxonomy and molecular methods to determine terrestrial invertebrate baseline data contribute to establishment of an efficient, long-term monitoring system for South Africa. Sampled sites will include various land uses and will also occur along a rainfall gradient in the Western Cape, to give insight into how land use and climate affect biodiversity. This will be done using a combination of well-established protocols focusing on well-known and new indicator taxa (McGeoch 1998, McGeoch et al. 2011, Gerlach et al. 2013). This multitaxon approach will not only provide baseline data on below and aboveground terrestrial invertebrate diversity, but will also establish methods to facilitate the monitoring of these populations. If the project is registered as a PhD project, additional approaches will be used to assess how land use practices and climate affect the relationships between above and belowground fauna and ecosystem functioning (Potapov et al. 2022).

In particular, the following questions will be addressed:
1. What is the alpha and beta diversity of the major above- and belowground terrestrial invertebrate indicators, and how do these differ with land use and climatic variables? (MSc. And PhD)
2. How do certain ecosystem functions, like decomposition or soil nutrient cycling vary with above- and belowground invertebrate faunal diversity? (PhD only)

This project will contribute to SANBI's programme to develop and implement a coordinated survey and monitoring strategy or protocols for species including their distribution and abundance.

Project 2

Title: Systematics of the *Arctotheca calendula* complex
Field: Systematics, Taxonomy
Supervisors: Dr Allan Ellis (Stellenbosch University Dr Nicola Bergh (SANBI)
University for registration: Stellenbosch University

Description:

This research will be conducted at MSc level, but could also be expanded to form a PhD. The complex known as *Arctotheca calendula* (Cape dandelion, capeweed) comprises morphologically variable annual daisies from the winter- and all-year coastal rainfall regions of South Africa. Some of these are naturalised weeds in temperate ecosystems globally, and this research forms part of a larger, multidisciplinary project examining the contribution of genetic variation and adaptive evolution to invasion success of capeweed in Australia. Both floral and vegetative variation is known across the natural range of the complex, possibly related to variation in insect pollinator distribution and abiotic environments. The project aims to discover and characterise the morphological and genetic variation in South African populations, in order to determine the best taxonomic circumscription for the complex, and to understand the provenance of invasive populations in Australia. Extensive fieldwork will be required to sample populations, and morphological variation will be documented using a combination of photographic and microscopic techniques. Multilocus genotyping will be used to examine the genetic variation, population history, and gene flow patterns across the complex.

Project 3

Title: Taxonomy and capitulum development in syncephalic *Oedera* species
Field: Systematics, Taxonomy
Supervisors: Prof Tony Verboom (UCT) and Dr Nicola Bergh (SANBI).
University for registration: University of Cape Town

Description:
This research is aimed at MSc level, but could be expanded to form a PhD project. Floral architecture is central to the diversification of flowering plants, and has implications for agriculture (e.g. increasing crop yields, pollination) and commercial horticulture. The daisy family (Asteraceae) is characterised by flowers arranged in a complex inflorescence (the capitulum) whose components mimic a simple flower. Little is known about the evolution of, and constraints on, daisy capitulum architecture, but research to date has been concentrated on model systems with simple, heterogamous capitula (e.g. sunflower). However, a small number of Asteraceae species have evolved a unique capitulum architecture involving doubling of the process of 'capitulum-isation' (i.e. inflorescence contraction and floral heteromorphism) to produce secondary heads (syncephalia). Although rare in the family globally (occurring in less than 5 % of genera), syncephalia characterise an endemic group of Cape daisies in the genus *Oedera*. This small group of ~ 5 species (*Oedera* sect. *Oedera*) is poorly known and in need of taxonomic revision, which will undoubtedly change the number of recognised taxa. In tandem with morphological and molecular investigations leading to a full taxonomic revision of the group, this project will characterise the inflorescence changes that have led to syncephalisation within the genus *Oedera*. The project will involve fieldwork to collect material, herbarium research, and microscope work using the light and potentially also the electron microscope to characterise morphology and

the development of the syncephalia. In addition, population-level genomic markers will be investigated to determine the genetic aspects of species delimitation.

Project 4

Title: A taxonomic revision of the genus *Prismatocarpus* L'Hért. (Campanulaceae Juss.) in southern Africa**.**
Field: Plant Systematics, Taxonomy
Supervisors: Prof Christopher Cupido (University of Fort Hare), Prof Alfred Maroyi (University of Fort Hare) and Prof Ramagwai Sebola (SANBI)
University for registration: University of Fort Hare

Description:
Prismatocarpus is a South African endemic genus that is concentrated in the Western Cape with only one species extending into the Eastern Cape Province. The genus was originally described by L'Héritier (Sert. Ang. 2. 1788) and since then had an unstable taxonomy. With the large number of herbarium specimens available at various institutions it is possible to evaluate the pattern of morphological variation within the genus with greater confidence.
In 1830, De Candolle restricted the genus and redefined it as being characterised by a two chambered ovary and a fruit with dehiscence by five longitudinal splits. Plants with three chambered ovary were transferred to the genus *Specularia*. According to De Candolle (1830), the genus is a natural one with uniform features and a limited geographical range. De Candolle (1830) recognised 12 species in *Prismatocarpus* and later recognised 17 in 1839. Sonder (1865) revised the genus for the Flora Capensis when he recognised 14 species. However, Adamson (1951) recognised about 30 species of which 11 were described for the first time. In 1974, Thulin transferred *P. rhodesicus* to a new genus *Gunillaea* because of its indehiscent capsule that opens slowly by irregular decomposition of the pericarp and has a hair-like projection on the testa. Similarly, Thulin (1974), transferred *P. schinzianus* to a new genus *Namacodon* because it differs in its unique mode of sceptical dehiscence, 3-locular ovary and pollen grains released in tetrads. Cupido (2016) presented evidence that supported the removal of the annual species, *P. crispus* into a new monotypic genus *Kericodon*. *P. hildebrandtii* is a heterotypic synonym of *P. crispus*. To date, *Prismatocarpus* comprise approximately 27 species and 2 well recognised sub-genera. The subgenera groupings were suggested by De Candolle who treated them as sections but without assigning names. Adamson (1954) later gave the names *Afrotrachelium* and *Euprismatocarpus.* The subgenus *Euprismatocarpus* is further subdivided into three series: Fruticosi, Stricti and Nitidi. Classifications of the series were based on the type of inflorescence, the length of bracts and the habit.
The proliferation in the numbers of species in previous accounts of *Prismatocarpus* and large number of misidentified herbarium specimens are testimony to the complex nature of the morphological variability of this genus. Various species exhibit forms that are often confused with each other, for example *P. pedunculatus* has two forms that are indistinguishable, except for ciliated calyx lobes that are shorter than the corolla in one form, whilst the other form has glabrous lobes usually longer than the corolla. There are no reliable characters to separate *P. fruticosus* from *P. brevilobus* and its forms with short calyx lobes look very much like *P. brevilobus.* On the other hand, *P. schlechteri* has been confused with *P. campanuloides,* and *P. lycioides* was placed at the end of the series *Nitidi,* together with *P. rhodesicus* on account of the leaf-like bracts but is not at all related to any of the others in the series or to one another. Adamson (1951) referred to them as species of uncertain affinity. Therefore, a comprehensive species level taxonomic study is required to determine species boundaries and ensure a stable classification. To this end, multivariate morphological analyses and DNA-based techniques will be employed to assess species boundaries, assess phylogenetic relationships; and produce a revised taxonomic account of

the *Prismatocarpus* species, including distributions maps, conservation status and a key for the identification of species.
This project is a component of the broader Systematic studies in the South African Campanulaceae with this study focusing on the Cape genus, *Prismatocarpus*.

DOCTORAL

Project 1

Title: Long-term soil and vegetation recovery monitoring following *Acacia* and *Eucalyptus* removal in Western Cape province of South Africa
Field: Restoration ecology
Supervisors: Dr Farai Tererai (SANBI), Dr Mlungele Nsikani (SANBI), Dr Sheunesu Ruwanza (Rhodes University)
University for registration: Rhodes University

Description:
Invasive alien plants are a major cause of ecosystem degradation in South Africa. Although considerable resources have been devoted to the clearing of invasive alien plants, improvements in clearing efficiency and monitoring are urgently needed if the current clearing programme is to yield positive ecological restoration outcomes. Recent studies have shown that effective ecological restoration of alien plant cleared areas requires detailed monitoring to determine its success. Unfortunately, few long-term monitoring studies have been conducted on cleared areas in South Africa, yet long-term monitoring is essential for investigating recovery trajectory, thus providing valuable information that can be used for adaptive management. The few short to long-term monitoring studies that have been conducted in South Africa have mainly concentrated on assessing vegetation recovery indicators, thus neglecting other indicators such as soil fertility and social perceptions. This PhD project aims to document long-term native vegetation (species structure and composition) and soil (physio-chemical properties and microfauna) recovery trajectory following *Acacia* and *Eucalyptus* removal in the Western Cape province of South Africa. The study will further assess stakeholder perceptions of *Acacia* and *Eucalyptus* removal for restoration purposes in the Western Cape province of South Africa. The four research questions are:

- which indicators are used to assess ecological restoration following *Acacia* and *Eucalyptus* removal?
- does *Acacia* and *Eucalyptus* removal 10 to 15 years ago facilitate the recovery of native vegetation structure and composition?
- do soil physico-chemical properties and microfauna recover 10 to 15 years after *Acacia* and *Eucalyptus* removal?
- What are the perceptions of stakeholders on *Acacia* and *Eucalyptus* removal for restoration purposes in the Western Cape province of South Africa?

Apart from generating knowledge that will be used by ecologists, land managers, and policy makers, results of this study will contribute to SANBI's report on the status of biological invasions and their management in South Africa.

Project 2

Title: Honeybush (*Cyclopia*) as an emerging indigenous crop in Cape fynbos: cost and benefits of wild harvesting, community and commercial farming, and farming guidelines to minimize genetic contamination
Field: Biodiversity conservation
Supervisors: Prof Sjirk Geerts (CPUT), Dr Mlungele Nsikani (SANBI)
University of registration: Cape Peninsula University of Technology

Description:

Honeybush (*Cyclopia* Vent.) is an endemic genus in the fynbos biome with considerable commercial value in the global tea industry (Schutte, 1997; Karsen 2022). With the expansion of this industry, cultivation is essential to prevent the over exploitation of this natural resource (Bester, 2013). And approximately 85% of wild harvested honeybush is composed of one species, *Cyclopia intermedia* (Joubert *et al*., 2011). Six of the 21 *Cyclopia* species are used commercially. For cultivation, species have been moved across their native range which has opened the possibility for cross-fertilization between wild and cultivated plants from different lineages within species but also between species (Galuszynski & Potts, 2020). Indeed, it has been shown that pollinators travel between wild and cultivated plants (Shaw pers. comm.). Based on this it, it is important to develop biodiversity friendly farming practices to minimize genetic contamination of wild honeybush.

This can be accomplished through the development of a planting protocol which should consider native range, flowering time, ploidy levels, seed dispersal, distance to wild populations and seed source. Furthermore, a molecular approach for the detection of gene flow between wild and cultivated plants can be utilized (some methods are available, see Galuszynski & Potts 2020). Gene flow through seed dispersal is thought to be low in *Cyclopia* but unexplored (see Schutte *et al*., 1995; Schutte, 1997). The implementation of such a protocol and tying this into current green certification for both commercial and community farmers form an integral part of this project.

Importantly, the current community honeybush farming initiatives in reducing wild harvesting and simultaneously uplifting communities, will be evaluated. Current community projects have had successes, but these need to be scaled up and expanded to fully utilise the benefits of farming honeybush as an indigenous crop. Through purposive sampling, the economic viability of government funded honeybush farming projects can be quantified. Furthermore, the potential role commercial farmers can play in community honeybush projects will be investigated.

Project 3

Title: Systematics and diversification of the genus *Aspalathus* L. (Crotalarieae, Fabaceae)
Field: Plant Systematics, Taxonomy
Supervisors: Prof Ramagwai Sebola (SANBI), Prof Muthama Muasya (University of Cape Town), Prof Charlie Stirton, and Dr Daniel Zhigila
University for registration: University of Cape Town

Description:
The genus *Aspalathus* L. (Crotalarieae, Fabaceae) comprises 291 species of shrubs and shrublets (POWO, 2022). It is the second-largest genus with about 98% of the species endemic to the Cape Floristic Region (CFR) (Cupido 2007, Manning and Goldblatt 2012). There are high levels of polymorphism in *Aspalathus* species in terms of their morphology, geographic distribution, ecology, and phenolic composition. Variable morphological characteristics include the large variety of leaf types from simple, subterete leaves to often trifoliolate, and those with and without spine-tipped leaves (such as the Callose, Decorae, and Vermiculatae groups); variation in flower size and color (often yellow and black when dried, to occasionally pink or white), and differing rhizobium types. The last extensive taxonomic treatment of the genus was conducted three decades ago by Dahlgren (1988) with 278 species reported in 34 groups. There are now ~291 species of *Aspalathus* documented in the Plants of the World Online (POWO 2022). The genus contains approximately 50 percent species categorized as Least Concern (LC), but Von Staden (2013) chronicles the low accuracy of assessments for taxa without or outdated revisions. The remaining half of the species are either extinct, threatened with extinction, or lack data

for appropriate conservation status. Research on species variation has been guided largely by studies of species complexes. By examining species complexes, we can better understand how species form, and will also provide more insight into biodiversity, biogeography, and speciation processes that are flawed if we have complete knowledge of the biodiversity status of the whole group. Along with the phylogenetic work done, the study intends to delineate the three most problematic and priority groups of species complexes within the Adnate group (Group 11, Dahlgren 1988) based on their unresolved variation, namely: *Aspalathus cymbiformis* DC*., A. ciliaris* L*.,* and *A. spicata* Thunb complex. The diversity of morphological traits among the above-mentioned species complexes, as well as their wide distribution ranges in the Cape (Dahlgren 1963), provides an opportunity for studying the species limits, reproductive isolation, and phylogeographic boundaries within the *Aspalathus* group.
Although various studies have been conducted on the genus and its morphology, a comprehensive phylogenetic analysis remains elusive. In the sectional systematic analysis, *Aspalathus* was supported as monophyletic and a sister to the genus *Wiborgia* (Boatwright *et al.,* 2008; Moiloa *et al.,* 2018). This project aims to contribute to the understanding of the systematics of the genus *Aspalathus* by proposing a molecular phylogeny-based infrageneric classification and inferring diversification by comparing the rates of molecular evolution among the species. This will be achieved by using the phylogeny as a tool for identifying clades that can be recognized at infrageneric ranks and their synapomorphies; inferring origin and biogeography, and diversification, and testing the role of functional traits in the evolutionary success of clades; as well as conducting piece-wise revision of the species complexes obtained - from the Adnate group (Group 11, Dahlgren 1988).

Project 4

Title: Systematics and taxonomy of the Penaeaceae
Field: Plant Systematics, Taxonomy
Supervisors: Prof Ramagwai Sebola (SANBI), Prof Muthama Muasya (University of Cape Town), Prof Kevin Balkwill (University of the Witwatersrand)
University for registration: University of Cape Town / University of the Witwatersrand

Description:
The family Penaeaceae is endemic to the southern and south-western parts of the Cape Province in South Africa. The genera are confined to the Cape 'fynbos' or Shrubmacchia but, within this vegetation type, they occur in a wide range of habitats. Most species grow on mountain slopes, some in rock crevices (e.g. *Sonderothamnus petraeus*) or other rocky habitats. *Penaea mucronata* is a common constituent of normal, low, sandstone fynbos whereas *Stylapterus fruticulosus* grows in sand. Currently seven genera are recognised within the Penaeaceae, but without any further subdivision of the family. Since Dahlgren's work, two new species have been described, *Penaea dahlgrenii* (Rourke and McDonald, 1989) and *Brachysiphon microphyllus* (Rourke, 1995). The latter author stated that these new species are not easily assigned to any particular genus, emphasizing the lack of clear-cut boundaries between genera. It seems therefore not surprising that the results of a recent molecular phylogenetic study based on chloroplast sequences partially contradict earlier generic circumscriptions (Schönenberger and Conti, 2003). It has become clear that some of Dahlgren's genera, specifically *Brachysiphon* and *Stylapterus*, are not monophyletic. The genus *Endonema* is considered sister to the rest of the family. In Schönenberger and Conti's (2003) work, the genera *Sonderothamnus*, *Sarcocolla* and *Brachysiphon mundii* form a well-supported clade but its exact position in the phylogeny remains unresolved. The same is true for the clade uniting *Brachysiphon mundii* and *Stylapterus micranthus*. The genus *Penaea* sensu Dahlgren (1971) appears monophyletic but its exact position in the family also

remains unknown. The more recently described *Penaea dahlgrenii* (Rourke and McDonald, 1989) is resolved as sister to *Stylapterus ericoides* (Schönenberger et al., 2003), but only with low support and this has brought to question the generic limits of *Penaea* and species relationships as it has become clear that *P. dahlgrenii* is not closely related to any other member of the genus.

Schönenberger et al. (2007) state that definitive taxonomic adjustments within the family will require additional molecular, preferably nuclear markers, as well as detailed studies of floral morphology. In light of the PGA III classification, this project aims to assess generic limits by investigating the DNA sequence-based phylogeny of the Penaeaceae, and provide a comprehensive taxonomic revision of the family