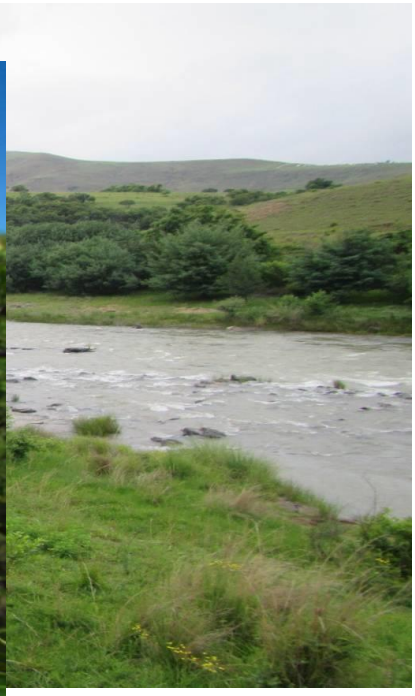
APPENDIX B5:

INVERTEBRATE IMPACT ASSESSMENT

uMKHOMAZI WATER PROJECT PHASE 1, KWAZULU-NATAL

Invertebrate Assessment

June 2018



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EXECUTIVE SUMMARY

Pachnoda Consulting cc was appointed by Nemai Consulting on behalf of Umgeni Water to undertake an Invertebrate Assessment Study for the uMkhomazi Water Project Phase 1 (uMWP-1), which includes the proposed new dam at Smithfield on the uMkhomazi River, near Bulwer, KwaZulu-Natal (KZN). This Study focused on the potential occurrence of *Capys penningtoni* (Pennington's Protea Butterfly) and *Gnomeskelus fluvialis* (Riverine Keeled Millipede) along suitable habitat within the Full Supply Level (FSL) of the proposed Smithfield Dam and the deviation of Provincial Road R617 (part of the deviation is located within the so-called "invertebrate corridor").

The scope of work for this Study included the following:

- A review of the Terrestrial Fauna and Flora Assessment Report undertaken as part of the Environmental Impact Assessment (EIA) for the uMWP-1.
- Confirm the presence of the endangered *Capys penningtoni* (Pennington's Protea Butterfly) and the endemic *Gnomeskelus fluvialis* (Riverine Keeled Millipede).
- Generate records of findings during fieldwork, including GPS co-ordinates and photographs.
- Assess the potential impacts of the uMWP-1 on threatened invertebrate species, and suggest suitable mitigation measures.
- Compile a report documenting the findings (this Report).

The study area is located approximately 48 km east-southeast of Pietermaritzburg and approximately halfway between Boston and Bulwer along the R617. The Impendle Nature Reserve is located to the immediate north of the "invertebrate corridor".

Site visits were conducted from 15 to19 November 2017 to search for *C. penningtoni,* and again from 11 to 15 December 2017 as well as from 19 to 22 February 2018 to search for *G. fluvialis*. However, the contract for this Invertebrate Assessment Study was awarded during the post-flight period (ca. post October) of the imago stage (adults) of *C. penningtoni*. Therefore, field surveys focused primarily on the identification, delineation and mapping of suitable host plant habitat (c. *Protea caffra* stands) within the FSL of the proposed Smithfield Dam and the "invertebrate corridor". A total of 30 sites consisting of forested, or vegetated woody stands were sampled during the *G. fluvialis* searches. The sampling sites were chosen to correlate for environmental, biophysical and topographical variability since information on the ecology of *G. fluvialis* is scant. The sampling sites differ in terms of aspect, slope, dominant woody plant composition, canopy height, basal herbaceous cover, altitude, soil texture (clay, loam and sandy soils) and the presence/absence of livestock.

Major findings and conclusions reached during the survey are the following:

- *C. penningtoni* was not observed during the respective site visits, although the probability for this species to occur on the "invertebrate corridor" as well as the higher-lying areas (c. 1200 - 136m.a.s.l) north of the Deepdale Road (in close proximity to Lundy's Hill) was **very high to definite.**
- Adults of *C. penningtoni* were recently observed (c. September 2017) during another independent survey at *Protea* stands in close proximity to the R617 corresponding Lot 93 1821.
- All natural and untransformed habitat (excluding forested areas) within the "invertebrate corridor" were classified as highly sensitive. The *Protea* stands were regarded as an important habitat component in ensuring high fecundity rates of this threatened butterfly species.
- According to a sensitivity analysis (pertaining to the "invertebrate corridor"), it was evident that 474.58 ha (c. 35% of the total surface area of the "invertebrate corridor") was represented by sensitive habitat (high and very high sensitivity). In addition, habitat of medium to high sensitivity and low-medium habitat covered respectively 159.8 ha (12%) and 707.76 ha (52%) of the total surface area of the "invertebrate corridor".
- *G. fluvialis* was not observed on the study area even during intensive searching within a variety of habitat types. The occurrence of *G. fluvialis* was regarded as **probable** (low confidence but could occur due to the lack of ecological information and current distribution data) on the study area, although the opinion was raised that suitable habitat was present.
- The absence of *G. fluvialis* could not be ruled out since it occurred in the area based on historical records (*c*. 1959), and potential suitable habitat was present along the uMkhomazi River. It may occur in low abundances or is naturally rare within its distribution range. Based on the above arguments, it was possible that this species was either easily overlooked and/or highly specialised whereby it may have already declined due to habitat degradation and inappropriate grazing regimes in the area.
- Important habitat units for *G. fluvialis* along the uMkhomazi River were perceived as units with a high probability to sustain moderate to high numbers of polydesmoid millipedes. Such habitat units occurred near Deepdale (not part of the dam's FSL), near the bridge where the R617 crosses a tributary of the uMkhomazi River and in forest types along the river with steep slopes on southern aspects.
- Four (4) other polydesmoid millipede species were sampled, including one exotic (introduced) species. Some of these species are endemic to KZN and some were previously only known from their type localities.

A number of impacts were anticipated and the significance of these is summarised in the table below:

Type of activity	Nature	Significance with Mitigation	Significance without Mitigation
Re-alignment of R617 - **Option 1**	Loss of *C. penningtoni* breeding habitat Dispersal and "barrier "effects Changes to local temperature regime Changes to local floristic structure and composition owing to defective storm water management	Low	Medium
Re-alignment of R617 - **Option 2**		Medium to High	High
Re-alignment of R617 - **Option 3**		High	High
Proposed gravel access road	Loss of *C. penningtoni* breeding habitat Dispersal and "barrier "effects Changes to local temperature regime Changes to local floristic structure and composition owing to defective storm water management	Medium to High	High
Below the proposed Smithfield Dam's FSL	Loss of habitat during inundation: *C. penningtoni*	Medium to High	High
Below the proposed Smithfield Dam's FSL	Loss of habitat during inundation: *G. fluvialis*	Medium to High	High

In order to mitigate against the impacts on the habitat of *C. penningtoni* and *G. fluvialis*, the following recommendations were proposed:

- *Re-alignment of the R617 road*: Three alternative route options were proposed of which Option 1 (either 1a or 1b) was considered as the preferred option from an invertebrate point of view.

- *Access road for residents/farmers living on the "invertebrate corridor*": It was strongly recommended that the alignment of the road be revised to avoid the dissection of the *Protea* stands, thereby retaining the original access which will require the construction or extension of a bridge over the Smithfield Dam's basin in order to link up with the deviated R617. Alternatively, access could be obtained from the western side of the "invertebrate corridor", thereby crossing the proposed Smithfield Dam's basin by means of a bridge and linking with Option 2 of the proposed R617 deviation.

- *Loss of C. penningtoni habitat during inundation*: Lost *Protea* trees due to inundation should be replaced with *ex situ* individuals, either purchased from a nearby nursery or reared from seed harvested from individuals occurring

within the project area. It was also recommended to consult a Reproductive Plant Biologist during the propagation process, and a representative from Ezemvelo KZN Wildlife should be consulted when choosing the localities where the trees should be planted.

- *Loss of G. fluvialis habitat during inundation:* As a precautionary principle, all habitat with high numbers of Keeled Millipedes downstream (e.g. Deepdale) and upstream (e.g. Bulwer area) of the proposed dam basin should be identified and incorporated into an offset or conservation area. Furthermore, an extensive collection excursion was proposed to search for *G. fluvialis* and other polydesmoid taxa confined to the inundation zone (the proposed Smithfield Dam's dam basin). Collected material could be relocated to other feasible habitat (as a "rescue" attempt) and part of the material could be donated to museums/taxonomists.

- *Compensatory/offsite mitigation measures*: It was proposed to extent the boundaries of the Impendle Nature Reserve southwards to include the "invertebrate corridor" immediately north of the uMkhomazi River. In addition, funding should be procured to assist Ezemvelo KZN Wildlife with the local (on site), as well as regional monitoring of *Capys penningtoni*. The monitoring should include population size estimates of *C. penningtoni* as well as the size of the sub-population occurring within the project area. Funding should also be procured to assist with synecological and autecological studies/research on *C. penningtoni* and *G. fluvialis* at a tertiary (e.g. universities) or statutorily level (in liaising with Ezemvelo KZN Wildlife). The implementation of a grazing and veld burning programme was also recommended to optimise the ecological condition of the montane grassland.

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LIST OF ABBREVIATIONS AND ACRONYMS

GDARD - Gauteng Department of Agriculture and Rural Development
EIA - Environmental Impact Assessment
FSL - Full Supply Level
GPS - Global Positioning System
IUCN - International Union for Conservation of Nature
KZN - KwaZulu-Natal Province
MAP - Mean Annual Precipitation
SABCA - South African Butterfly Conservation Assessment
SANBI - South African National Biodiversity Institute
ToR - Terms of Reference
QDG - Quarter degree grid cell
uMWP-1 - uMkhomazi Water Project Phase 1 (uMWP-1)

LIST OF UNITS AND SYMBOLS

c. - with reference to a particular entity
ca - with reference to a date or metric unit
ha - hectare
m - metre
masl. - mean above sea level
mm - millimetre
pers. comm - personal communication

DECLARATION OF INDEPENDENCE

I, Lukas Niemand (Pachnoda Consulting CC) declare that:

- I act as the independent specialist in this application to Nemai Consulting or the applicant Umgeni Water;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have no vested financial, personal or any other interest in the application;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority; and
- All the particulars furnished by me in this form are true and correct.

Lukas Niemand (Pr.Sci.Nat)
08 June 2018

Lukas Niemand is registered with The South African Council for Natural Scientific Professionals (400095/06) with more than 15 years of experience in ecological-related assessments and more than seven years in the field of entomological assessment. He has conducted numerous ecological and entomological impact assessments in South Africa and other African countries (e.g. Republic of Congo, Liberia, Mozambique, Zambia, Malawi and Ethiopia).

Specialist Report Requirements in terms of Appendix 6 of the EIA Regulations (2014)

A Specialist Report prepared in terms of the Environmental Impact Regulations of 4 December 2014 must contain:	Relevant section in the report
Details of the specialist who prepared the report	See Appendix 1: CV of specialist
The expertise of that person to compile a specialist report including a Curriculum Vitae (CV)	See Appendix 1: CV of specialist
A declaration that the person is independent in a form as may be specified by the competent authority	See page vi
An indication of the scope of, and the purpose for which, the report was prepared	Section 1.2
The date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 3.2
A description of the methodology adopted in preparing the report or carrying out the specialised process	Section 3
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Section 5
An identification of any areas to be avoided, including buffers	Section 5
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 5
A description of any assumptions made and any uncertainties or gaps in knowledge;	Section **Error! Reference source not found.**
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Section 3
Any mitigation measures for inclusion in the EMPr	Sub-section 5.3
Any conditions for inclusion in the environmental authorisation	Sub-section 5.3
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Sub-section 5.3
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised and	Section 5 & 6
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Section 5 and sub-sections contained within.
A description of any consultation process that was undertaken during the course of carrying out the study	Part of Section 3
A summary and copies if any comments that were received during any consultation process	Not applicable
Any other information requested by the competent authority.	None requested

1. INTRODUCTION

1.1 Background

Pachnoda Consulting cc was appointed by Nemai Consulting on behalf of Umgeni Water to undertake an Invertebrate Assessment Study for the uMkhomazi Water Project Phase 1 (uMWP-1), which includes the proposed new dam at Smithfield on the uMkhomazi River, near Bulwer, KwaZulu-Natal (KZN). This Study focused on the potential occurrence of *Capys penningtoni* (Pennington's Protea Butterfly[1]) and *Gnomeskelus fluvialis* (Riverine Keeled Millipede) along suitable habitat within the Full Supply Level (FSL) of the proposed Smithfield Dam and the deviation of Provincial Road R617 (part of the deviation is located within the so-called "invertebrate corridor").

The current water resources of the Integrated Mgeni System in KZN are insufficient to meet the long-term water requirements of the Mgeni System. Therefore, the uMWP-1 is earmarked to transfer water from the undeveloped uMkhomazi River Catchment to augment the Mgeni System. This will entail the construction of a new dam at Smithfield, referred to as the proposed dam hereafter, near Bulwer and the re-alignment of Provincial Road R617. The area for the proposed deviation of the R617 is herewith referred to as the "invertebrate corridor".

1.2 Scope of Work

The scope of work for this Study includes the following, as per the Terms of Reference (ToR) issued on 21 September 2017:

- A review of the Terrestrial Fauna and Flora Assessment Report (Nemai Consulting, 2016) undertaken as part of the Environmental Impact Assessment (EIA) for the uMWP-1.
- Confirm the presence of threatened and/or endemic invertebrate species within the defined study area. Species to include is *Capys penningtoni* (Pennington's Protea Butterfly) and *Gnomeskelus fluvialis* (Riverine Keeled Millipede).
- Generate records of findings during fieldwork, including GPS co-ordinates and photographs.
- Assess the potential impacts of the proposed uMWP-1 to threatened invertebrate species, and suggest suitable mitigation measures.
- Compile a report documenting the findings (this Report), since the Invertebrate Study will be submitted as a Specialist Report as part of an Addendum to the EIA Report.

[1] For consistency purposes and scientific convention, the scientific names (Latin names) of the target species (c. *Capys penningtoni, Gnomeskelus fluvialis* and *Protea caffra*) were used throughout the document instead of common names. Because common names are non-standardised they are often misleading and volatile, while many authors use different names for the same species.

2. DESCRIPTION OF THE STUDY AREA

2.1 Locality

The study area is located approximately 48 km east-southeast of Pietermaritzburg and approximately halfway between Boston and Bulwer along the R617 as shown on **Figure 1** below. The Impendle Nature Reserve is located to the immediate north of the "invertebrate corridor".

2.2 Land Use, Existing Infrastructure and Important Landscape Features

The study area corresponds primarily to open undulating grassland that changes to species rich ("late successional") grassland on steep slopes within the "invertebrate corridor". Most of the area is rural and used for grazing and/or subsistence farming. Deep valleys along drainage lines, including south and west-facing slopes along the uMkhomazi River, support remnant "forest" and mixed bush clumps of which the canopy is dominated by River Bushwillow (*Combretum erythrophyllum),* Bluebush *(Diospyros lycioides),* Glossy-leaf (*Rhamnus prunoides)*, Glossy Bottlebrush (*Greyia sutherlandii)* and Pompon Tree (*Dais cotinifolia).* In addition, higher-lying rocky grassland along south-facing slopes are often covered by Highveld Protea (*Protea caffra* subsp. *Caffra)*, while north-facing slopes of similar altitude appear hot and arid, and often dominated by Natal Aloe (*Aloe spectabilis)* and woody members of the genus *Senegalia* (c. Flame Thorn *S. ataxacantha*)*.*

According to the National Land Cover Dataset of 2013-2014, it is evident that the majority of the study area is covered in grassland, followed by cultivation and built-up areas. Sheltered valleys and drainage lines are often covered by thicket (**Figure 2**; Geoterraimage, 2015).

2.3 Biophysical Description

2.3.1 Climate

The climate is characterised by summer rainfall with lower temperatures recorded in summer when compared to other warm-temperate climatic regions. The Mean Annual Precipitation (MAP) is approximately 920 mm. The mean annual temperature is 15.6ºC (Mucina and Rutherford, 2006), and frost and snow is frequent in winter.

2.3.2 Geology

The entire study area is underlain by arenite and conglomerate of the Turffontein sub-group of the Randian Erathem.

2.3.3 Regional Vegetation Type

The study area is located in the Grassland Biome and more particularly the sub-escarpment Grassland Bioregion, which is found along the flat plains of the foothills of the Drakensberg. It corresponds to an ecological type known as Southern KZN Moist Grassland (Gs11, Mucina & Rutherford, 2006) as shown on **Figure 3** below. The distribution of this regional vegetation type in South Africa is confined to the KZN

and Eastern Cape Provinces along the interior valley basins of the uMkhomazi River, although it also extends from Creighton in the south to Howick in the north.

Southern KZN Moist Grassland occurs on gentle sloping valley bottoms that are characterised by a species rich floristic composition consisting primarily of Red Grass (*Themeda triandra),* Treat-leaved Bluestem (*Diheteropogon filifolius),* Caterpiller Grass (*Harpochloa falx)* and Giant spear Grass (*Trachypogon spicatus)* when in pristine condition (see **Table 1** below). When subject to frequent grazing the graminoid composition is replaced by Common Thatching Grass (*Hyparrhenia hirta)* and many of the "mtshiki" species consisting of Weeping Love Grass (*Eragrostis curvula),* Tough Love Grass (*E. plana),* Ratstail Dropseed (*Sporobolus africanus)* and Catstail Dropseed (*S. pyramidalis)*. Selective grazing also results in the dominance of Wire Grass (*Elionurus muticus)* and Gongoni Three-awn (*Aristida junciformis)*.

Southern KZN Moist Grassland is threatened and vulnerable with approximately 4% thereof conserved within the nearby Impendle Nature Reserve, as well as in the Midmar, Igxalingenwa and Ingelabantwana Reserves. It also occurs within the Sada Forest Nature Reserve and the uKhahlamba Drakensberg Park. More than 30 % of it is already transformed[2] owing to cultivation, overgrazing, afforestation and the construction of impoundments.

Table 1: A list of the characteristic plant species for each stratum (e.g. grass, forb & woody layer) representing the Southern KwaZulu-Natal Moist Grassland (Mucina & Rutherford, 2006).

Grassy Layer	Forb Layer	Woody Layer
Alloteropsis semialata, Andropogon appendiculatus, A. shirensis, Eragrostis chloromelas, Digitaria ternata, E. curvula, E. plana, Hyparrhenia hirta, Microchloa caffra, Paspalum dilatatum, Setaria nigrirostris, Sporobolus africanus, Tristachya leucothrix, Brachiaria serrata, Elionurus muticus, Heteropogon contortus, Themeda triandra, Aristida junciformis, Trachypogon spicatus	***Non-succulents:*** *Acrotome inflata, Ocimum obovatum, Conyza pinnata, Acanthospermum australe, Berkheya setifera, Chamaecrista mimosoides, Helichrysum nudifolium, Lobelia erinus, Hilliardiella aristata* ***Climbers:*** *Rhynchosia totta* ***Geophytic herbs****: Oxalis corniculata, O. smithiana, Pteridium aquilinum, Cheilanthes bergiana, Zantedeschia albomaculata*	***Low shrubs:*** *Asparagus virgatus, Erica caffrorum, Rubus cuneifolius* ***Small Trees****: Protea caffra*

It is worth noting that the Southern KZN Grassland is one of four (4) Sub-escarpment Grassland types that provides habitat for the Endangered *Capys penningtoni* butterfly. In addition, the grassland corresponding to the north of the uMkhomazi River within the "invertebrate corridor" is part of the Impendle Highlands, which is an

[2] It is implied that the original pre-disturbed floristic composition has changed and is no longer typical of the regional vegetation type. The floristic composition on transformed land often includes pioneer, secondary and alien weed species.

endangered ecosystem (see **Figure 4** below). This particular ecosystem supports a large stand of *Protea caffra,* which is the host-plant of *Capys penningtoni*.

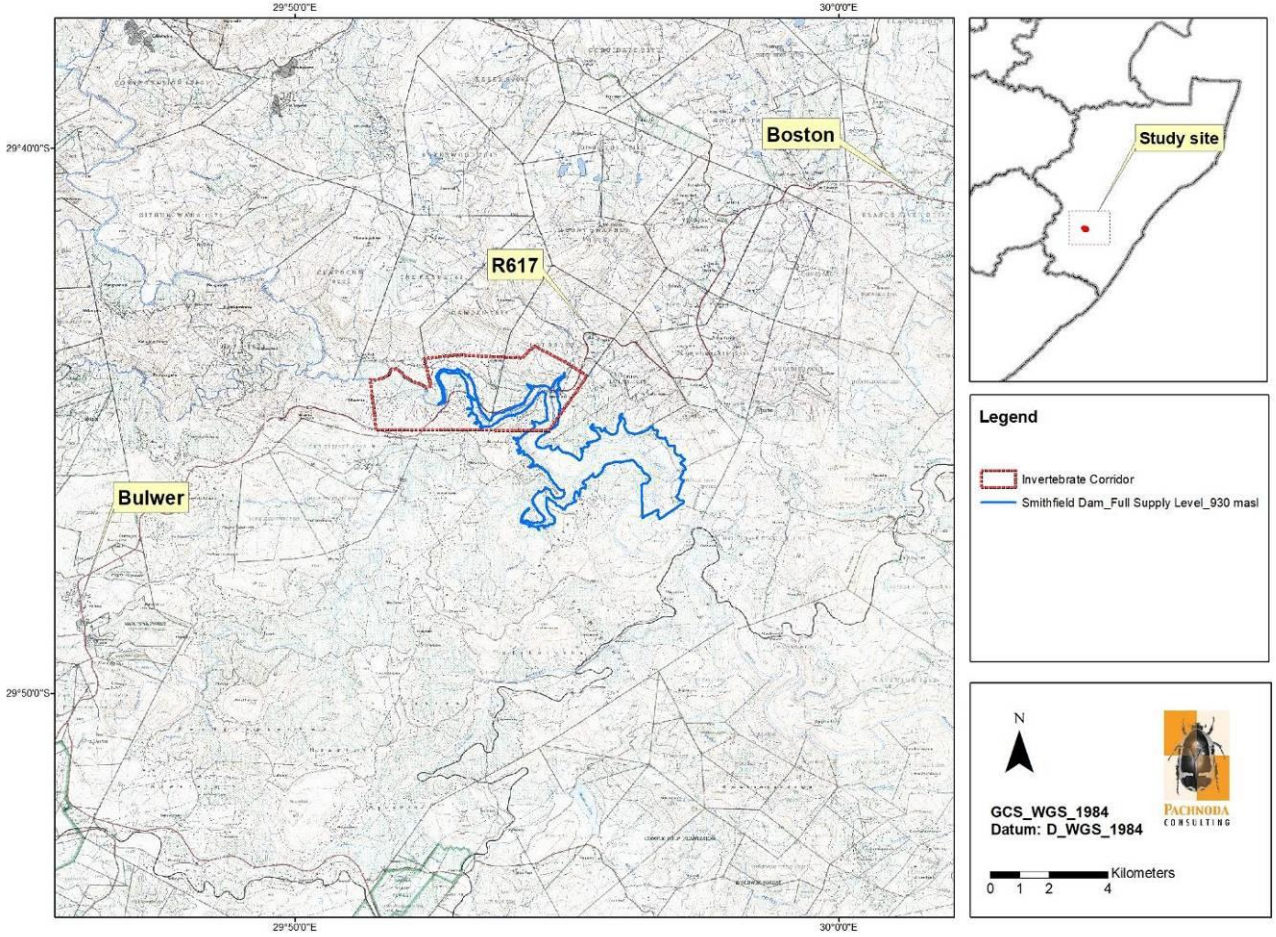

Figure 1: Topographical map showing the study area and its spatial position relative to Boston and Bulwer.

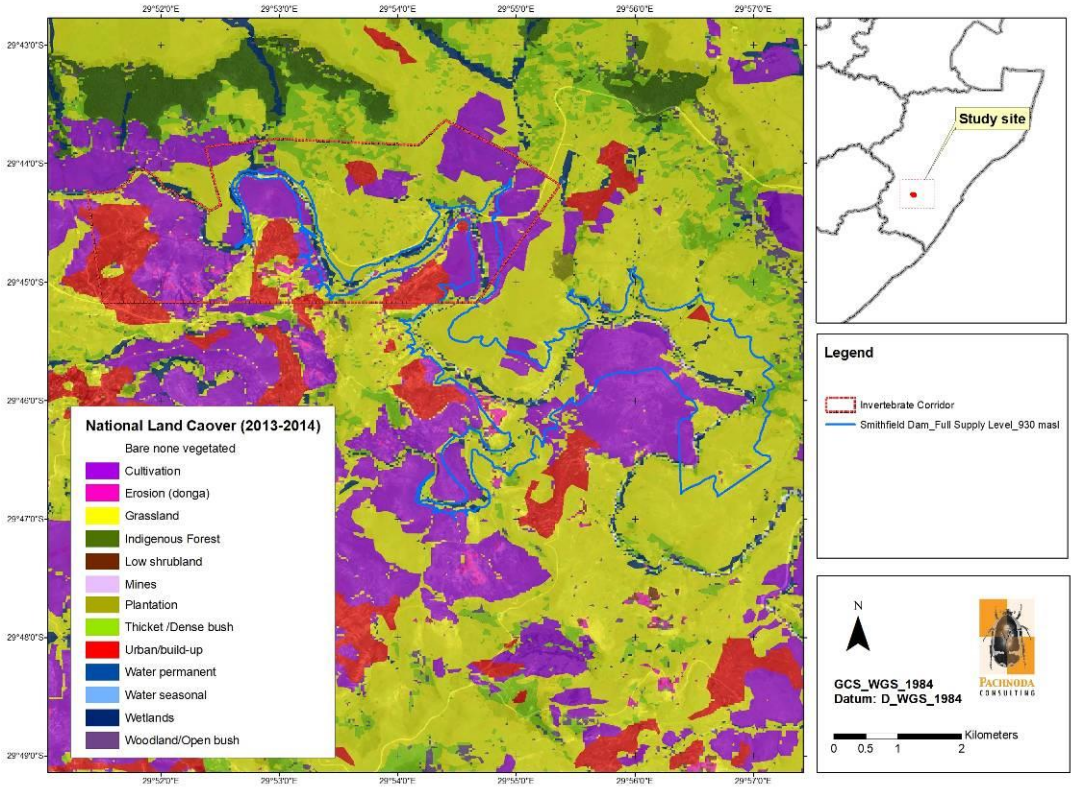

Figure 2: A satellite image of the study area illustrating the national land cover categories.

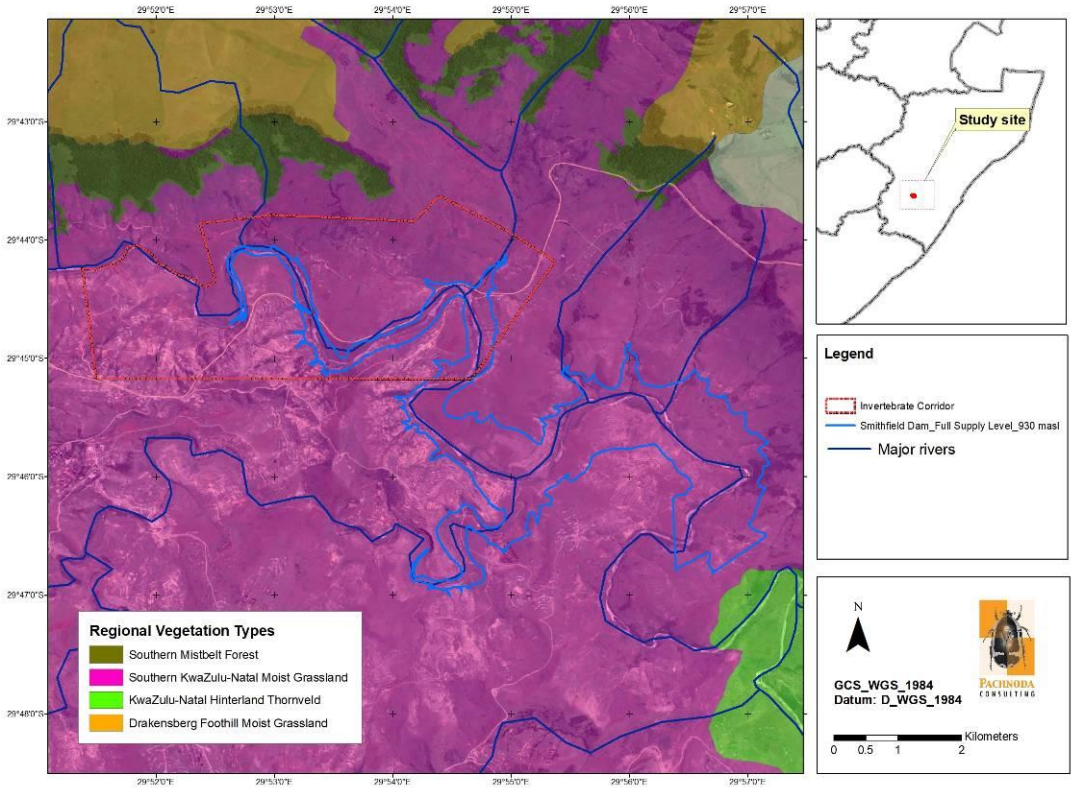

Figure 3: A satellite image of the study area illustrating the regional vegetation types

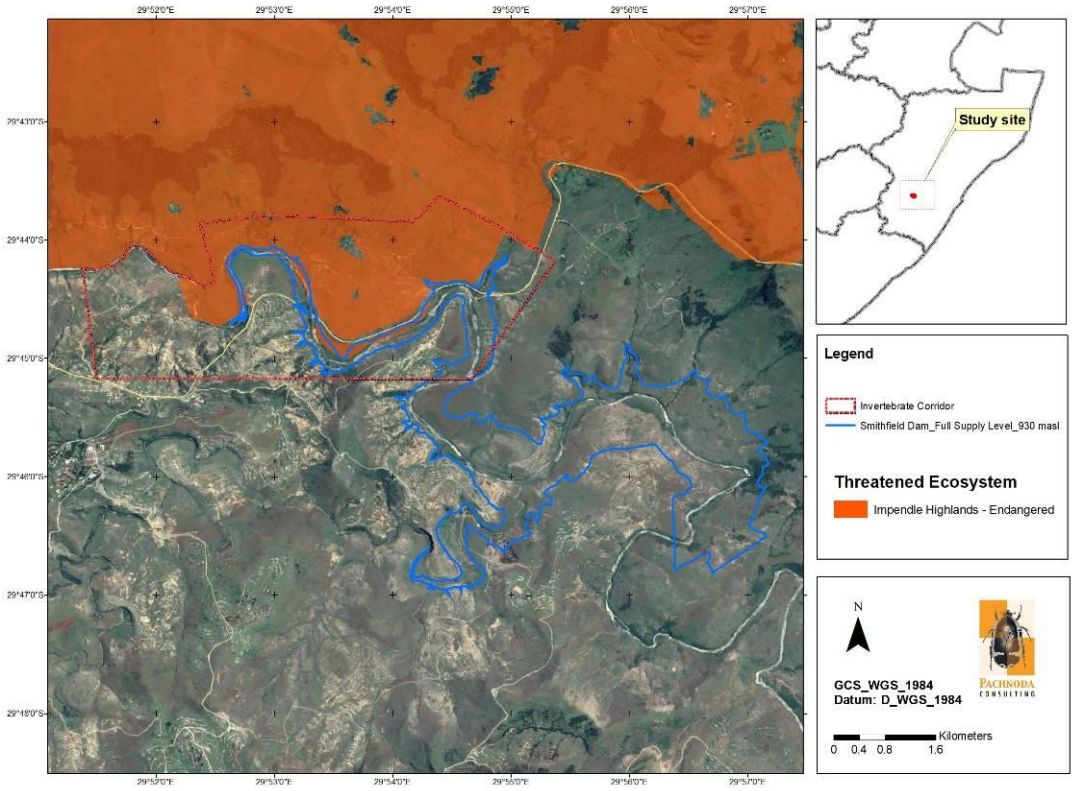

Figure 4: A satellite image of the study area illustrating the remaining extent of national threatened ecosystems

2.3.4 KwaZulu-Natal Biodiversity Sector Plan

According to the Harry Gwala Biodiversity Sector Plan (Ezemvelo KZN Wildlife, 2014) and the KZN Biodiversity Spatial Planning Terms and Processes (Ezemvelo KZN Wildlife, 2016), it is evident that the area of "Invertebrate Corridor" north of the uMkhomazi River falls within a Critical Biodiversity Area that is defined as Irreplaceable (see **Figure 5** below). In addition, several Critical Biodiversity Areas of "optimal" habitat are located below the proposed Smithfield Dam's FSL.

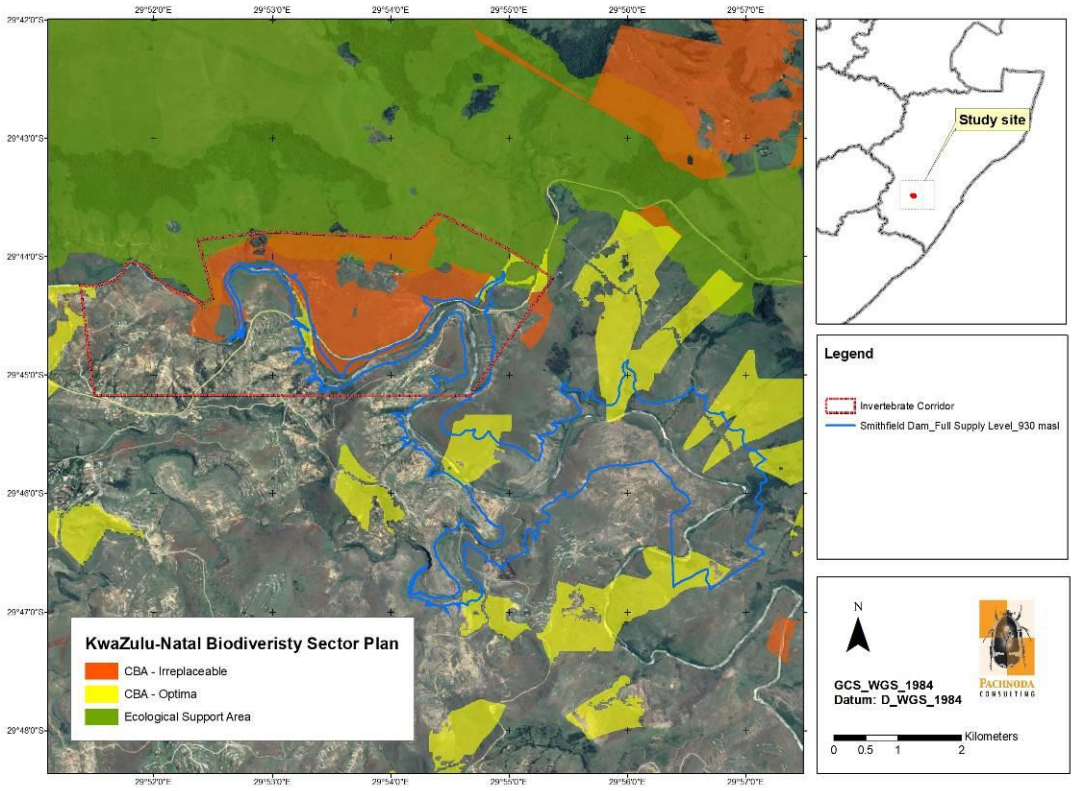

Figure 5: A satellite image illustrating the KZN Biodiversity Sector Plan for the region

3. METHODS AND APPROACH

3.1 Literature Review and Database Acquisition

3.1.1 Capys penningtoni (Pennington's Protea Butterfly)

The following literature and datasets were consulted prior to the site visits to obtain information on the ecology, natural history, conservation status and distribution of the target species:

- The national and global conservation status of *C. penningtoni* were based on the International Union for Conservation of Nature (IUCN) Red List (2018) and the South African Butterfly Conservation Assessment (SABCA) (Mecenero et al., 2013);
- The historical and extent (recent) distribution range of *C. penningtoni* was sourced from the Animal Demography Unit's online database, LepiMap and the Scientific Services (Biodiversity Spatial Planning and Information) from Ezemvelo KZN Wildlife. Additional distributional information was augmented by Mecenero et al. (2013) and various applicable field guides, in particular Woodhall (2005);
- The ecology and natural history of *C. penningtoni* was sourced from Pringle et al. (1994), Woodhall (2005), Picker and Griffiths (2011) and personal communication with specialists, in particular Dr. Adrian Armstrong (Entomologist & Herpetologists at Ezemvelo KZN Wildlife) and Mr Reinier Terblanche (private consultant and lepidopterist), and
- General and universal measures and protocols for insect diversity conservation and invertebrate habitat (especially for butterflies) were obtained from Samways et al. (2010), New (2014, 1998), Samways (2005) and Morrison (2009).

3.1.2 Gnomeskelus fluvialis (Riverine Keeled Millipede)

The following literature and datasets were consulted prior to the site visits to obtain information on the ecology, natural history, conservation status and distribution of the target species:

- The historical distribution range of *G. fluvialis* was sourced from Lawrence (1958) and Hamer (1998), and
- The ecology and natural history of *G. fluvialis* was sourced from Lawrence (1958) as well as personal communication with specialists, in particular Dr. Adrian Armstrong (Entomologist & Herpetologists at Ezemvelo KZN Wildlife) and Dr. Michelle Hamer (SANBI and taxonomist on Myriopoda).

3.2 Field Surveys

3.2.1 Capys penningtoni (Pennington's Protea Butterfly)

A site visit was conducted from 15 to19 November 2017 to search for *C. penningtoni*. However, the contract to undertake this Invertebrate Assessment Study was awarded during the post activity period (ca. post October) of the imago stage (adults). Therefore, field surveys focused primarily on the identification, delineation and mapping of suitable host plant habitat (c. *Protea caffra* stands) below the proposed Smithfield Dam's FSL and within the "invertebrate corridor" (see **Figures 6** to **8** below). The field surveys were aimed to identify suitable breeding habitat (e.g. stands of *Protea caffra*), other foraging habitat and access to higher-lying areas when butterfly males engage in "hill-topping" behaviour. In addition, estimates on population size and extent of occupancy were not possible to obtain during the site visit. If estimates are required on the population size, then a follow-up site visit is recommended. The follow-up site visit should overlap with the peak flight period of the butterfly (September and October).

To augment the field surveys (to verify the occurrence of *C. penningtoni*), searching for larvae was also conducted. This method involves the removal and dissection of developing *Protea* flower heads which may contain developing larvae (see **Figure 9** below). Since this method is "intrusive", sampling was limited to a maximum of five (5) developing flower heads per *Protea* stand. A total of 30 heads were sampled and dissected. Caution should be exercised when using this method to verify the occurrence of *C. penningtoni*, since it occurs sympatric (or co-occur) with *C. alpheus extentus* (Orange Banded Protea). The larvae of both species are remarkably similar and hence difficult to distinguish the two species apart solely on morphology. In order to confirm the species, it is necessary to rear all the recovered larvae to adulthood, meaning that pupation is only likely to occur during the next season.

Figure 6: Typical suitable breeding habitat of *Capys penningtoni* observed from the "invertebrate corridor" represented by stands of *Protea caffra*. Note the steep gradients and the patchy spatial distribution of the *Protea* stands.

Figure 7: Potential breeding habitat of *Capys penningtoni* observed from the edge of the proposed Smithfield Dam's FSL.

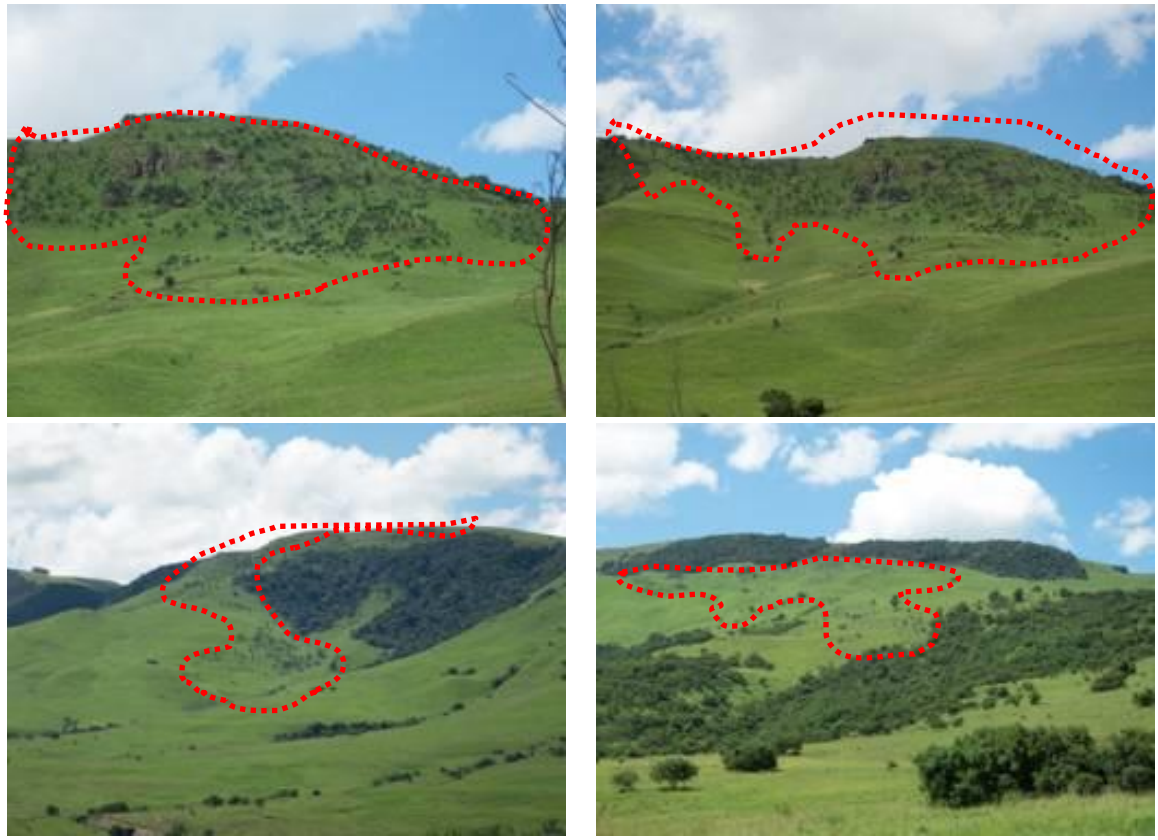

Figure 8: Typical breeding habitat of *Capys penningtoni* near one of the collection sites (a confirmed locality of *C. penningtoni*) along the southern aspects of the Lundy's Hill ridge system represented by *Protea caffra* stands. The area is located above the 930 m contour line of the proposed Smithfield Dam's FSL at an altitude that corresponds to 1200 - 1360 masl. The *Protea* stands can be viewed from the Deepdale Road.

Figure 9: An example of developing *Protea caffra* flower buds.

3.2.2 Gnomeskelus fluvialis (Riverine Keeled Millipede)

Limited information is available on the ecology and habitat requirements of *G. fluvialis,* except that it probably occurs in mesic micro-sites in close proximity to perennial rivers or streams. Searches for *G. fluvialis* were restricted to "forest", thicket and bush clumps located along the uMkhomazi River riparian zone based on the supposition that most *Gnomeskelus* species live in forest or closed canopy habitat (pers. comm., Dr. M Hamer). Searches were also conducted along tributaries of the uMkhomazi River where the woody vegetation layer is continuous with the main riparian zone of the uMkhomazi River (see **Figure 10** below). In addition, searches were also conducted near the type locality[3], which include a number of habitat types at Deepdale, including the "Deepdale Forest" next to the uMkhomazi River (see **Figure 11** below).

A total of thirty (30) sites consisting of forested or vegetated woody stands were sampled as indicated on **Figure 12** below. The sampling sites were chosen to correlate for environmental as well as biophysical and topographical variability (since information on the ecology of *G. fluvialis* is scant). These sites vary in terms of aspect, slope, dominant woody plant composition, canopy height, basal herbaceous cover, altitude, soil texture (clay, loam and sandy soils) and the presence/absence of livestock.

The following methods were applied at each searching locality:

- At each site, a 50 m^2 plot of 25 m by 2 m was demarcated and searched for members of the genus *Gnomeskelus*.
- The searching effort within each sampling plot took approximately 30 minutes.
- The searching involved the removal of the leaf litter using a stick, which was used to "sweep-away" or raking the leaf litter[4].

[3] The type locality refers to the locality where the holotype specimen was collected from. The holotype (or "type") refers to the specimen that was used during the formal description of the species.
[4] Referring to decomposing but recognisable leaves and other organic debris forming a layer on top of the soil.

- At each site, in addition to the 50 m^2 plot searching, random searching was conducted for another 30 min. Millipedes were searched for by means of using hands at selected areas or micro-habitat sites.
- Random searching also included the edges of woody sites and was extended into riparian grassland (owing to our limited knowledge on the habitat of *G. fluvialis*).
- Sampling and searching were undertaken from 11 to 15 December 2017 and from 19 to 22 February 2018.
- The sampling effort at Deepdale was not standardised and only hand searching was conducted.




















Figure 10: A collage of the different habitat types and habitat structure that was sampled for *Gnomeskelus fluvialis* during the respective site visits.

Figure 11: A collage of the different habitat types and habitat structure that were sampled for *Gnomeskelus fluvialis* at Deepdale.

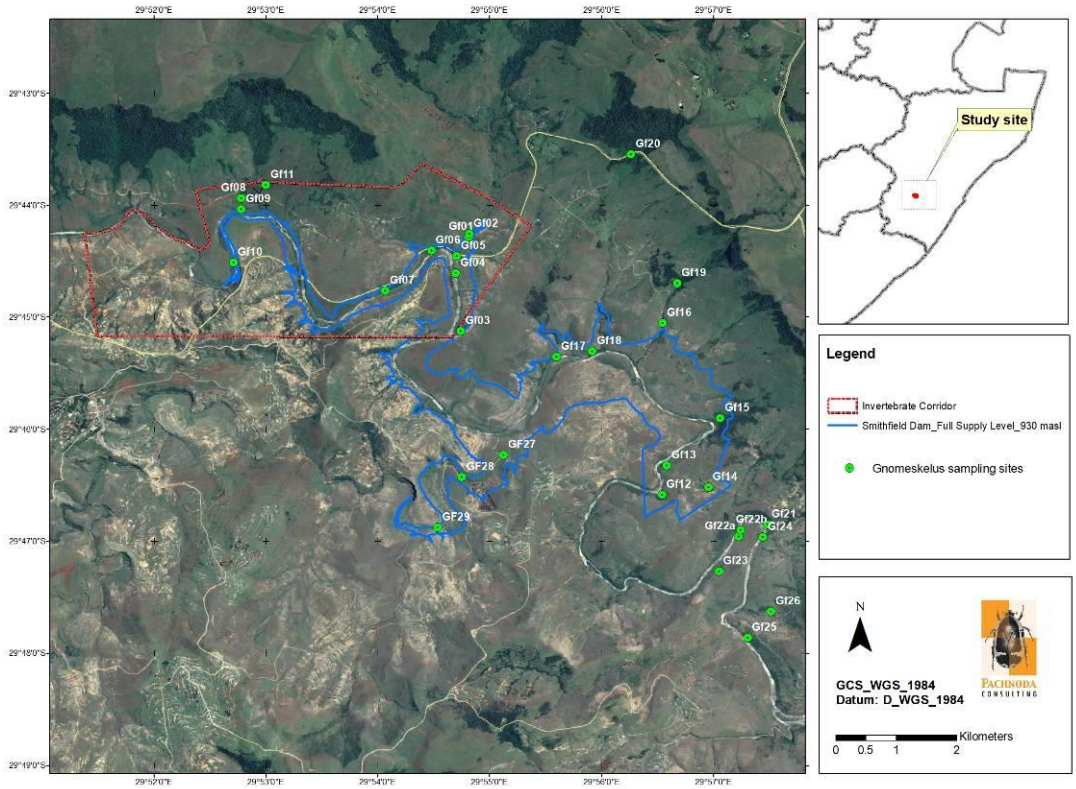

Figure 12: A Satelite image illustrating the sampling sites where searches for *Gnomeskelus fluvialis* were conducted.

4. TAXON DESCRIPTIONS

4.1 *Capys penningtoni* (Pennington's Protea Butterfly)

4.1.1 Natural History and Background (sensu Pringle et al., 1994)

Capys penningtoni was first discovered in July 1929 by G.E. Pennington (who was also the farther of K.M. Pennington) on Farrer's Farm near Boston when a pupa was collected, which subsequently hatched into an adult male in October 1929. During September in the same year, I. Morphew collected a series of males from Inhlozane Mountain (currently known as the iNhlozane Massif) near Dargle. In addition, K.M. Pennington visited Inhlozane Mountain on 11 October 1930 when he also collected a male specimen and realised that it occurs alongside with *C. alpheus extentus*.

C. penningtoni was only formally described in 1932, and since then it was collected from a number of nearby localities including Howard Hill near Elandskop (in 1940), Inhlozane Mountain near Dargle and the hills and mountains of the "Little Berg" from Elandskop to Bulwer and Loteni.

4.1.2 Taxonomy and Description

The type locality[5] is from Inhlozane Mountain in KZN from which it was firstly described in 1932 by Riley. The genus *Capys* is an Afrotropical genus of 18 species. Of these, *C. penningtoni* is one of three species endemic to South Africa and restricted to montane grassland in association with *Protea* stands. It belongs to the rather large Lycaenidae family (Subfamily: Theclinae; Tribe: Deudorigini).

Members of the genus *Capys* are medium to large lycaenids with a rather robust build and hence a fast-flying behaviour. The upperwings are predominantly orange-red with black borders, while the underparts are cryptically coloured. *C. penningtoni* occurs alongside *C. a. extentus* and it is possible that the two species could be confused with each other. *C. penningtoni* is less brightly coloured than *C. a. extentus*, and the marginal border on the upperwings is narrower and almost indistinct on the hindwings (see **Figure 13** below). In addition, the underwing pattern is drab, and less brightly coloured when compared to *C. a. extentus*. The sexes of *C. penningtoni* are similar and the wings of the females are more angular when compared to *C. a. extentus*. *C. a. extentus* often outnumbers C*. penningtoni* where both species co-occur.

[5] The locality where the species was described from.

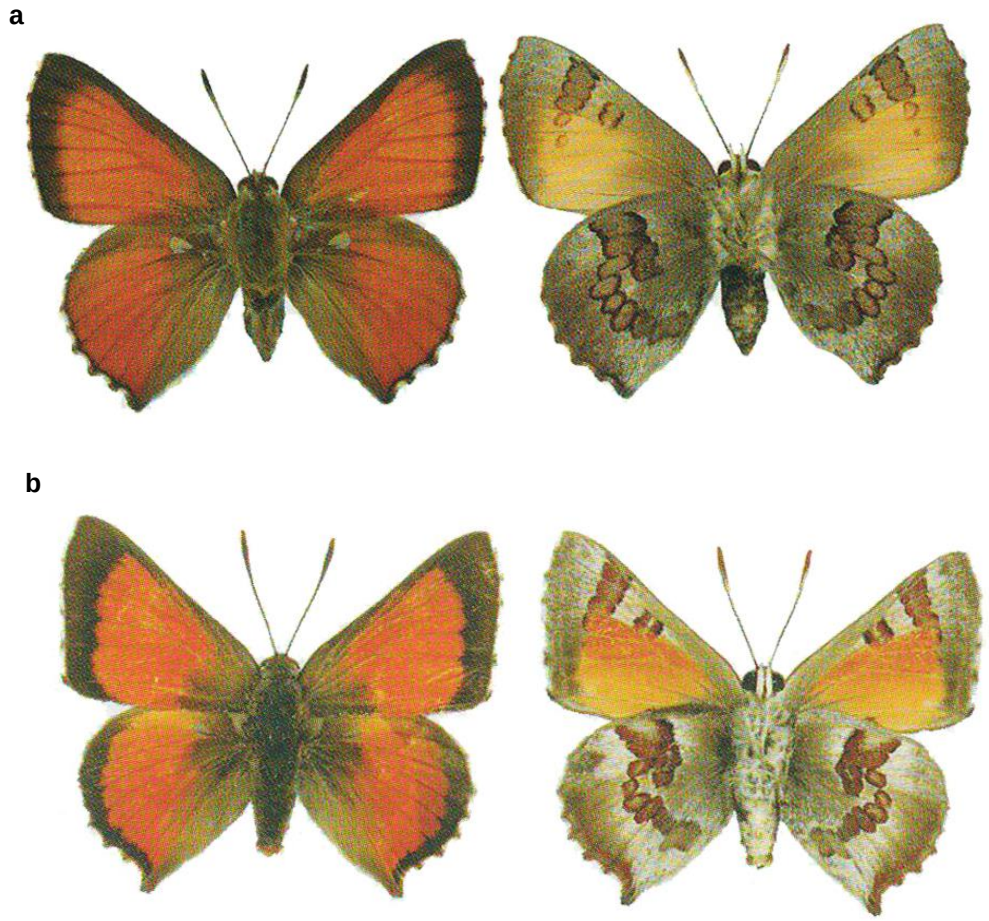

Figure 13: The dorsal and ventral view of (a) *Capys penningtoni* and (b) *C. alpheus extentus* (images courtesy and copyright of Mecenero et al., 2013).

4.1.3 Ecology, Habitat and Life-history Characters

This species is closely associated with their larval host plant which are members of the genus *Protea* (Proteaceae). *C. penningtoni* occurs in montane grassland with *Protea caffra* stands in the Drakensberg foothills between 900 and 1900 masl. Females oviposit their eggs on developing flower heads, whereby the larvae bore into the heads and feed on the immature seeds of the flowers. As the larvae develops, it enlarges inside the flower head. The larvae then pupates in the flower head and emerges as an adult butterfly, thereby escaping through the hole at the base of the head. The species is seldom found away from *Protea* stands, although males ascend to nearby hill-tops (known as "hill-topping") to defend territories and to mate with females.

The imago stage (adults) is only on the wing between September and October, and the species is univoltine (single-brooded).

4.1.4 Distribution and Range

C. penningtoni is a range-restricted species with a highly localised global distribution range. It is endemic to KZN where it occurs from Bulwer to Elandskop in the south, and northwards to Loteni and the iNhlozane Massif. Recently it was only regularly observed at Bulwer, Loteni and near Boston as well as Lundy's Hill, which are all localities in close proximity to the "invertebrate corridor" (see **Figure 14** below). The estimated extent of occurrence is 1 200 km^2 and its area of occupancy is not greater than 30 km^2 (Mecenero et al., 2013). The population resolves seasonally between two to five sub-populations. It is currently known from only nine quarter-degree grid cells, and was also recently observed from the Hammersdale Area (see **Figure 15** below).

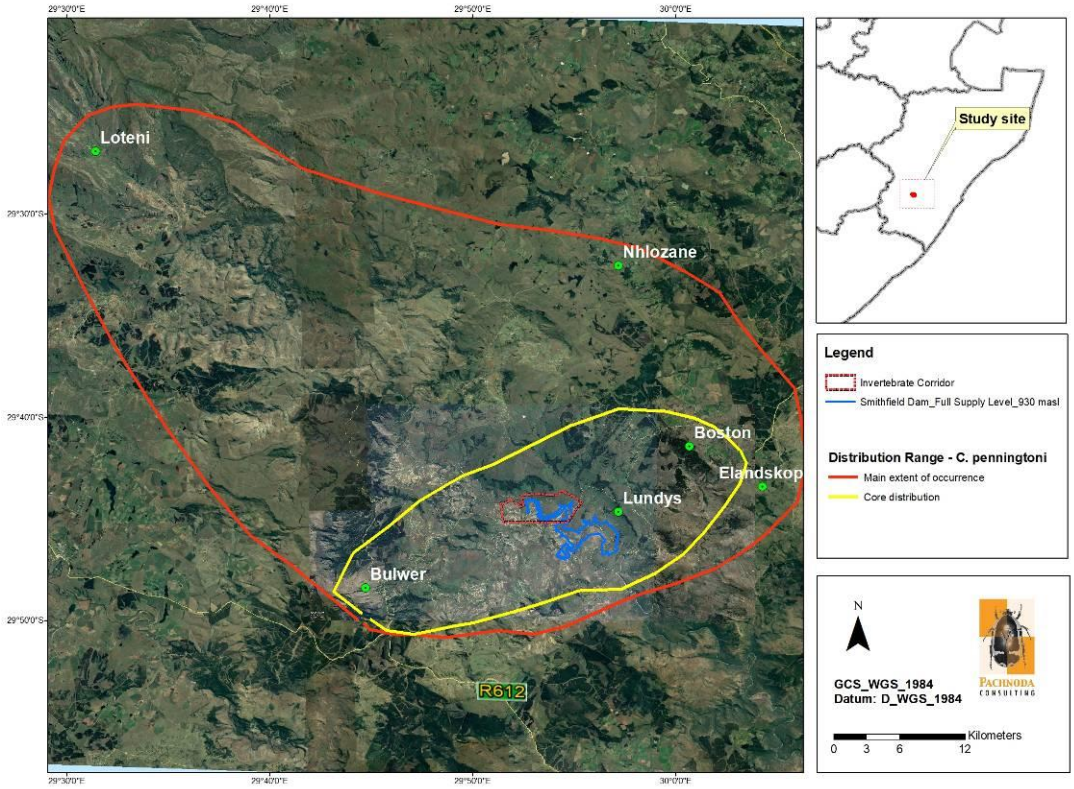

Figure 14: The main distribution range and extent of occurrence of *Capys penningtoni* (according to collected material).

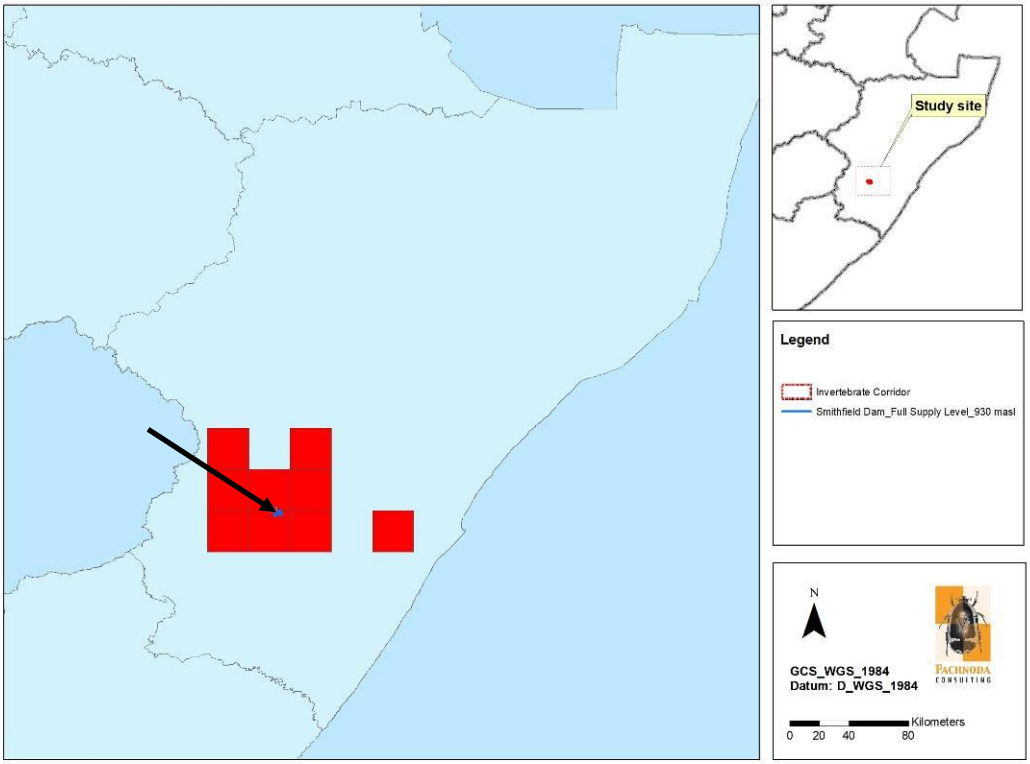

Figure 15: The distribution range of *Capys penningtoni* based on QDG cells.

4.1.5 Conservation Status and Threats

Capys penningtoni is endemic to South Africa and listed as **Endangered** B1ab(i, ii, iii)+2ab(i, ii, iii) given its small area of occupancy, and the continual decline of its habitat within its area of occupancy (Mecenero et al., 2013). It is a habitat specialist which occur within a specific habitat, and owing to the continual loss of habitat quality, the population is declining to the point that its status may be uplisted to the **Critically Endangered Category** in the near future (pers. comm., Dr. A. Armstrong).

It is threatened mainly by the loss of habitat, habitat quality and predation by alien invasive species as described below:

- *Predation by alien invasive species*: Predation of eggs by the Harlequin or Asian Lady Beetle (*Harmonia axyridis)*, which is a beetle of the Coccinellidae, poses a great threat to the population. It originates from central and eastern Asia where it was purposefully introduced into Europe and the Americas as a biocontrol agent against aphids. Its introduction into South Africa is unknown, although it was recorded for the first time in 2001 in the Western Cape. By 2010 it has spread through the temperate areas of southern, eastern and east-central South Africa. It is regarded as one of the worst invasive and harmful insect species in the world. It is a voracious generalist predator of insect species, including *Capys* species. This species should be accorded the highest status to an alien invasive species.

- *Fires*: Inappropriate and uncontrolled fires resulted in the decline of *Protea* trees - the host plant of *Capys* species. In most instances the moribund grass cover beneath the *Proteas* is responsible for hot burns with tall fires that not only cause a die-back to *Protea* stands, but the flames also burn the developing flower buds that contain the larvae.
- *Overgrazing*: Inappropriate grazing regimes result in the loss of nectar plants, but also graminoid diversity. Overgrazing beneath *Protea* stands make it possible for Bramble (*Rubus* spp.) as well as tall coarse grass species such as *Hyparrhenia* grass species to invade these areas and outcompete the short, natural grass species. This in turn discourages future selective grazing of the area and increase the fuel load of the graminoid cover beneath *Protea* stands (rendering the *Protea* stands very vulnerable for uncontrollable fires).

4.2 *Gnomeskelus fluvialis* (Riverine Keeled Millipede)

4.2.1 Natural History and Background

Information on *G. fluvialis* is scant except that it was collected along the uMkhomazi River by R. F. Lawrence in November 1957 at Lundy's Hill, approximately 27.4 km east of Bulwer. *It was not collected since 1959*.

4.2.2 Taxonomy and description

The type locality of *G. fluvialis* is from the Umkomaas River near Lundy's Hill (1957). *G. fluvialis* is a poorly known species that belongs to the Dalodesmidae (Class: Diplopoda; Order: Polydesmida), a primitive family containing mainly "keeled" millipedes of the genera *Gnomeskelus, Allawrencius, Drakensius, Platytarropus, Platytarrus, Rhopaleskelus* and *Schubartina*. Nearly all the Polydesmoid Millipedes, including the genus *Gnomeskelus,* inhabit indigenous forest with the highest diversity found within the slopes and foothills of the Drakensberg (Lawrence, 1953). Of the Dalodemid Millipedes, the genus *Gnomeskelus* contains the highest number of species.

Members of the genus *Gnomeskelus* are separated from other Polydesmoid Millipedes by separate telepodites (not coalescent with the midline). The genus *Gnomeskelus* contains small tibio-tarsi on the gonopods and a prefemur, while the distal joints of the anterior legs of males bear spherical nodules and smooth tergites. The keels are represented by laterally rounded prominences. *G. fluvialis* is best separated from other keeled millipede members by way of gonopod morphology (see **Figure 16** below). The telepodite is very long and slender without any bristles near its base. The canal branch of the gonopod is divided into two apical forks and the tibio-tarsus is unusually long and spine-like. Adults are small (10.5 mm long and 1.1 mm wide), light brown of which the head and anterior segment being tinged with pink. The tergites are faintly reticulated in brown with pale legs. Segment six of the antennae is elongated. The prefemur, femur and post-femur of the legs contain distinctive spherical bristles.

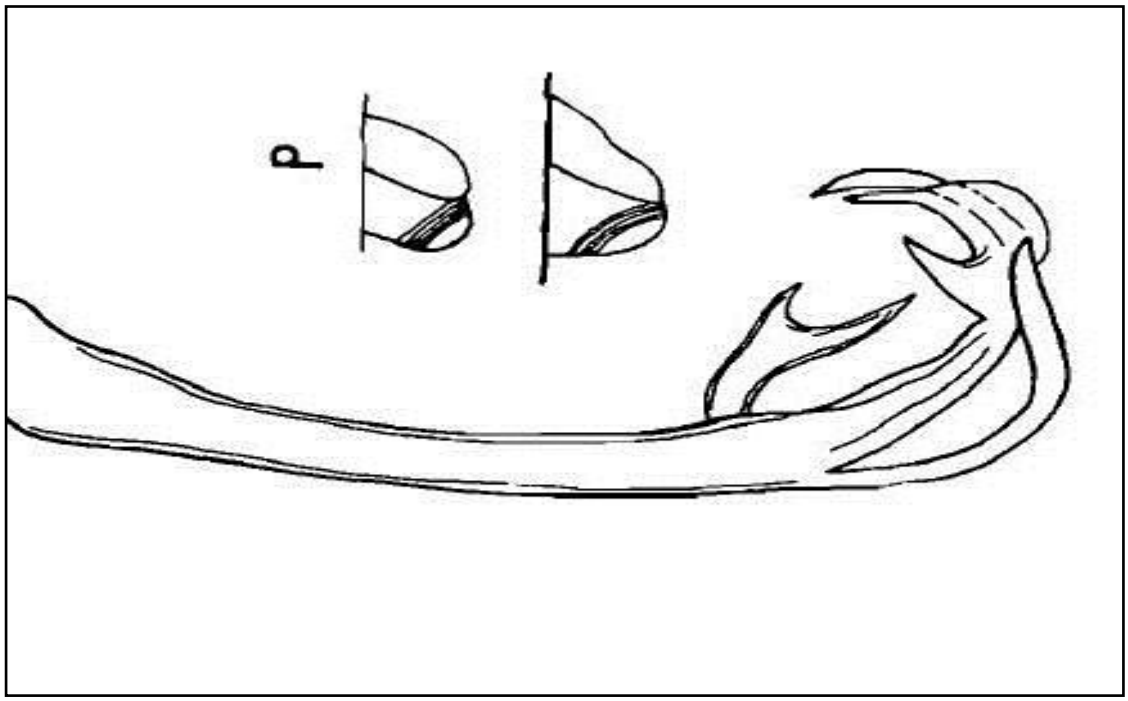

Figure 16: An illustration of the male gonopod and bristles on the pre- and postfemur (images courtesy and copyright of Lawrence, 1958).

4.2.3 Ecology, Habitat and Life-history Characters

Virtually nothing is known about the ecology and habitat requirements of *G. fluvialis*, except that it is assumed to occur in close proximity to the riparian zone of rivers or streams (*sensu* "fluvialis").

4.2.4 Distribution and Range

The distribution range of *G. fluvialis* is poorly known and it is currently known from only two historical localities, namely: Lundy's Hill along the uMkhomazi River and from Deepdale. Furthermore, it has not been collected since 1959.

4.2.5 Conservation Status

The species is only known from the uMkhomazi River Catchment and is endemic to KZN.

5. RESULTS AND DISCUSSION

5.1 Occurrence of *Capys penningtoni* on the Study Area

Although *C. penningtoni* was not observed during the respective site visits, the probability for this species to occur on the "invertebrate corridor", as well as the higher-lying areas (c. 1200 – 136 masl) north of the Deepdale Road (in close proximity to Lundy's Hill) is **very high to definite**. The montane grassland on the "invertebrate corridor" north of the R617 contains several stands of *Protea caffra,* which provide critical important breeding habitat for *C. penningtoni* (see **Figures 17** to **19** below). In addition, adults were also recently observed (*c*. September 2017) by Dr. Adrian Armstrong at *Protea* stands in close proximity to the R617 corresponding Lot 93 1821 (pers. comm.) - the latter area coincides with the "invertebrate corridor" (see **Figures 18** and **19** below).

Nevertheless, due to the threatened conservation status of this species, it is mandatory that all natural and untransformed habitat (excluding forested areas) within the "invertebrate corridor" be classified as highly sensitive as is the *Protea* stands. The *Protea* stands are an important habitat component in ensuring high fecundity rates of the butterfly (see **Figure 20** below). Although it can be argued that there are many *Protea* stands available, and the consequential loss of one stand might be buffered by another nearby stand, reasoning prevails where these *Protea* stands are cumulative inter-linked with one another and their importance is mutually inclusive. For example, one particular stand may provide foraging habitat for a generation of butterfly larvae at a particular season, while the following season it is possible that fires may destroy the flower buds, whereby another nearby stand is suitable to rear another generation.

In addition, the floristic richness and ecological quality of the montane grassland (being untransformed and consisting of many late-successional graminoid taxa) is positively correlated with altitude. At higher altitudes the slope increases and grazing pressure on these graminoid areas is less severe. The latter is important foraging habitat for a number of adult butterfly species (owing to the abundance of nectar producing forb species), but it also provides essential "hill-topping" habitat for male lycaenid butterflies. Not only is the topography and grassland important in facilitating essential behavioural response mechanisms for different butterfly species, but the montane grassland shows a high connectivity with the *Protea* stands, which thereby facilitate butterfly dispersal across the landscape.

Buffer zones were applied to the *Protea* stands, which were subsequently modified and calibrated according to the presence of transformed habitat and/or habitat rendered as unsuitable for *C. penningtoni* to occupy. Buffer zones are intended to protect sensitive features from disturbances. The size of the buffer zone depends on the type and potential impacts of the intended activities on these sensitive features. Considering that KZN has no prescribed buffer zones, the buffer zone widths as prescribed by the Gauteng Department of Agriculture and Rural Development (GDARD) were applied to this Study. According to the GDARD sensitivity mapping

rules (GDARD, 2014), a buffer of 400 m is required and was allocated from the edge of the *Protea* stands. The adopted buffer width is currently prescribed for two other **Endangered** butterflies (*Lepidochrysops praeterita* and *Chrysoritis aureus*), which both have distribution ranges coinciding with the Gauteng Province.

According to the sensitivity analysis (pertaining to the "invertebrate corridor"), it is evident that 474.58 ha (c. 35% of the total surface area of the "invertebrate corridor") is represented by *sensitive habitat* (high and very high sensitivity). In addition, habitat of *medium to high sensitivity* and *low-medium habitat* cover respectively 159.8 ha (12%) and 707.76 ha (52%) of the total surface area of the "invertebrate corridor".

The proposed buffer zone allocated to the *Protea* stands in the region covers approximately 1331.754 ha in extent, of which approximately 6.1 % (ca. 81.26 ha) corresponds to the FSL of the proposed Smithfield Dam.

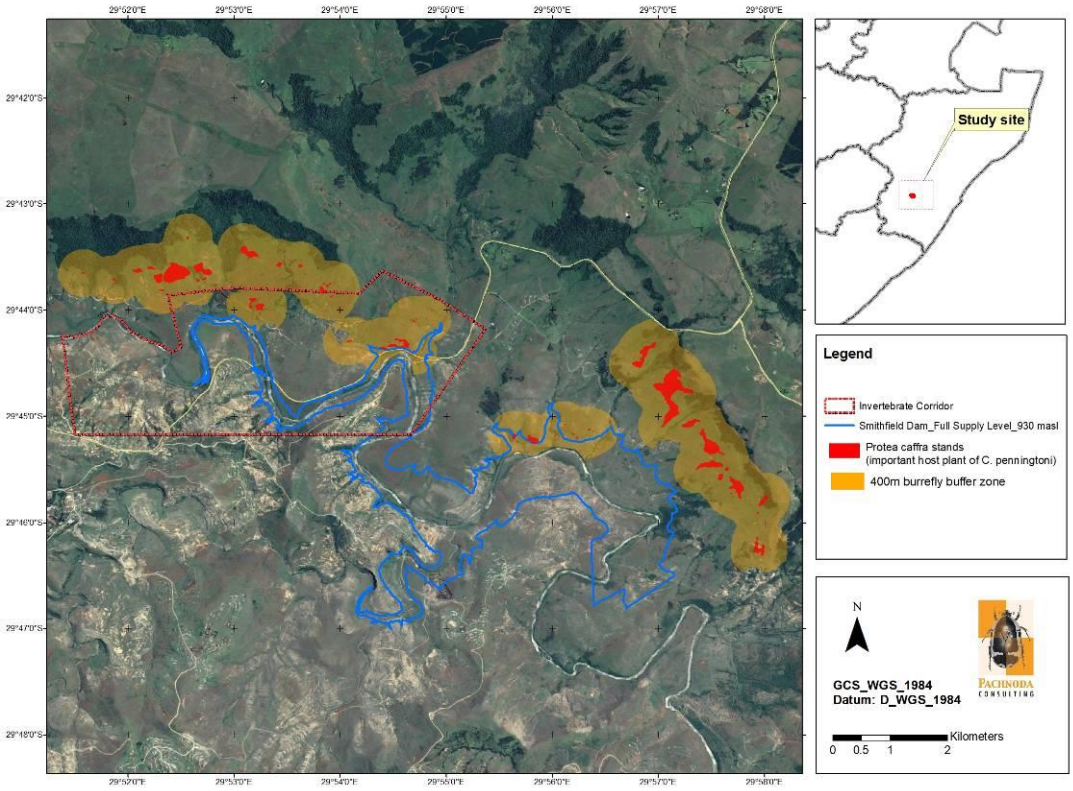

Figure 17: Map illustrating the spatial position of potential breeding habitat (*Protea caffra* stands) for *Capys penningtoni* on the study area. A 400 m buffer zone is included and modified where it occurs with habitat that is either transformed or unsuitable for occupancy.

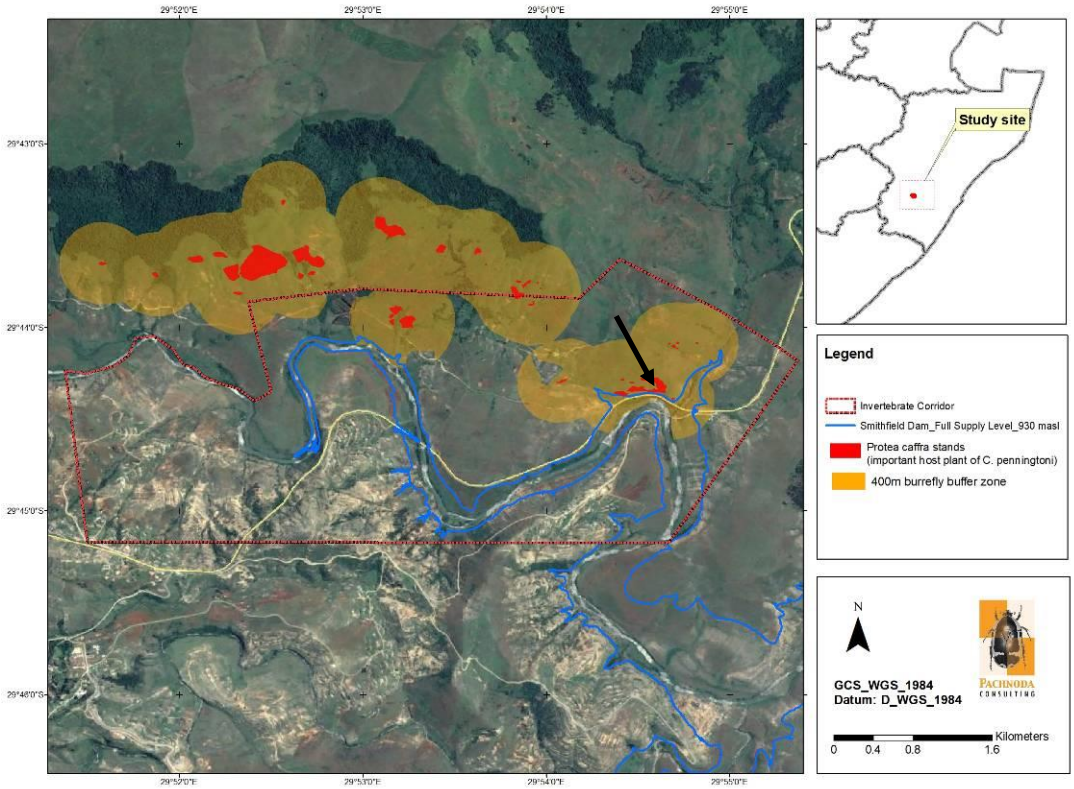

Figure 18: Map illustrating the spatial position of potential breeding habitat (*Protea caffra* stands) for *Capys penningtoni* on the "invertebrate corridor". A 400 m buffer zone is included and modified where it occurs with habitat that is either transformed or unsuitable for occupancy. The arrow indicates the area where *C. penningtoni* was confirmed (September 2017).

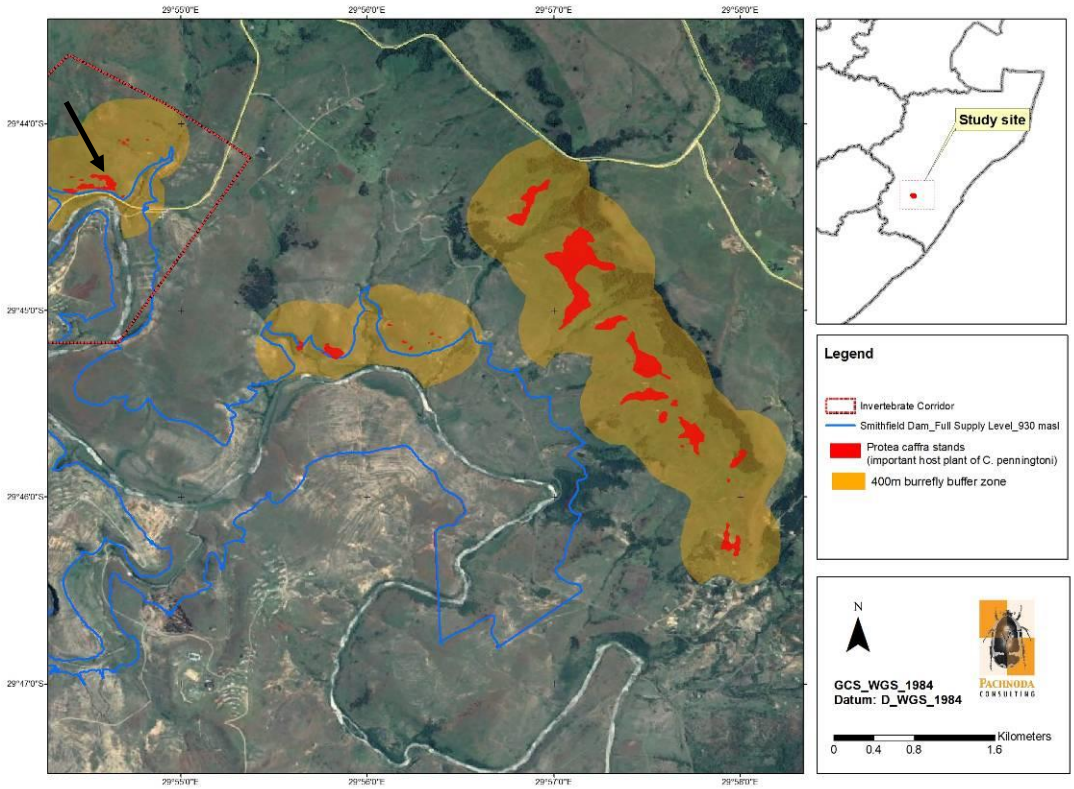

Figure 19: Map illustrating the spatial position of potential breeding habitat (*Protea caffra* stands) for *Capys penningtoni* on the eastern part of the study area. The arrow indicates the area where *C. penningtoni* was confirmed (September 2017).

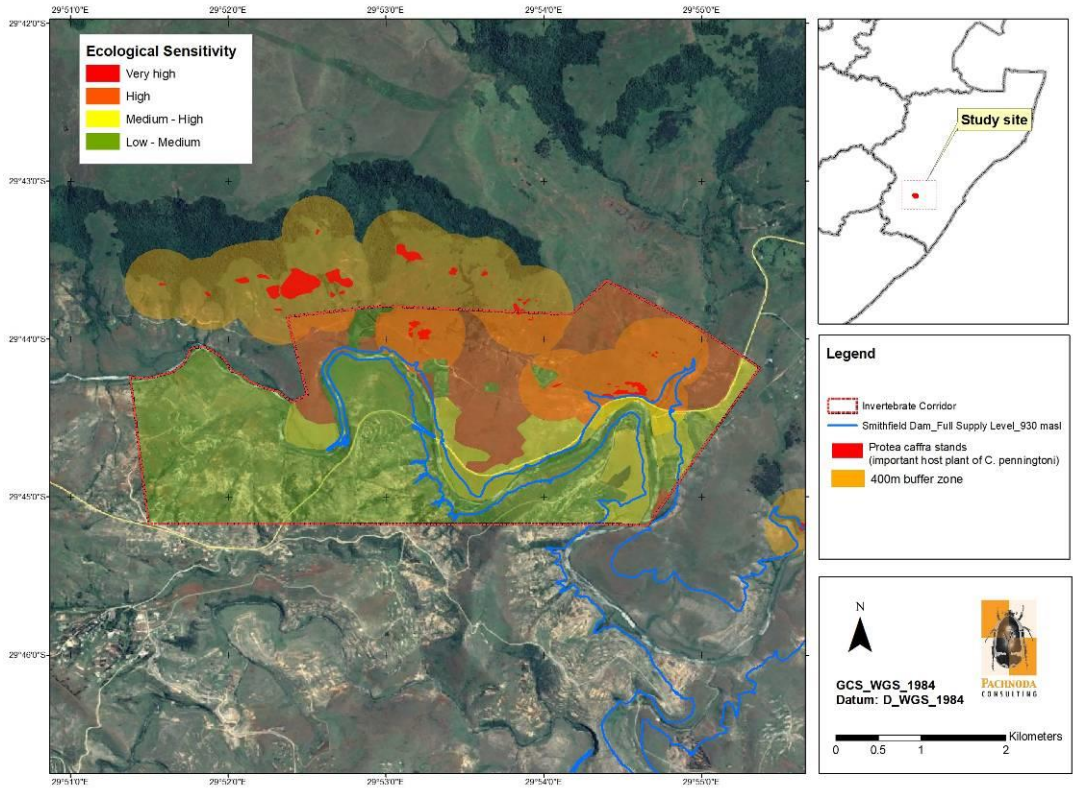

Figure 20: Sensitivity map of the "invertebrate corridor". Note that most of the untransformed grassland is earmarked with a "high sensitivity", while the *Protea* stands have a "very high" sensitivity (with buffer zone).

5.2 Occurrence of *Gnomeskelus fluvialis* on the Study Area

G. fluvialis was not observed on the study area even during intensive searching in a variety of habitat types. However, the occurrence of *G. fluvialis* is regarded as **probable** (low confidence) on the study area. Absence of this species could not be ruled out since (1) it is known to occur based on historical records (*c*. 1959), (2) potential suitable habitat is present along the uMkhomazi River and (3) it may naturally occur in low abundances, or is naturally rare within its distribution range. Based on the above arguments, it is possible that this species are either easily overlooked and/or highly specialised whereby it may have already declined owing to habitat degradation and inappropriate grazing regimes.

In order to compare riparian habitat with one another with a high apparent probability for *G. fluvialis* to occur, habitat with high numbers of polydesmoid millipedes (in particular habitat types with high numbers of *Gnomeskelus* spp.) were regarded as important. Most of these habitat types have western or southern aspects on slopes that range from steep to moderate. In addition, Keeled Millipedes (*sensu lato*) are invariably absent, or rare, in habitat types that are accessible to cattle (owing to tramping and soil compaction), or are absent in habitat types with clayey soils with a high base status.

As shown on **Figure 21** below, it is evident that important habitat units with a high probability to sustain moderate to high numbers of Polydesmoid Millipedes occur near (1) Deepdale, which is not beneath the proposed Smithfield Dam's FSL, (2) near the bridge where the R617 crosses a tributary of the uMkhomazi River and (3) in forest types with steep slopes on southern aspects. It is highly recommended that habitat types conforming to the above habitat structure form part of the proposed Offset Identification and Allocation Process.

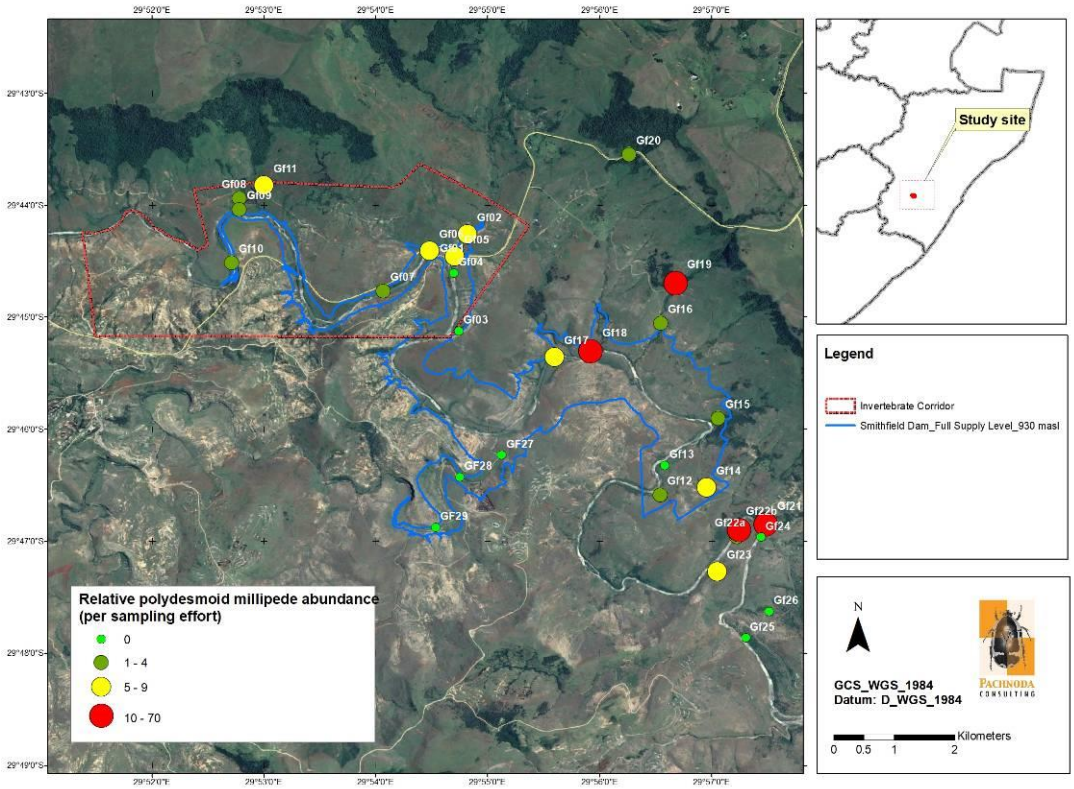

Figure 21: Map illustrating the relative abundance (per sampling effort) of polydesmoid millipedes sampled in a variety of habitat types along the uMkhomazi River. Habitat types sustaining moderate to high numbers of millipedes provide potential habitat for *G. fluvialis*.

A number of Polydesmoid Millipedes were sampled from the study area along the uMkhomazi River. These are briefly summarised below along with key features:

5.2.1. Gnomeskelus cf. burius (Plough-share keeled millipede)

Figure 22: *Gnomeskelus cf. burius* (Plough-share Keeled Millipede)

- *Gnomeskelus cf. burius* is of the most widespread species on the study area.
- *G. cf. burius* was formerly believed to represent a mistbelt forest endemic, but was subsequently collected from lower-lying forest along the uMkhomazi River.
- *G. cf. burius* was previously only known from Karkloof and Pietermaritzburg (Swartkops, Town bush and Hilton Road).

- The study area may represent a range expansion of the species.

5.2.2. Gnomeskelus cf. silvaticus

Figure 23: *Gnomeskelus cf. silvaticus*

- *Gnomeskelus cf. silvaticus* is currently only known from the Western Cape between Knysna and Riversdale and known collection records date back to 1940.
- *G. cf. silvaticus* was also recorded from Inchanga (1953), although Hamer (1998) mentioned that this locality is unlikely.
- *G. cf. silvaticus* could represent a novel or undescribed species.

5.2.3. *Ulodesmus cf. securifer minor* (Little-axed armed Soil Millipede)

Figure 24: ***Ulodesmus cf. securifer minor (Little-axed armed soil millipede)***

- *Ulodesmus cf. securifer minor* is only known from its type locality at Bulwer where it was collected in 1936.
- The study area may represent a range expansion of the species.

5.2.4. *Oxidus gracilis* (Greenhouse Millipede)

Figure 25: *Oxidus gracilis (Greenhouse millipede)*

- *Oxidus gracilis* is exotic and has been widely introduced around the world.
- *O. gracilis* was only collected from Deepdale among leaf litter wedged between rocks.
- *O. gracilis* only occurred in forest edges in close proximity to the uMkhomazi River.

5.3 Potential Impacts and Proposed Recommendations

Table 2: Summary of the Anticipated Impacts.

Area	Nature	Extent	Duration	Intensity	Probability	Status	Significance with Mitigation	Significance without Mitigation
Re-alignment of R617 - **Option 1**	Loss of *C. penningtoni* breeding habitat	Site	Short-term	Low	Likely	Negative	Low	Medium
Re-alignment of R617 - **Option 2**	Dispersal and "barrier "effects Changes to local temperature regime Changes to local floristic structure and composition owing to defective storm water management	Site	Long term	High	Definite	Negative	Medium to High	High
Re-alignment of R617 - **Option 3**		Site	Permanent	High	Definite	Negative	High	High
Proposed gravel access road	Loss of *C. penningtoni* breeding habitat Dispersal and "barrier" effects Changes to local temperature regime Changes to local floristic structure and composition owing to defective storm water management	Site	Long term	High	Definite	Negative	Medium to High	High
Below the	Loss of	Local	Long term	High	Highly Probable	Negative	Medium to High	High

Area	Nature	Extent	Duration	Intensity	Probability	Status	Significance with Mitigation	Significance without Mitigation
proposed Smithfield Dam's FSL	habitat during inundation: *C. penningtoni*							
Below the proposed Smithfield Dam's FSL	Loss of habitat during inundation: *G. fluvialis*	Local	Permanent	High	Probable	Negative	Medium to High	High

5.3.1 Re-alignment of the R617

The R617 needs to be re-aligned since it will be inundated by the proposed Smithfield Dam. Three (3) options are proposed, Option 1 is located south of the uMkhomazi River, Options 2 and 3 are located north of the uMkhomazi River as shown on **Figure 26** below. It is obvious from the sensitivity map that Option 1 will traverse habitat of low to medium sensitivity, while Options 2 and 3 will traverse habitat of high sensitivity. In addition, the spatial locality of both Options 2 and 3 corresponds with the allocated buffer zone, while both routes traverse through *Protea* stands. It is eminent that Option 3 will traverse a large stand of *Protea caffra* habitat where *C. penningtoni* was recently observed.

The impacts of roads are well described, and in the context of the study area these are summarised as follow:

- *Loss of invertebrate breeding habitat*: Both Options 2 and 3 traverse through sensitive montane grassland habitat and stands of *Protea caffra* - the breeding habitat of *C. penningtoni*. It is anticipated that the loss of *Protea* individuals, or clumps of *Protea* stands, will exacerbate the current observed decline of the *C. penningtoni* population especially since it is known to be present on the study area.
- *Dispersal and "barrier" effects caused by roads*: Linear infrastructure, especially hard surfaced roads, results in the fragmentation of habitat. However, such fragmentation will become more severe for dispersing animals with low dispersal abilities. For example apterous or flightless invertebrates will find it more difficult to cross roads than flying invertebrates. Road mortalities owing to oncoming traffic of small-bodied and low-flying invertebrates pose a higher risk than large-bodied or high-flying taxa. Therefore, it is possible that oncoming traffic could result in butterfly mortalities, especially for day-flying (diurnal) small-bodied species. In addition, the males of many lycaenid butterflies, including *C. penningtoni,* disperse daily to higher lying

areas to establish territories, a behaviour known as "hill-topping". The proposed road may "barrier" or interrupt dispersing butterflies, therefore preventing them from participating in "hill-topping".

- *Changes to local ambient temperature regime*: Hard surfaced roads warm-up through solar radiation during the day. Therefore, the ambient temperature of paved roads will be higher (owing to solar irradiation) than the surrounding habitat that is covered by vegetation. Such temperature gradients are often perceived as dispersal barriers for small invertebrate taxa, making it difficult if not impossible to cross such roads.
- *Changes to the local floristic composition and structure owing to potential changes in storm water management*: Poorly constructed, or designed, storm water infrastructure not only facilitates erosion, but the excess run-off may initiate changes to the floristic composition along the road. Therefore, storm water run-off into the surrounding vegetation is likely to alter the vegetation structure and composition, which could also elicit "barrier" effects in dispersing invertebrates.

Option 1 (either 1a or 1b) is therefore recommended as the most feasible route option for the proposed re-alignment of the R617 from an invertebrate point of view.

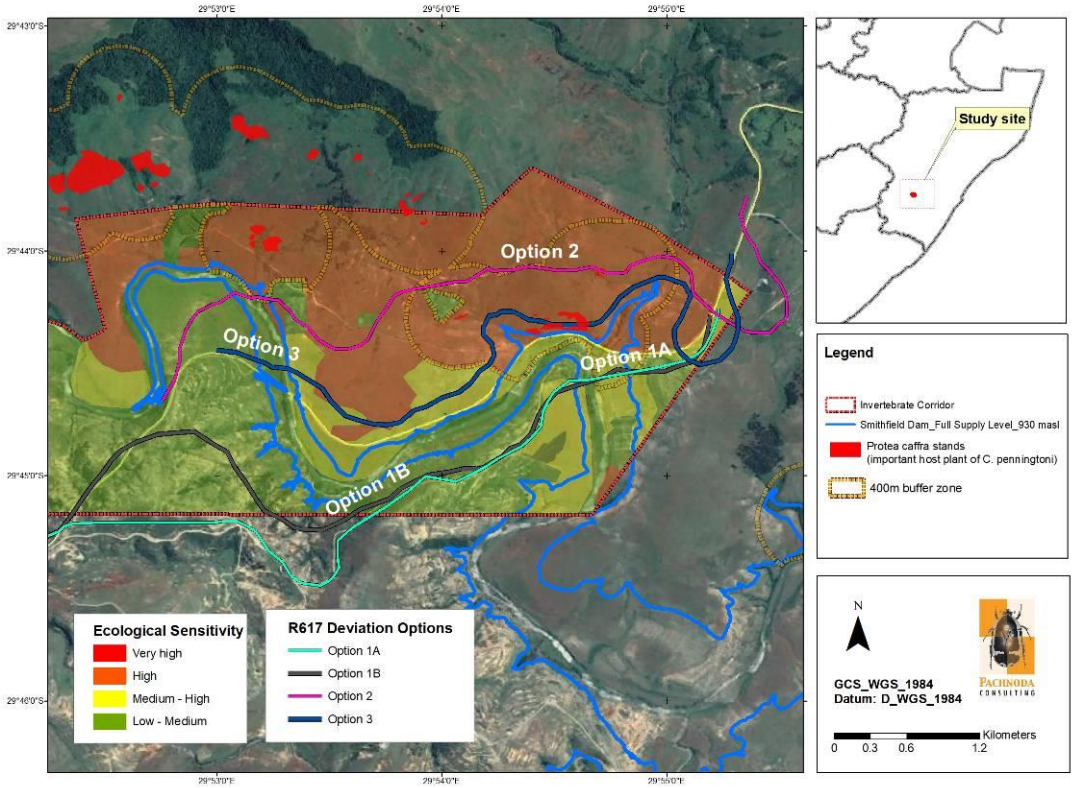

Figure 26: Map illustrating the three proposed R617 realignment options corresponding to the "invertebrate corridor".

5.3.2 Access Road

A gravel access road is planned to provide residents who live/farm within the "invertebrate corridor" access to the R617 (see **Figure 27** below). The potential impacts of this road are considered to be similar to the afore-mentioned discussion pertaining to the deviation of the R617, although the magnitude and severity of the impacts are lower (e.g. the temperature gradient on gravel roads is less intense when compared to hard surfaced roads - see **5.3.1** above). However, the planned access road will traverse through sensitive grassland, including a patch of *Protea* stands. Therefore, construction activities could result in the loss of the *Protea* stands, and the road reserve itself is likely to fragment the *Protea* trees. In addition, stormwater run-off could result in erosion and further deterioration of the grassland habitat in the area. It is also possible that airborn dust during the construction and operation from the road could settle on the *Protea* flower buds, which could impair or deter *C. penningtoni* ovipositing on the *Protea* buds.

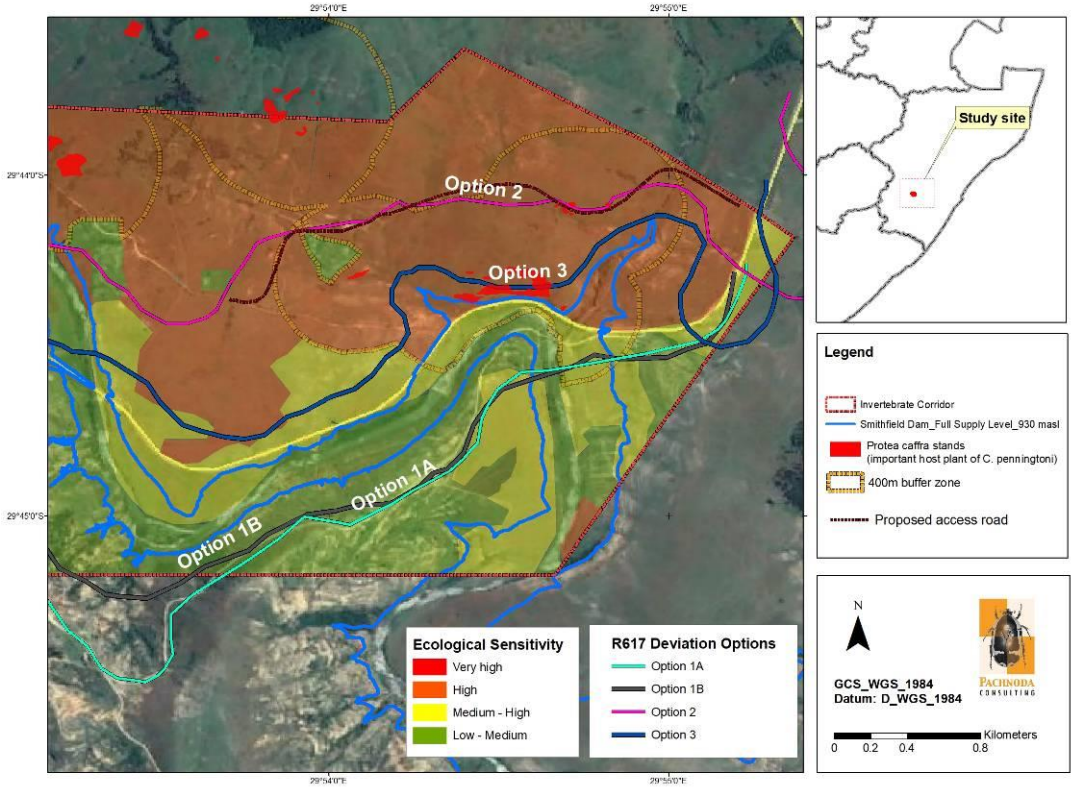

Figure 27: Map illustrating the proposed gravel access road corresponding to the "invertebrate corridor".

Since it is difficult to mitigate the impacts of the gravel access road, besides the implementation of an effective storm water drainage system, it is therefore **strongly recommended** that the alignment of this proposed access road be revised to avoid the dissection of the *Protea* stands. Furthermore, it is proposed that the existing access road be used/retained. This option will, however, require the construction, or

extension, of bridge infrastructure over the proposed Smithfield Dam's basin in order to link up with the deviated R617 as shown on **Figure 28** below.

Another option could be to access the "invertebrate corridor" from the west, thereby crossing the proposed Smithfield Dam's basin by means of a bridge exactly where Option 2 of the proposed R617 deviation crosses the dam basin. From here the gravel access road will mainly traverse through habitat of low sensitivity and will link up with an existing gravel road as shown on **Figure 28** below. The extension of the Impendle Nature Reserve's boundaries southwards to include the "invertebrate corridor" north of the uMkhomazi River is also recommended.

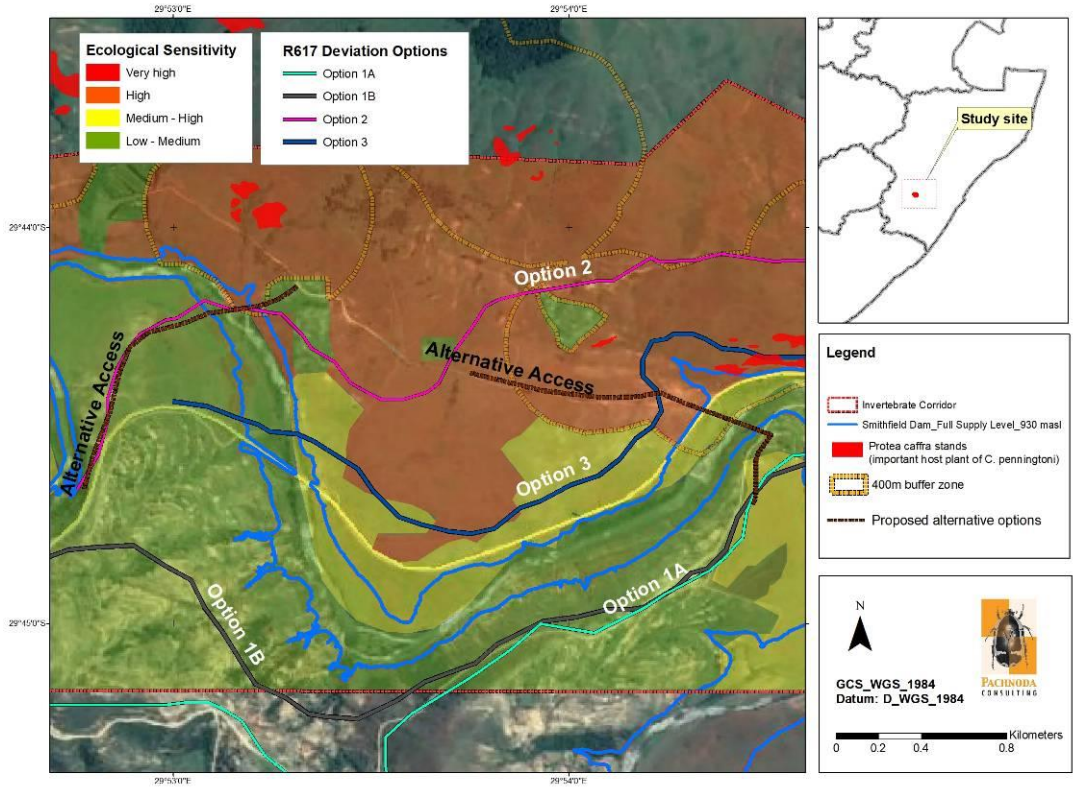

Figure 28: Map illustrating the two alternative proposed access road options.

5.3.3 Loss of Habitat during Inundation: Capys penningtoni

Inundation and rising water levels could potentially result in the loss of *Protea* stands in close proximity to the proposed Smithfield Dam's FSL. Inundation and increased soil moisture over time could result in the drowning and die-back of individual *Protea* trees. According to **Figures 29** and **30** below it is evident that two particular areas of *Protea* trees on the "invertebrate corridor" and on the eastern part of the study area are at risk of drowning. The probability of drowning of *Protea* stands on the eastern part (see **Figure 30** below) is definite since these coincide with the proposed Smithfield Dam's FSL. However, the number of trees associated with these stands is low (consisting of only a few individuals).

Nevertheless, the stand of *Protea* trees as illustrated on **Figure 29** below (corresponding to the "invertebrate corridor") is large and it was also at this particular stand where *C. penningtoni* was observed during September 2017. There is a lower probability that these trees will drown, but the risk of the trees drowning is eminent or high during exceptional flood events when the water levels would exceed the proposed Smithfield Dam's FSL.

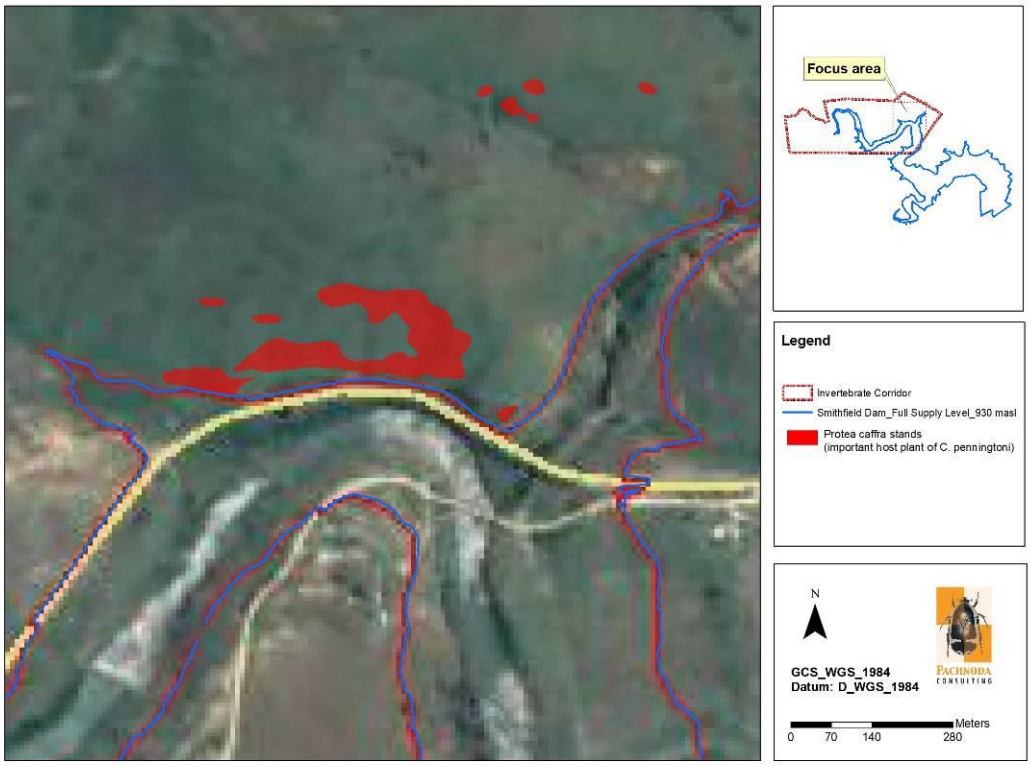

Figure 29: Map illustrating the spatial position of *Protea* stands on the "invertebrate corridor" in close proximity to the FSL of the proposed Smithfield Dam.

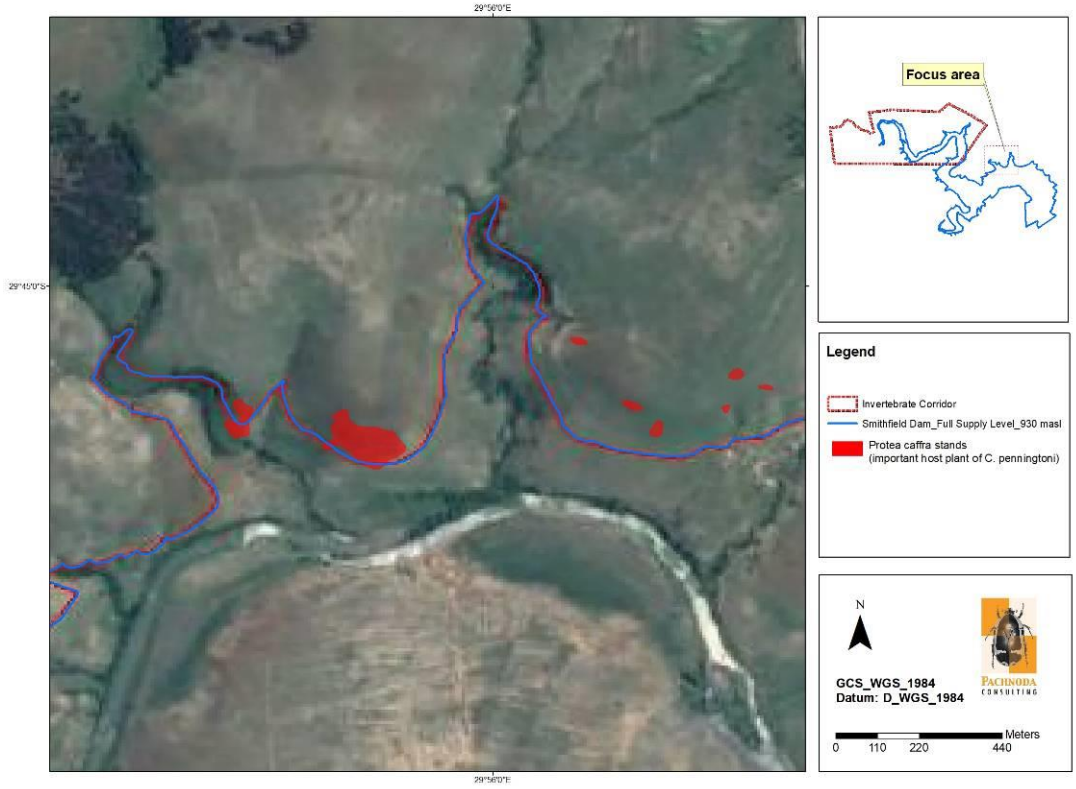

Figure 30: Map illustrating the spatial position of *Protea* stands on the eastern part of the study area corresponding to the FSL of the proposed Smithfield Dam.

It is recommended that:

- Measures should be put into place to prevent accidental flooding or an unexpected rise in water levels above the proposed Smithfield Dam's FSL.
- Lost *Protea* trees due to inundation should be replaced with *ex situ* individuals, either purchased from a nearby nursery (e.g. within 50 km radius of the project area) or reared from seed harvested from individuals occurring within the project area. It is important to maintain the genetic integrity of the *Protea* tree population in the area, whereby the preferred method of sourcing with seed harvesting from the *Proteas* in the area. Furthermore, a Reproductive Plant Biologist should also be consulted when *Protea* plants are reared from the seeds. A Terrestrial Ecologist and preferably also a representative from Ezemvelo KZN Wildlife should be consulted when choosing the localities where the trees should be planted. Implanting should be avoided in areas of untransformed montane grassland since soil disturbances could result in erosion over time.

5.3.4 Loss of Habitat During Inundation: Gnomeskelus fluvialis

Inundation and rising water levels could potentially result in the loss of *G. fluvialis* habitat within the proposed Smithfield Dam's dam basin below the dam's FSL.

Several areas were identified with moderate to high numbers of millipedes that will be inundated by the proposed Smithfield Dam.

Since it is not possible to mitigate against the loss of habitat due to inundation by the proposed Smithfield Dam, it is recommended, as a precautionary principle, to identify habitat holding high numbers of Keeled Millipedes downstream (e.g. Deepdale) and upstream (e.g. Bulwer area) of the proposed dam and incorporate these habitat patches into an offset or conservation area. Furthermore, an extensive collection excursion should also be initiated to search for *G. fluvialis* and other polydesmoid taxa confined to the inundation zone (the proposed Smithfield Dam's dam basin). Collected material could be relocated to other feasible habitat (as a "rescue" attempt), or the material (specimens) could contribute towards a better understanding of the distribution of Keeled Millipedes and the scientific knowledge as well as the taxonomy of Polydesmoid Millipedes. Members of the scientific community and Entomologists with an interest in Diplopoda (in particular the Natal Museum or SANBI) should also be invited to collect material for scientific use.

5.3.5 Other compensatory recommendations

The following recommendations are of a compensatory nature with the intent to promote and/or facilitate *inter alia* butterfly and invertebrate conservation in the area:

- Extent the boundaries of the Impendle Nature Reserve southwards to include the "invertebrate corridor" immediately north of the uMkhomazi River.
- Procure and distribute funds to assist with local (on site), as well as regional monitoring of *Capys penningtoni* as currently undertaken by staff of Ezemvelo KZN Wildlife. Monitoring should also include other known localities of *C. penningtoni,* and should include a geographic area that encompasses the entire known extent of occurrence of *C. penningtoni*. Furthermore, monitoring should also aim to estimate the population size of *C. penningtoni* as well as the size of the sub-population occurring within the project area. Through monitoring the necessary information will also be gained on the ecological requirements of *C. penningtoni,* and to apply adaptive management to veld and grazing regimes in the area.
- Procure and distribute funds to assist with synecological and autecological studies/research on *C. penningtoni* and *Gnomeskelus fluvialis* at a tertiary (e.g. universities) or statutorily level (in liaising with Ezemvelo KZN Wildlife).
- Apply funding to assist with the taxonomic and phylogenetic revision of Polydesmoid Millipedes, in particular the genus *Gnomeskelus*.
- Assist with a strategy and develop an adaptive management guideline for grazing and burning practices in the area with the intent to optimise the ecological condition of the montane grassland. Typical examples would include the development of a comprehensive and practical Grazing Capacity Management Plan and a Fire Management Plan.

6. CONCLUSIONS AND RECOMMENDATIONS

The study area was evaluated in terms of its potential to provide habitat for the endangered butterfly *Capys penningtoni* and the endemic millipede *Gnomeskelus fluvialis*. The potential occurrence for *C. penningtoni* was very high to definite, and it was also recently observed on the study area during another independent survey. *G. fluvialis* was not observed on the study area although the opinion was raised that suitable habitat was present.

The most sensitive butterfly habitat occurred between the Impendle Nature Reserve southwards to the uMkhomazi River, which was regarded as an important habitat component for *C. penningtoni*. It was evident that 35% of the area between the Impendle Nature Reserve southwards to the uMkhomazi River were represented by sensitive habitat (high and very high sensitivity).

The absence of *G. fluvialis* could not be ruled out since it occurred in the area based on historical records, and the fact that potential suitable habitat was present along the uMkhomazi River. The reasons might be that it occurred in low abundances, or that it was naturally rare within its distribution range. Based on the above-mentioned arguments, it was possible that this species could either be overlooked easily and/or highly specialised whereby it might have already declined due to habitat degradation and inappropriate grazing regimes in the area.

In order to mitigate against the impacts of the proposed project infrastructure on the habitat of *C. penningtoni* and *G. fluvialis*, the following recommendations were proposed:

- *Re-alignment of the R617 road*: Three alternative route options were proposed of which Option 1 (either 1a or 1b) was considered as the preferred option from an invertebrate point of view.

- *Access road for residents/farmers living on the "invertebrate corridor*": It was strongly recommended that the alignment of the road be revised to avoid the dissection of the *Protea* stands, thereby retaining the original access which will require the construction or extension of a bridge over the Smithfield Dam's basin in order to link up with the deviated R617. Alternatively, access could be obtained from the western side of the "invertebrate corridor, thereby crossing the proposed Smithfield Dam's basin by means of a bridge and linking with Option 2 of the proposed R617 deviation.

- *Loss of C. penningtoni habitat during inundation*: Lost *Protea* trees due to inundation should be replaced with *ex situ* individuals, either purchased from a nearby nursery or reared from seed harvested from individuals occurring within the project area. It was also recommended to consult a Reproductive Plant Biologist during the propagation process, and a representative from Ezemvelo KZN Wildlife should be consulted when choosing the localities where the trees should be planted.

- *Loss of G. fluvialis habitat during inundation:* As a precautionary principle, all habitat with high numbers of Keeled Millipedes downstream (e.g. Deepdale) and upstream (e.g. Bulwer area) of the proposed dam basin should be identified and incorporated into an offset or conservation area. Furthermore, an extensive collection excursion was proposed to search for *G. fluvialis* and other polydesmoid taxa confined to the inundation zone (the proposed Smithfield Dam's dam basin). Collected material could be relocated to other feasible habitat (as a "rescue" attempt) and part of the material could be donated to museums/taxonomists.

- *Compensatory/offsite mitigation measures*: It was proposed to extent the boundaries of the Impendle Nature Reserve southwards to include the "invertebrate corridor" immediately north of the uMkhomazi River. In addition, funding should be procured to assist Ezemvelo KZN Wildlife with the local (on site), as well as regional monitoring of *Capys penningtoni*. The monitoring should include population size estimates of *C. penningtoni* as well as the size of the sub-population occurring within the project area. Funding should also be procured to assist with synecological and autecological studies/research on *C. penningtoni* and *G. fluvialis* at a tertiary (e.g. universities) or statutorily level (in liaising with Ezemvelo KZN Wildlife). The implementation of a grazing and veld burning programme was also recommended to optimise the ecological condition of the montane grassland.

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7. REFERENCES

1. Ezemvelo KZN Wildlife. 2014. *Harry Gwala Biodiversity Sector Plan, V1.0.* Unpublished Report of Ezemvelo KZN Wildlife, Biodiversity Conservation Planning Division, Ezemvelo KZN Wildlife, P. O. Box 13053, Cascades, Pietermaritzburg.

2. Ezemvelo KZN Wildlife. 2016. *KZN Biodiversity Spatial Planning Terms and Processes, Version 3.3*. Unpublished Report, Biodiversity Spatial Planning and Information Division, Ezemvelo KZN Wildlife, P. O. Box 13053, Cascades, Pietermaritzburg, 3202.

3. GDARD. 2014. GDARD requirements for Biodiversity Assessments. Version 3. Directorate of Nature Conservation: Technological Services

4. Geoterraimage. 2015. The South African National Land cover Dataset. Version 05.

5. Hamer, M.L. 1998. Checklist of Southern African millipedes (Myriapoda: Diplopoda). *Annals of the Natal Museum,* 32: 11-82.

6. International Union for Conservation of Nature. 2018. http://www.iucnredlist.org/

7. Lawrence, R.F. 1953. A revision of the Polydesmoidea (Diplopoda) of Natal and Zululand. *Annals of the Natal Museum*, XII (3): 291-350.

8. Lawrence, R.F. 1958. Contributions to the Myriopoda of Natal and Zululand. *Annals of the Natal Museum*, XIV (2): 279-301.

9. Mecenero, S, Ball, J.B., Edge, D.A., Hamer, M.L., Henning, G.A., Krüger, M., Pringle, E.L., Terblanche, R.F. & Williams, M.C. (Eds.) 2013. *Conservation assessment of butterflies of South Africa, Lesotho and Swaziland*: Red list and atlas. Saftronics (Pty) Ltd., Johannesburg & Animal Demography Unit, Cape Town.

10. Morrison, M.L. 2009. *Restoring Wildlife, ecological concepts and practical applications*. Society for Ecological Restoration International.

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

12. Nemai Consulting. 2016. *Proposed umMkhomazi Water Project Phase 1 Raw Water Component Terrestrial Fauna and Flora Assessment Report.* Authority Reference No: Smithfield Dam - 14/12/16/3/3/3/94. Report prepared for Department of Water and Sanitation.

13. Nemai Consulting. 2017. uMkhomazi Water Project Phase 1 Environmental Impact Assessment. Terms of Reference: Invertebrate Study.

14. New, T.R. 1998. *Invertebrate surveys for Conservation*. Oxford University Press.

15. New, T.R. 2014. *Lepidoptera and Conservation*. John Wiley and Sons.

16. Picker, M. & Griffiths, C. 201. *Alien and Invasive Animals, a South African perspective.* Struik Nature, Cape Town.

17. Pringle, E.L.L., Henning, G.A. & Ball, J.B. 1994. *Pennington's Butterflies of Southern Africa*. Second Edition. Struik Winchester, Cape Town.

18. Samways, M.J. 2005. *Insect diversity conservation*. Cambridge University Press.

19. Samways, M.J., McGeoch, M.A. & New, T.R. 2010. *Insect Conservation. A handbook of approaches and methods*. Oxford University Press.

20. Woodhall, S. 2005. *Field guide to the butterflies of South Africa*. Struik Publishers, Cape Town.

APPENDIX 1: CV OF SPECIALIST.

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Date of Birth:	1974-03-12
Nationality:	South African
Languages:	English and Afrikaans

EDUCATIONAL QUALIFICATIONS

1992	Hoërskool Hartbeespoort, Hartbeespoort - Senior Certificate.
1996	University of Pretoria, Pretoria - B.Sc. (Zoology and Entomology).
1997	University of Pretoria, Pretoria - B.Sc. (Hons) (Entomology).
2001	University of Pretoria, Pretoria - M.Sc. (Restoration Ecology/Zoology).

MEMBERSHIP IN PROFESSIONAL SOCIETY

- Professional Natural Scientist (Pr. Sci. Nat.) (Reg. no. 400095/06)
- BirdLife South Africa
- Hartbeespoort Natural Heritage Society

EXPERIENCE

A. Work conducted in South Africa

1. General Ecological Assessments:

- Belvedere Trust, Proposed retirement village on Amorosa Agricultural Holdings, Roodepoort, Gauteng (2004);
- City of Joburg Property Development Company, Proposed upgrade and development of the Orlando Dam Intersection, Soweto, Gauteng (2004);
- PDNA, Proposed NASREC development, Johannesburg, Gauteng (2004);
- 17 Shaft Conference and Education Centre, Proposed establishment of the Veteran's Heritage Education Centre, Crown Mines, Gauteng (2004);
- GAUTRANS, Proposed re-alignment of Road D781 and construction of a road bridge over the Rietvleispruit, Kempton Park, Gauteng (2004);
- Mr. N. Lang, Ecological Opinion on the proposed establishment of a township, Muldersdrift, Gauteng (2004);
- AGES, Proposed Equestrian Centre, Leeufontein 299 IR, Gauteng (2004);
- PDNA, Proposed new bridge and re-alignment of a portion of provincial road P101-2 (R51), Laversburg, Gauteng (2004);
- Blenneerville Investment (Pty) Ltd, Proposed construction of a residential and commercial development on of Paradiso Estate, Tweefontein 372 JR, Gauteng (2004);
- Les Roches (Pty) Ltd, Proposed zoning of holdings 1, 2 & 3 of Hyde Park Agricultural Holdings, Gauteng (2004);

- Transnet Limited, Terrestrial Faunal Ecological Opinion: Phase 1B expansion of the Sishen-Saldanha Iron ore export corridor, Saldanha Bay, Western Cape (2005);
- Celebration North Riding (Pty) Ltd, Proposed mixed land-use development, North Riding, Gauteng (2005);
- Wilderness Safaris, Proposed upgrade of the Manzengwenya Dive Camp, Greater St. Lucia Wetlands Park, KwaZulu-Natal (2005);
- Wilderness Safaris, Proposed upgrade of the Rocktail Bay Camp, Greater St. Lucia Wetlands Park, KwaZulu-Natal (2005);
- GAEA Projects, Corridor Assessment for the proposed Sibaya Precinct, KwaZulu-Natal (2005);
- Computer Domain Holdings (Pty) Ltd, Red Data Floral Scan on portion 3 of the farm Elandshoek, portions 12 & 27 of the farm Groot Suikerboschkop, and portions 5 & 10 of the farm Palmietfontein, Dullstroom (2005);
- Zong's Property Investments, Proposed establishment of a residential development on a portion of Pomona Estates Agricultural Holdings, Pomona, Gauteng (2005);
- GJ van Zyl Trust, Proposed development of a resort on the Farm Witpoort 216 JS, Mpumalanga (2005);
- Mr. Howard Walker, Proposed subdivision of the Farm Lunsklip 105 JT, and the Farm Morgenzon 122 JT, for the establishment of a private resort, Dullstroom, Mpumalanga (2005);
- Lavender Manor cc, Proposed establishment of a retail, commercial and Lavender Manor Township on part of farm Rietfontein 189 IQ, Muldersdrift, Gauteng (2005);
- Geo Pollution Technologies, Proposed establishment of a residential development: Noordwyk Ext 65 & 80 on Erand Agricultural Holdings, Midrand, Gauteng (2005);
- Mr. A. Le Roux, Proposed Cradle View Country Estate, Muldersdrift, Gauteng (2006);
- Viking Bay Development Company (Pty) Ltd, Proposed Viking Bay freshwater marina and hotel development, Vaal Dam, Gauteng (2006);
- Land for Africa (Pty) Ltd, Ecological Opinion for the proposed establishment of a residential township on holding 122 Erand Agricultural Holding Extension 1, Halfway House, Midrand, Gauteng (2006);
- Brickot Developments cc, Ecological opinion for the proposed Bethal Retirement Village on the remainder of portion 3 of the farm Mooifontein 108 IS, Bethal, Mpumalanga (2006);
- Brawild (Pty) Ltd, Red Data Scan for the proposed Annlin Ex 117, Pretoria, Gauteng (2006);
- Mbombela Local Municipality, Ecological Opinion for the proposed extension of the Lowveld Botanical Gardens, Nelspruit, Mpumalanga (2006);

- Natural Scientific Services cc, Botanical survey for the SASOL Mafutha coal project near Lephalale, Limpopo Province, RSA (2008);
- SRK Consulting, Ecological assessment on Vlakfontein area, NW of Ogies, Mpumalanga. Report compiled in association with EkoInfo (2009); and
- Aurecon, Desktop biodiversity assessment and wetland scan: upgrade of the River View waste water treatment works, eMalahleni, Mpumalanga province. Report compiled in association with Imperata Consulting (2009).
- 2. Mining and Industrial related projects (ecological):
- Lonmin Platinum (Western Platinum Limited), Ecological Assessment for the proposed MK3 Shaft Complex on the farm Wonderkop 400 JQ, Rustenburg, North West Province (2004);
- Impala Platinum Limited, Ecological Assessment for prospecting SEMPs on the farms Buffelshoek 386 KT, Kalkfontein 367 KT, Spitskop 333 KT, Steelpoortpark 366 Kt and Tweefontein 360 KT and Hackney 116 KT (all Sekhukhuneland), Mpumalanga and Limpopo Province (2004);
- Trans-Caledon Tunnel Authority (TCTA), Ecological Assessment for borrow pit SEMPs on the TCTA pipeline, Vaal Marina to Secunda (2005);
- Boynton Platinum (Pty) Ltd, Ecological Assessment for the proposed establishment of platinum mines on the farms Tuschenkomst 135 JP, Witkleifontein 136 JP and Ruighoek 169 JP, North West Province (2005);
- Impala Platinum Holdings, Ecological Assessment for prospecting SEMPs on the Impala Platinum Bafokeng Mining Complex, North West Province (2005);
- Ceramic Industries Limited, Ecological Assessment of the Rietspruit Clay Quarries, Vanderbijlpark, Gauteng (2005);
- Ekurhuleni Metropolitan Municipality, Ecological Assessment Report for the proposed GLB Landfill Site on the farm Zesfontein 27 IR, Benoni, Gauteng (peer reviewed, 2006);
- Ceramic Industries Limited, Ecological Assessment of the Leeukuil Clay Quarries, Vanderbijlpark, Gauteng (2006);
- Council for Geoscience, Habitat sensitivity assessment scoping report for Bon Accord quarry on a portion of the farm de Onderstepoort 300-JR, Tshwane, Gauteng (2007);
- Fraser Alexander, Biodiversity action plan for Lonmin Limpopo & Platinum, North West & Limpopo Province, RSA (2008-2009);
- Envirolution Consulting (Pty) Ltd., Ecological screening report and site selection process for an Eskom general landfill and hazardous waste storage facility near Lephalale, Limpopo Province, RSA (2009);
- Envirolution Consulting (Pty) Ltd., Ecological assessment for the proposed construction of an Eskom general landfill and hazardous waste storage facility at the Matimba Power Station, Limpopo Province, RSA (2009);

- Shangoni/Vergenoeg Mining Company, Ecological assessment for the proposed construction of a slurry pipeline and waste rock dump at the Vergenoeg Mine, Gauteng (2011);

- ENVASS, An ecological evaluation (vertebrate & avifaunal component) for the proposed alternative energy plant on Portion 3, 4 & 5 of the Farm Groenwater 453, Northern cape (2012); and

- ENVASS, Ecological evaluation (vertebrate & avifaunal component) for the proposed alternative energy plant on !xun & khwe, Northern cape (2012).

3. Avifaunal and Invertebrate Assessments:

- Lavender Manor cc, Red Data Bird Assessment for the proposed establishment of a retail, commercial and Lavender Manor Township on part of the farm Rietfontein 189 IQ, Muldersdrift, Gauteng (2004);

- Helga Schneider & Associates, Avifaunal & Invertebrate Red Data Assessment for the proposed rezoning & subdivision on Erf 6486 Orange Farm Ext 2, Johannesburg, Gauteng (2005);

- TOWNDEV, Avifaunal and Arachnid Assessment for the proposed subdivision of Grootfontein 349 JR, Rievlei Dam, Gauteng (2006);

- Prof. Van Rensburg, Red Data Invertebrate Scan for the proposed Rietvalleirand Extension 59, Gauteng (2006);

- Group Five Property Development, Invertebrate Assessment for the proposed Buccleuch Ex 1, Gauteng (2006);

- Zong's Property Investments, Avifaunal and *Metisella meninx* assessment for the establishment of a residential development on a portion of Pomona Estates Agricultural Holdings, Pomona, Gauteng (2006);

- Waterval Islamic Institute, Avifaunal and Invertebrate Assessment for the proposed Northern Golf Course Development, Midrand, Gauteng (2006);

- Ekurhuleni Metropolitan Municipality, Avifaunal & Invertebrate Red Data Assessment for the proposed low-cost housing development on Olifantsfontein 410 JR, Gauteng (2006);

- City of Tshwane Metropolitan Municipality, Invertebrate Red Data Scan for the proposed flood remediation and river upgrade at Soshanguve, Gauteng (2006);

- AGES, Invertebrate assessment for the proposed mining activities on the farm Thorncliffe 374 KT, Xstrata Eastern Mines, Mpumalanga (2007)

- AGES, Mammal and invertebrate assessment for the proposed Kalplats project, Stella, North West Province (2007)

- Exigent Engineering Consultants, Invertebrate assessment for the proposed Derdepoort X 11, Derdepoort, Gauteng (2007);

- Exigent Engineering Consultants, Invertebrate and Avifaunal scan for the proposed Cutty Sark hotel extension, Scottburgh, Kwazulu-Natal (2007);

- Strategic Environmental Focus, African Grass Owl assessment on the proposed Cradle View country estate on portion 60 of the farm Driefontein 179 IQ, Muldersdrift, Gauteng (2007);

- GEOLAB, Ecological assessment for the West Rand Gold Operations (WERGO) Witfontein tailings disposal facility, Mintails, Gauteng, RSA (2008);

- Coastal Environmental Services, Avifaunal Assessment for the proposed mining of heavy minerals at Port Durnford (Exxaro KZN-Sands), KwaZulu-Natal (2008);

- SRK & Natural Scientific Services cc, A feasibility study for the mining of coal north of the Limpopo Province. Avifaunal & invertebrate assessment, Rio Tinto Exploration, Limpopo Province, RSA (2009);

- Eskom/Baagi Environmental, An environmental management plan (avifaunal & faunal component) for the proposed Dinaledi - Spitskop 400 kV transmission line, North West Province (2010);

- Eskom/Baagi Environmental, An avifaunal impact report for the proposed 400 kV Ariadne-Venus transmission line between Estcourt and Pietermaritzburg, KwaZulu-Natal (2010);

- Eskom/Baagi Environmental, An avifaunal impact assessment report for a 275 kV power line between the substations of Glockner and Kookfontein, Vanderbijlpark, Gauteng (2010);

- Groundwater Consulting Services (Pty) Ltd/EkoInfo, An invertebrate and avifaunal specialist report for the proposed expansion of Exxaro's Glisa coal mine, Belfast, Mpumalanga (2010);

- Eskom/Baagi Environmental, An environmental management plan (avifauna component) for the proposed 400 kV Medupi-Massa transmission lines, Limpopo Province (2011);

- Eskom/Baagi Environmental, An avifaunal and fauna impact assessment report for the proposed 400 kV Arnott-Gumeni transmission line, Mpumalanga Province (2012);

- Eskom/Baagi Environmental, An environmental management plan (avifaunal component) for the proposed 400 kV Ngwedi transmission line and substation, North West Province (2012);

- Exxaro/EkoInfo, An avifaunal and invertebrate assessment (as part of a Biodiversity Assessment and action plan) for the Gravelotte MagVanTi Mining Area, Limpopo Province (2012);

- Groundwater Consulting Services (Pty) Ltd/EkoInfo, An invertebrate and avifaunal specialist report for the proposed Paardeplaats coal mine area, Belfast, Mpumalanga (2012);

- Groundwater Consulting Services (Pty) Ltd/EkoInfo, An invertebrate and avifaunal specialist report for the proposed Leeuwpan coal mine area, Belfast, Mpumalanga (2013);

- Eskom/Baagi Environmental, An environmental management plan (avifaunal component) for the proposed Medupi - Borutho 400 kV transmission line, Limpopo Province (2012);

- Eskom/Baagi Environmental, An environmental management plan (avifaunal component) for the proposed Gromis - Oranjemund 400 kV transmission line, Northern Cape (2013);

4. Other Assessments:

- Facilitation, project management and conduction of environmental scoping exercises, Environmental Impact Assessments, Environmental Management Plans, Feasibility Reports, for a range of projects and issues such as:
    - Housing Projects (West Rand Housing Projects) for the Gauteng Department of Housing;
    - Planning and facilitation of environmental awareness workshops (Winterveldt Workshops for the Department of Environmental Affairs and Tourism);
    - Compilation and evaluation of EIA reports and Environmental Management Plans (EMPs) for both the private and public sector (e.g. Scoping Report for the relocation of oxidation ponds for the Moqhaka Local Municipality and the installation of an underground additive tank for Sasol Oil (Pty) Ltd).
    - Urban Renewal Projects: Bekkersdal Urban Renewal Project and the Greater Evaton Urban Renewal Project for the Gauteng Department of Housing.
- Douglas Collieries (Inkwe Collieries), Biodiversity Assessment and database compilation of the Douglas Collieries (2005);
- Orion Group, Ecological Sensitivity Map for the proposed golf course and related facilities, Mont-Aux-Sources (2005);
- City of Joburg Property Development Company, Specialist *Lepidium mossii* assessment for the proposed upgrade and development of the Orlando Dam intersection, Soweto, Gauteng (2005);
- Johannesburg Roads Agency, Alien Eradication and Rehabilitation Programme for the proposed upgrade of 14th Avenue, Randburg, Gauteng (2006);
- City of Joburg Property Development Company, Ecological Management Plan for the Orlando Dam intersection, Soweto, Gauteng (2006);
- GJ van Zyl Trust, Alien Eradication Programme for the proposed development of a resort on the Farm Witpoort 216 JS, Mpumalanga (2006);
- GJ van Zyl Trust, Fire Management Plan for the proposed development of a resort on the Farm Witpoort 216 JS, Mpumalanga (2006); and

  Khutala Collieries (Inkwe Collieries), Biodiversity Assessment and database compilation (2006)

5. Linear Assessments:

- Johannesburg Roads Agency, Ecological Assessment for the Proposed upgrade of 14th Avenue, Randburg, Gauteng (2004).
- Trans-Caledon Tunnel Authority (TCTA), Proposed Vaal River Eastern Sub-Augmentation (VRESAP) pipeline from Vaal Marina to Secunda (2005);
- PBA International (in association with Bathusi EC), Ecological Scoping Report for the proposed Eskom Delta-Epsilon 765 kV Transmission lines (2007);
- Bohlweki Environmental (in association with Bathusi EC), Ecological Scoping Report for the proposed Eskom Malelane-Boulders 132 kV Distribution line (2007);
- Bohlweki Environmental (in association with Bathusi EC), Ecological Scoping Report for the proposed Eskom Marathon-Delta 132 kV Distribution line (2007);

- Strategic Environmental Focus, Avifaunal EIA Report for the proposed Eskom Hendrina-Prairie-Marathon 400 kV Transmission line, Mpumalanga (2007);
- Natural Scientific Services cc, Botanical survey for the proposed upgrade of the Transnet railway line between Hotazel, Northern Cape and the Port of Ngqura, Eastern Cape, RSA (2008);
- Envirolution Consulting (Pty) Ltd, Ecological Report for the proposed Eskom Apollo-Lepini 400kV transmission line (2009);
- Arcus Gibb, An ecological investigation for the Tumelo 132 kV distribution line and power line near Kagiso, Gauteng (2010);
- Ekoinfo/SANRAL, Faunal investigation for the upgrade of the N3 highway (2011); and
- Aurecon (Pty) Ltd, Baseline vegetation survey for the Mokolo – Crocodile River Augmentation Project (MCWAP) pipeline from Mokolo Dam to Thabazimbi (2011).

B. Work Conducted in other African countries:

- Rural Maintenance, Invertebrate study for four mini-hydroelectric generation plants, Northern Malawi, Africa (2010);
- Impacto, An avifaunal study (Phase 1) for the proposed Mpanda Nkwua Dam in the Zambezi River, Mozambique, Tete Province (2010);
- Conseil Régional des Pays de la Loire, An avifaunal investigation of the Rusizi and Ruvubu National Parks (Burundi), and the feasibility of establishing an avi-tourism network with specific emphasis on the protection of important flyways used by Palearctic birds - of - prey (2010);
- Impacto, An avifaunal study (Phase 2) for the proposed Mpanda Nkwua Dam in the Zambezi River, Mozambique, Tete Province (2011);
- Rural Maintenance, Invertebrate scan for the expansion of coal mining activities at Kayelekera, Northern Malawi, Africa (2011);
- Rural Maintenance, Invertebrate study for a mini-hydroelectric plant at the Chisanga Falls, Nyika National Park, Malawi (2011);
- Impacto/ERM/Enviro-Insight, Avifaunal investigation for the proposed Ncondezi Coal Mine, Tete Province, Mozambique (2011);
- Enviro-Insight, Avifaunal investigation for the Riversdale Coal Mine complex, Tete Province, Monzambique (2011);
- Anadarko Petroleum/ERM/Enviro-Insight, Avifaunal investigation for the proposed Anadarko Mozambique Area 1 Liquefied Natural Gas plant in northern Mozambique, Cabo Delgado Province, Mozambique (2012);
- Coffey Environments/EkoInfo, Avifaunal investigation for the mining of iron ore by Baobab Resources, Tete Province, Mozambique (a scoping-level assessment); and
- SRK/Flora, Fauna and Man Ecological Services, An avifaunal and invertebrate assessment for the establishment of a potash mine at Konkoati, Republic of the Congo (2012);
- China Union/ERM/Enviro-Insight, Avifaunal investigation for the proposed mining of iron ore in Bong County, Liberia (2012);
- SRK/Flora, Fauna and Man Ecological Services, An invertebrate assessment for the mining of iron ore by DMC Congo Mining/Exxaro at Mayoko, Republic of the Congo (2012);

- Western Cluster/ERM/Enviro-Insight, Avifaunal investigation for the proposed mining of iron ore at Bomi Hills, ,Bomi County, Liberia (2013);
- SRK/Flora, Fauna and Man Ecological Services, An invertebrate assessment for the establishment of an ecological offset for the DMC Congo Mining/Exxaro Iron Ore Mine at Mayoko, Republic of the Congo (2013);
- Western Cluster/ERM/Enviro-Insight, Avifaunal investigation for the proposed mining of iron ore at Bea Mountain, Grand Cape Mount County, Liberia (2013);
- Western Cluster/ERM/Enviro-Insight, Avifaunal investigation for the proposed mining of iron ore at Mano River, Grand Cape Mount County, Liberia (2013); and
- WSP/Flora, Fauna and Man Ecological Services, An invertebrate assessment for the establishment of a phosphate mine, Hinda Phosphate Project, Republic of the Congo (current); and
- Aureus Mine/Enviro-Insight, An avifaunal investigation for the proposed mining of gold at the New Liberty Gold Mine, Liberia (current)

C. Additional Experience:

- Monitoring and evaluation of the rehabilitation programme for the mining company Richards Bay Minerals (RBM) with special reference to vegetation, bird, small mammal and millipede assemblages.
- Other responsibilities include assessment of the ecological standard operating procedures (SOP) according to RBM's environmental management programme in compliance with ISO 14001 environmental standards accreditation process.
- Participated in the annual relief programme on the S.A Agulhas voyage to Sub-antarctic Marion Island (Prins Edward group). Took part in the research to estimate the population dynamics and demography of the alien house mouse (*Mus musculus*) on the island (under supervision of the University of Pretoria).
- Participated in the preparation of a conservation management plan for a game and trout farm in conjunction with Mpumalanga Parks Board (in charge of the bird section) for the farm Nu-Scotland Bavaria.
- Lead a successful professional bird tour (party of 12) to the Eastern Zimbabwean highlands and adjacent Mashonaland Plato (10 days).
- Lead a successful professional bird tour (party of 9) to the Cape Peninsula, Karoo and West Coast (10 days).
- Lead a successful professional bird tour (party of 12) to the Swaziland and Northern Zululand (10 days).
- Lead a successful professional bird tour (party of 15) to the Namibia (10 days).
- Lead a successful professional bird tour (party of 14) to the Eastern Drakensberg and Lesotho (10 days).

EMPLOYMENT HISTORY:

March 2007 – Current: of Director of Pachnoda Consulting cc

2004- January 2007: Strategic Environmental Focus (Pty) - Terrestrial Ecologist

2003 – 2004: Enviro-Afrik (Pty) Ltd– Environmental Consultant

2001 – 2003: University of Pretoria - Research Assistant

PUBLICATIONS:

- McEWAN, K.L., ALEXANDER, G.J., NIEMAND, L.J. & BREDIN, I.P. 2007. The effect of land transformation on diversity and abundance of reptiles. Paper presented at the 50th Anniversary Conference of the Zoological Society of Southern Africa.
- NIEMAND, L. 1997. Distribution and consumption of a rust fungus *Ravenelia macowaniana* by micro-lepidopteran larvae across an urban gradient: spatial autocorrelation and impact assessment. Hons publication, University of Pretoria, Pretoria
- NIEMAND, L. 2001. The contribution of the bird community of the regenerating coastal dunes at Richards Bay to regional diversity. MSc Thesis, University of Pretoria, Pretoria.
- VAN AARDE, R.J., WASSENAAR, T.D., NIEMAND, L., KNOWLES, T., FERREIRA, S. 2004. Coastal dune forest rehabilitation: a case study on small mammal and bird assemblages in northern KwaZulu-Natal, South Africa. In: Martínez, M.L. & Psuty, N. (Eds.) *Coastal sand dunes: Ecology and Restoration*. Springer-Verlag, Heidelberg.
- VAN AARDE, R., DELPORT, J. & NIEMAND, L. 1999. Of frogs and men. *Mechanical Technology,* June: 32-33.
- VAN AARDE, R., DELPORT, J. & NIEMAND, L. 1999. Gone Frogging. *Getaway,* January: 80-83.

PRESENTATIONS:

- Co-presenter at the Wetland Training Course (30 July – 3 August 2007) entitled: “Wetland-associated fauna”. University of Pretoria, Pretoria.
- Co-presenter and lecturer of the pre-conference training course (entitled "Can rehabilitation contribute towards biodiversity?") at the 3rd Annual LaRSSA (Land Rehabilitation Society of Southern Africa) Conference (8-11 September 2015), Glenburn Lodge, Muldersdrift, Gauteng.