Species sensitivity to acidification in highly endemic regions of South Africa

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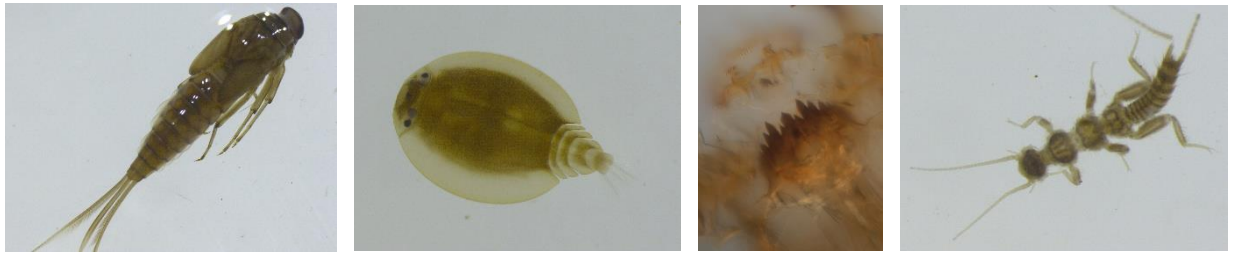

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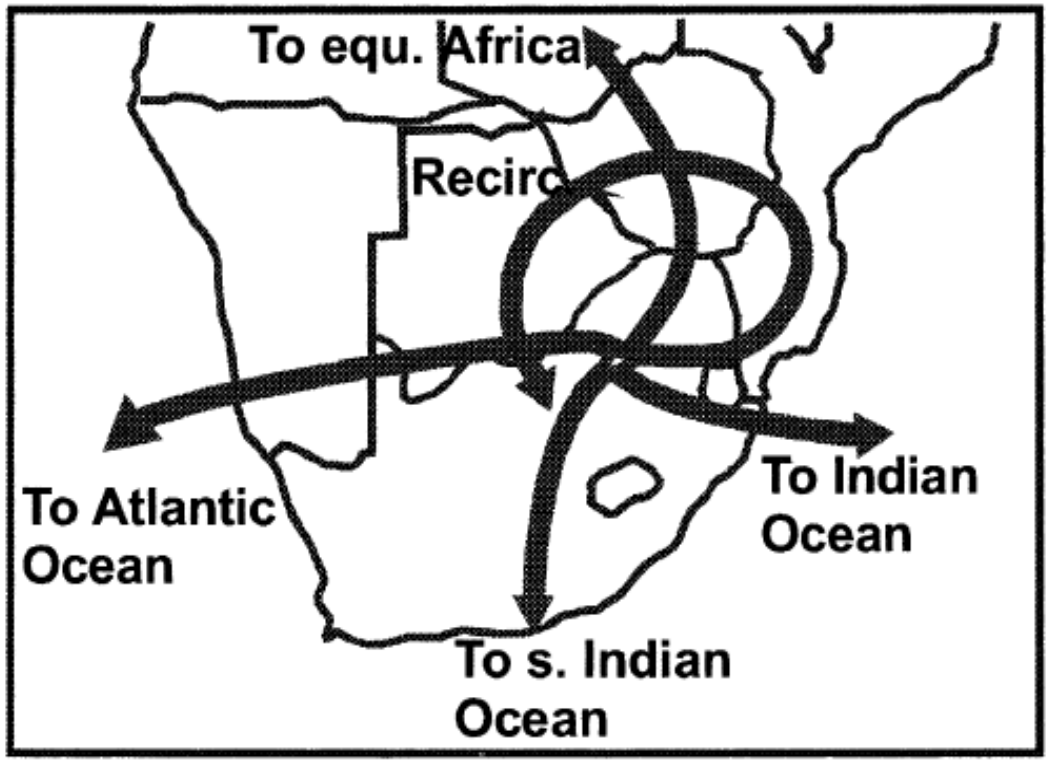
Introduction

- South Africa is a major consumer of coal and is among the twenty most carbon intensive economies in the world
- About 74% of the countries energy demand is met by coal resources
- Pressure on the energy sector over the past 18 years
  - Increase energy demands
    - economic growth
    - Free Basic Energy Policy (1998)
- Two new coal power stations (4 800 MW)
- 16 coal power stations and 75% of these are concentrated in the Highveld (HV) region of South Africa


Matimba power station (Limpopo)


Medupi power station (Limpopo)

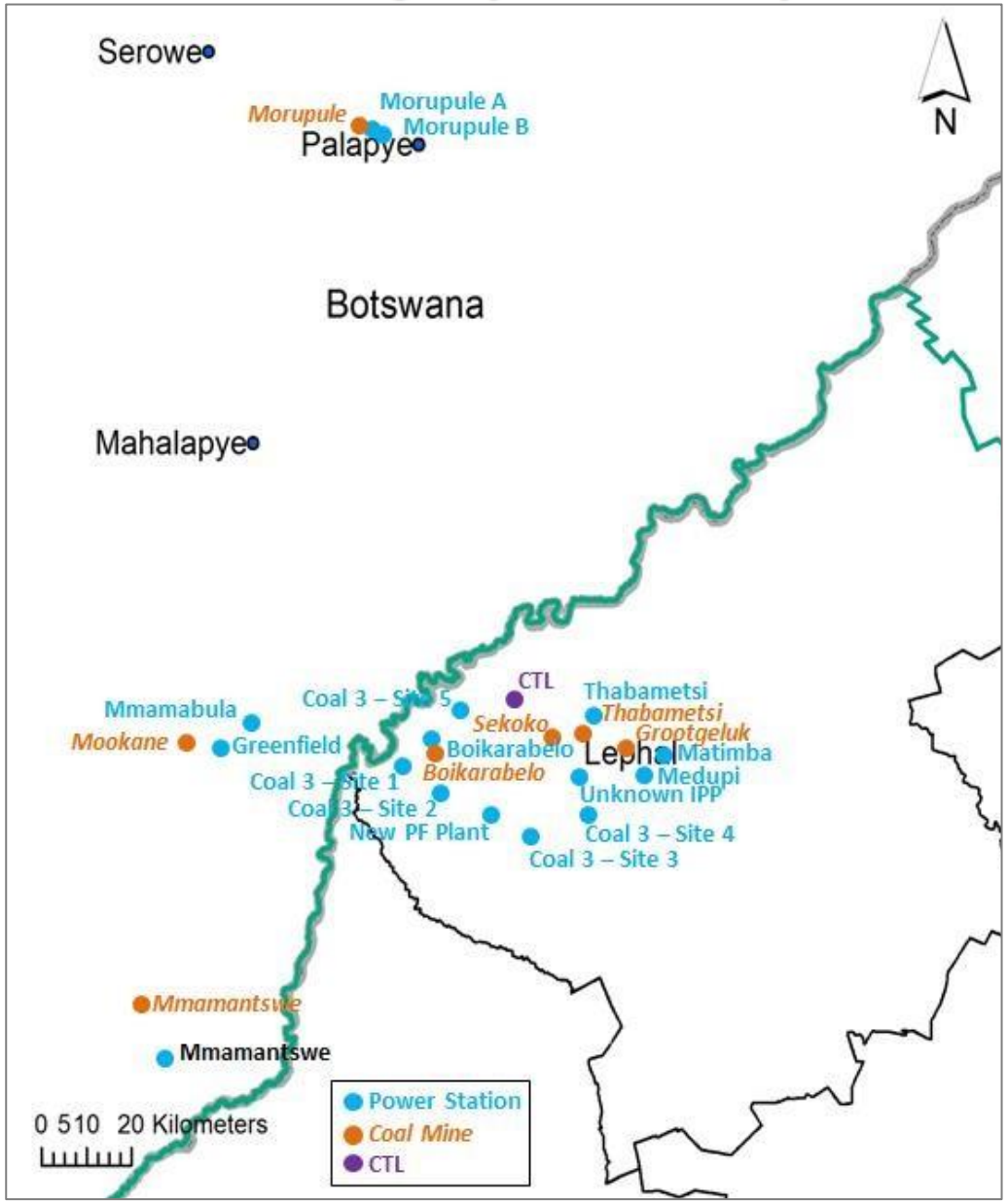
Main pathways transporting air in and out of the Highveld



Abbreviations: South (s.), Equatorial (equ.) and Recirculated (Recirc.)

Source: Freiman, M. T. and Piketh, S.J. (2003) Air transportation into and out of the industrial Highveld Region of South Africa. American Meteorological Society 42.

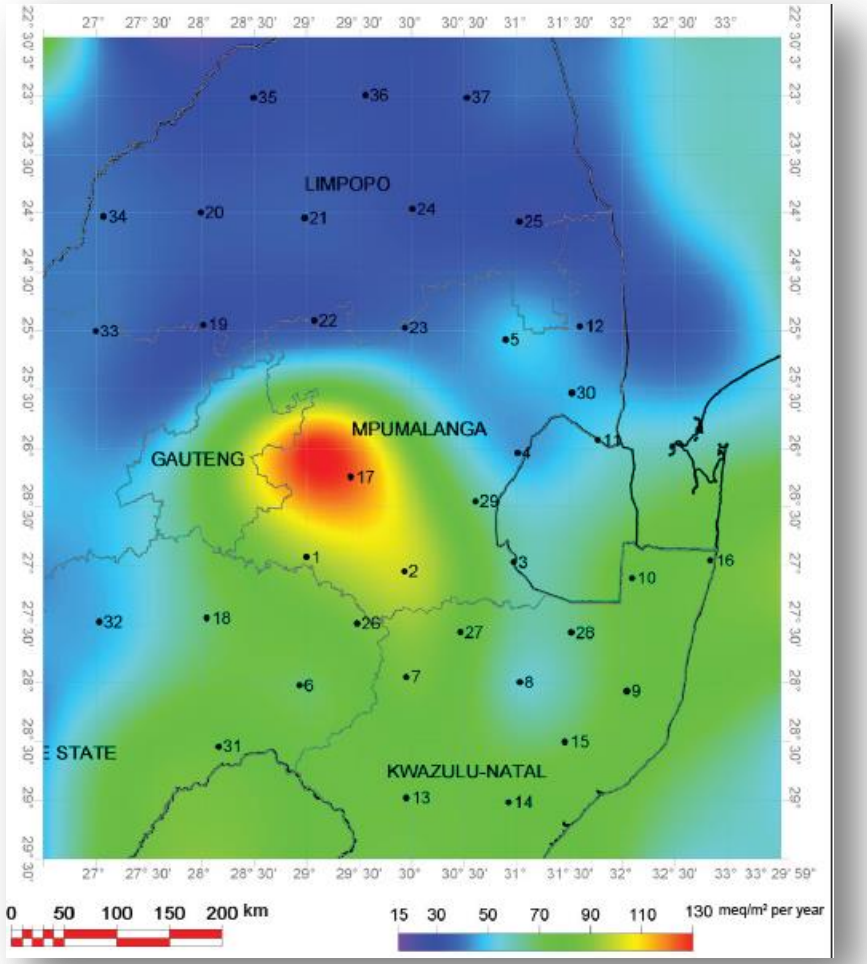
The Waterberg-Bojanala Priority Area



Source: DEA, 2014. Waterberg-Bojanala Priority Area Air Quality Management plan- Threat Assessment, December 2014

Relative locations of the proposed energy-based and mining projects are indicated in blue and brown respectively while the proposed location for the coal-to-liquid (CTL) plant is shown in purple.

Total dry and wet acid deposition rate (meq/m²/year)



Source: Josipovic, M., Annegarn, H.J., Kneen, M.A., Pienaar, J.J. and Piketh, S.J. (2011) Atmospheric dry and wet deposition of sulphur and nitrogen species and assessment of critical loads of acidic deposition exceedance in South Africa. South African Journal of Science 107, 01-10.

Key Hypothesis

- Current levels of acid deposition exceed the critical load for acidification of acid sensitive streams
- Future point sources of S and N deposition pose a threat in acid loading to sensitive streams
- Anticipate climate change will exacerbate present-day acidification state

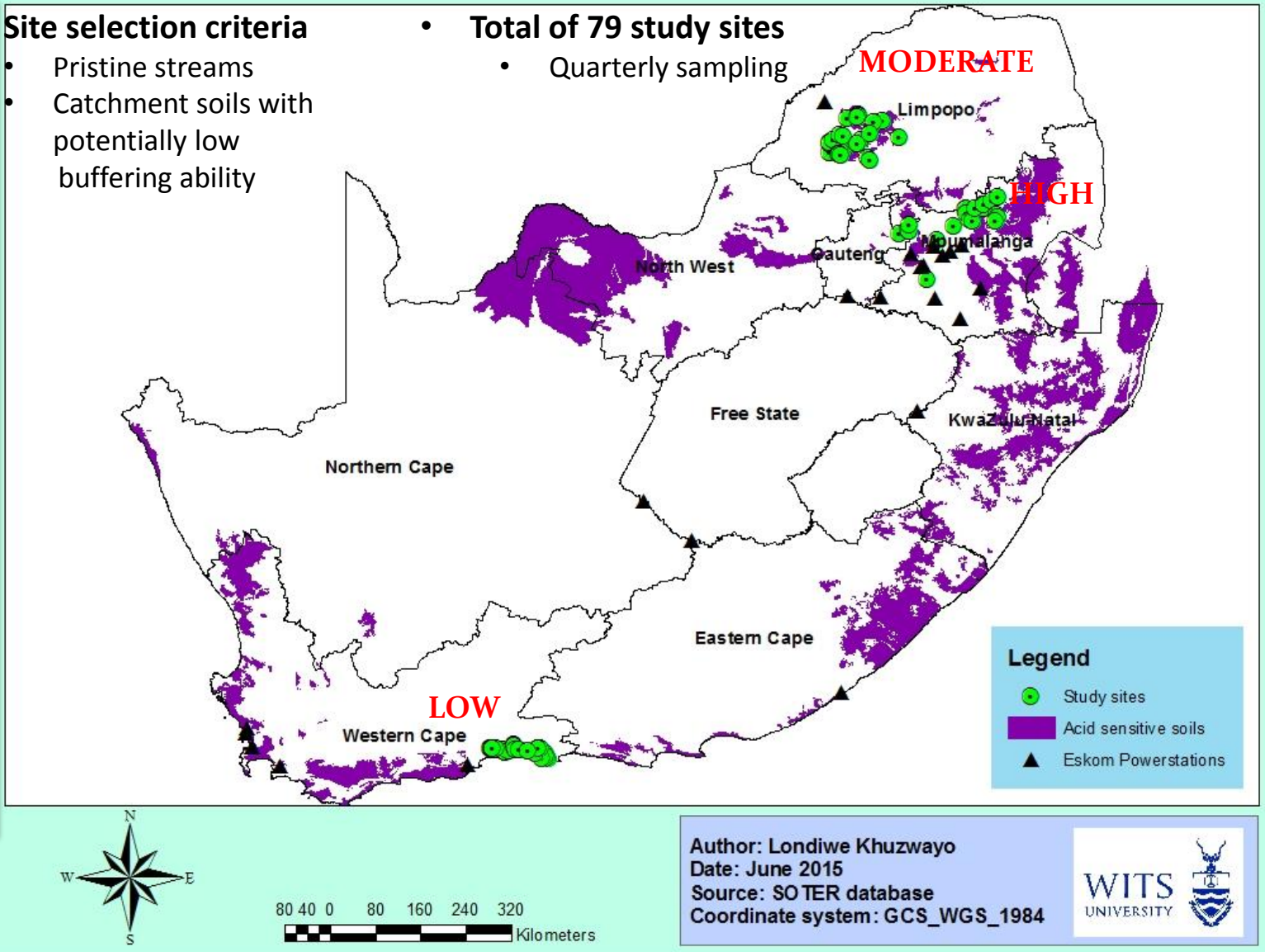
The aim of this study was to investigate differences in the aquatic ecosystem related to acidification by looking at water chemistry and macroinvertebrates.

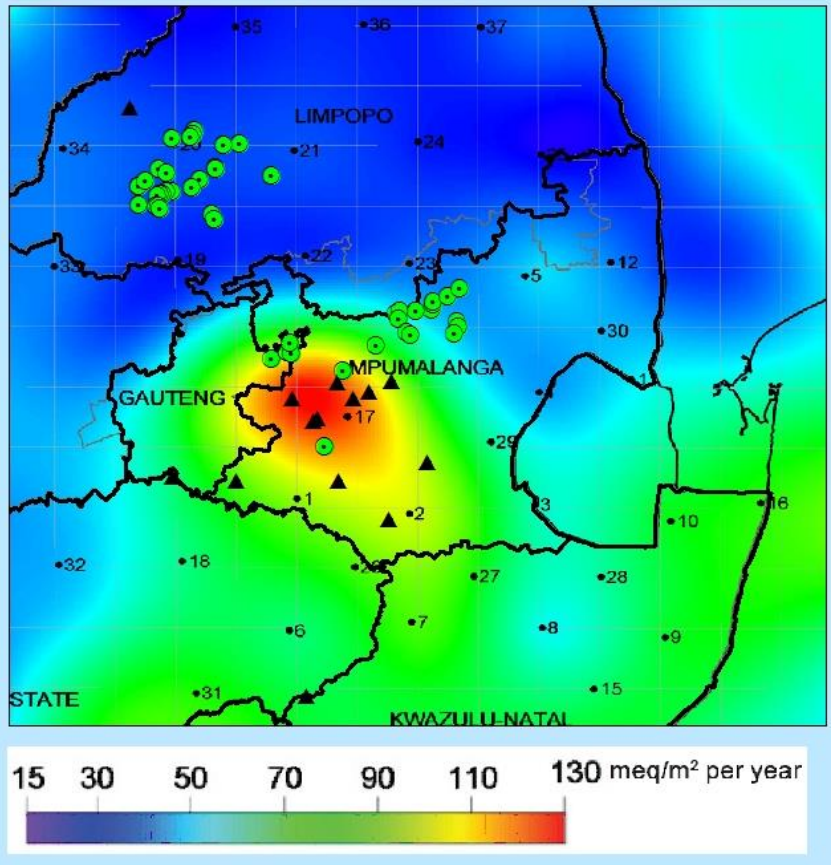
Study Regions

Site selection criteria

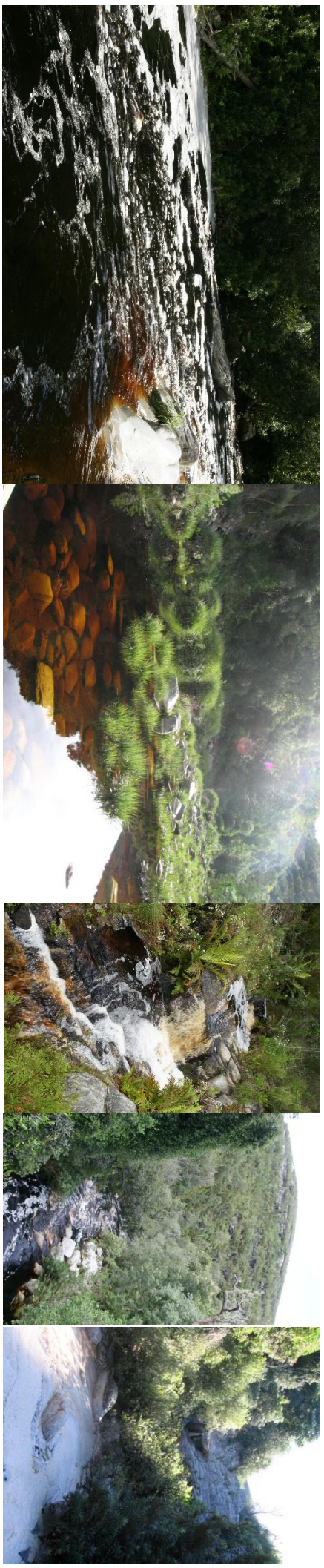
- Pristine streams
- Catchment soils with potentially low buffering ability

- **Total of 79 study sites**
  - Quarterly sampling



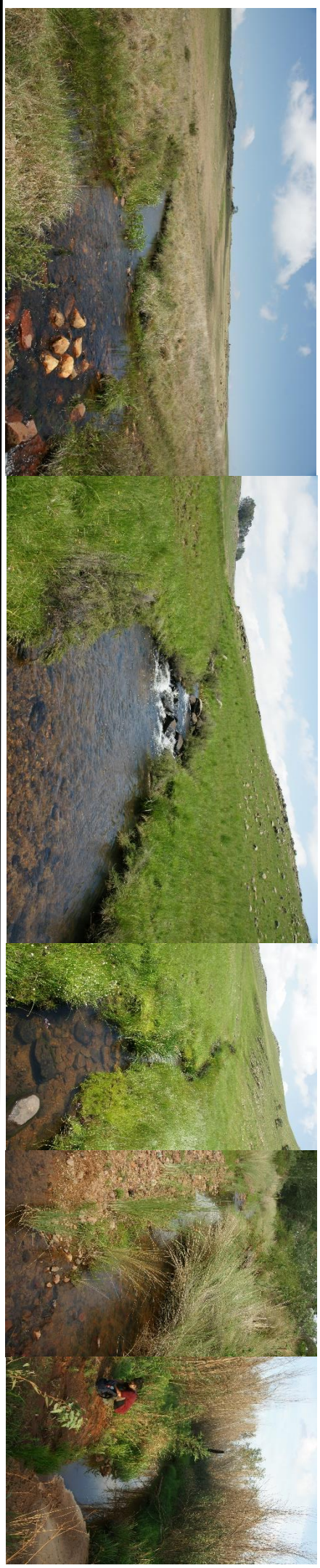


South-western Cape (SWC)



Waterberg (WB)

Highveld (HV)



Methods

- Biotope – Stoney riffle
- SASS5 net (1mm mesh with 30cm square frame
- Kick sampling (2mins)

Preserved in 70% Ethanol

Sample emptied into a tray.
Individual species picked
Out and analysed under the microscope

Key focus groups

- Order
  - Ephemeroptera (Mayflies)
    - Baetidae
    - Caenidae
    - Heptageniidae
    - Leptophlebiidae
    - Oligoneuriidae
    - Prosopistomatidae
    - Teloganodidae
    - Tricorythidae
  - Diptera (Trueflies)
    - Simuliidae (Blackflies)
    - Chironomids (Non-biting midges)
  - Plecoptera (Stoneflies) - One of the key indicator sp. for clean / non-polluted waters in South Africa

Trichoptera (Caddisflies)

Distribution of some Mayfly species across all three study regions

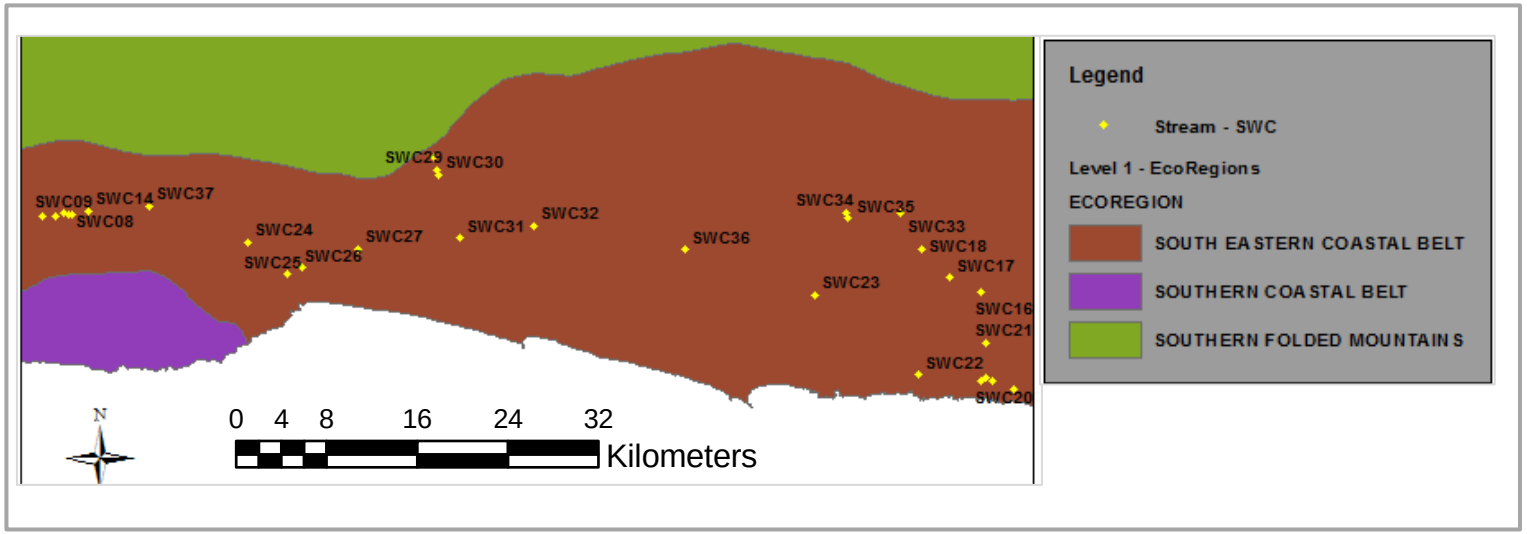
Order	Family	*Genus/ species name*	South-western Cape	Waterberg	Highveld
Ephemeroptera	Tricorythidae	*Tricorythus reticulatus*			
	Leptophlebiidae	*Adenophlebia auriculata*			
		Adenophlebiodes bicolor			
		Aprionyx intermedius			
		Castonophlebia calida			
		Choroterpes			
		Euthraulus sp.			
	Baetidae	*Acanthiops varius*			
		Afroptilum sudafricanum			
		Baetis harrisoni			
		Baetis sp. (Unknown)			
		Bugilliesia margaretae			
		Cheleocloeon excisum			
		Cheleocloeon sp. (unknown)			
		Cloeodes sp. (unknown)			
		Cloeon sp. (unknown)			
		Crassabwa flava			
		Dabulamanzia indusii			
		Demoreptus capensis			
		Demoreptus monticola			
		Demoreptus sp. (unknown)			
		Demoulinia crassi			
		Labiobaetis vinosus			
		Pseudocloeon glaucum			
		Pseudocloeon latum			
		Pseudocloeon piscis			
		Pseudocloeon sp. (unknown)			
		Pseudopannata maculosa			
		Susua sp. (unknown)			

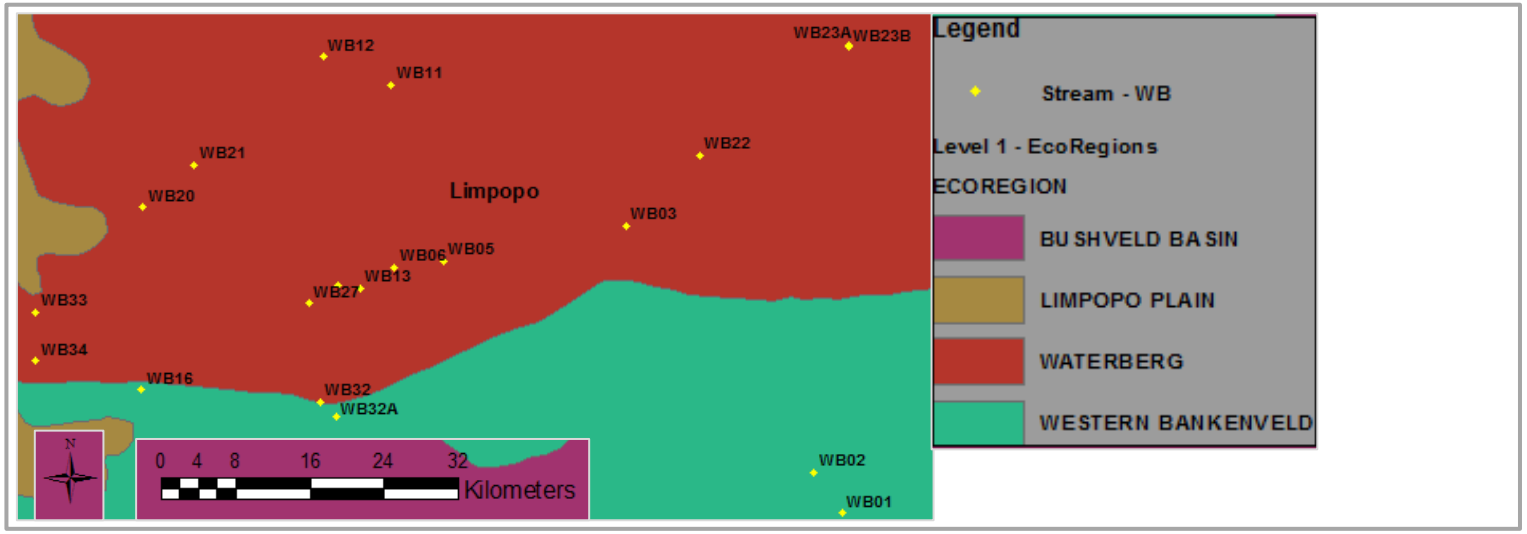
Present Found in 70% or more sites sampled in that region / season

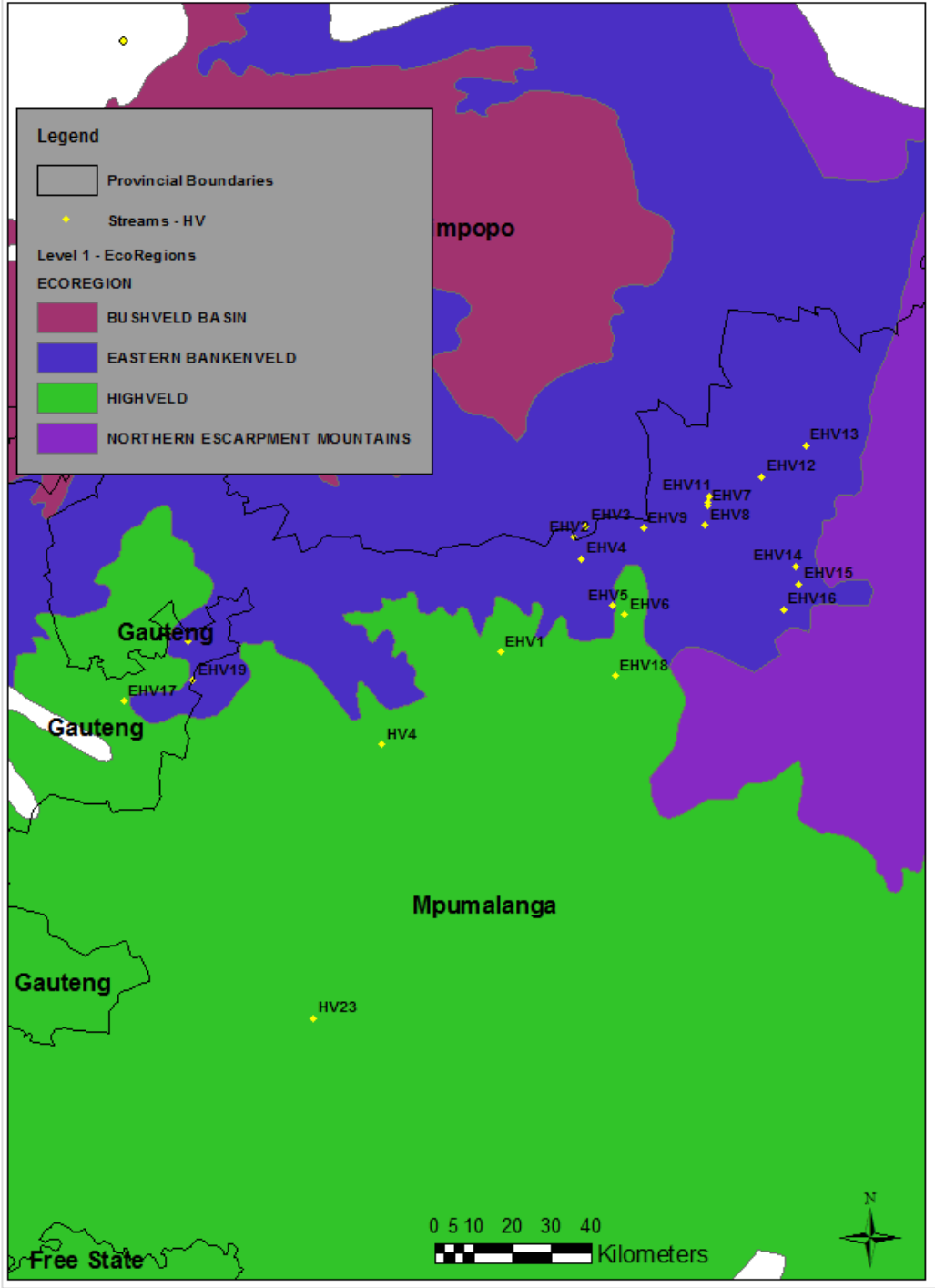
Absent Not found in any of the sites sampled in that region

Sparse Found in 40% or less sites in that region / season

EcoRegions


Legend
Stream - SWC
Level 1 - EcoRegions
ECOREGION
SOUTH EASTERN COASTAL BELT
SOUTHERN COASTAL BELT
SOUTHERN FOLDED MOUNTAINS
SWC09 SWC14 SWC37
SWC08
SWC29 SWC30
SWC24
SWC27
SWC31
SWC32
SWC25
SWC26
SWC36
SWC34 SWC35
SWC33
SWC18
SWC17
SWC23
SWC16
SWC21
SWC22
SWC20
N
0 4 8 16 24 32
Kilometers


Legend
Stream - WB
Level 1 - EcoRegions
ECOREGION
BUSHVELD BASIN
LIMPOPO PLAIN
WATERBERG
WESTERN BANKENVELD
WB12
WB11
WB23A WB23B
WB21
WB22
WB20
Limpopo
WB03
WB06 WB05
WB13
WB27
WB33
WB34
WB16
WB32
WB32A
WB02
WB01
N
0 4 8 16 24 32
Kilometers


Legend
Provincial Boundaries
Streams - HV
Level 1 - EcoRegions
ECOREGION
BUSHVELD BASIN
EASTERN BANKENVELD
HIGHVELD
NORTHERN ESCARPMENT MOUNTAINS
mpopo
EHV13
EHV12
EHV11
EHV7
EHV3
EHV9
EHV8
EHV2
EHV4
EHV14
EHV15
EHV5
EHV6
EHV16
Gauteng
EHV1
EHV19
EHV18
EHV17
Gauteng
HV4
Mpumalanga
Gauteng
HV23
Free State
0 5 10 20 30 40
Kilometers
N

Highveld region

- The Highveld region had the least number of overall sampling site and Macroinvertebrate sites
- High pH values
- Historical data (1954 -1965) obtained from Albany museum
  - 10 Simuliidae spp. were described during that time of which four were identified in this project
  - Ephemeroptera was largely dominated by Baetidae spp. While samples collected during this project were mainly dominated by Tricorythus reticulatus and Euthraulus spp.
  - Neoperla is still the only genus found in this region with just one described sp., Neoperia spio
- These observations suggest that spp. composition has changed over the years and there has been a huge decline in Baetidae spp. for this region, which may be accounted to changes in land-use
- The high pH values in the mist of well documented deterioration of air quality suggests that the soils in this region have a high buffering ability

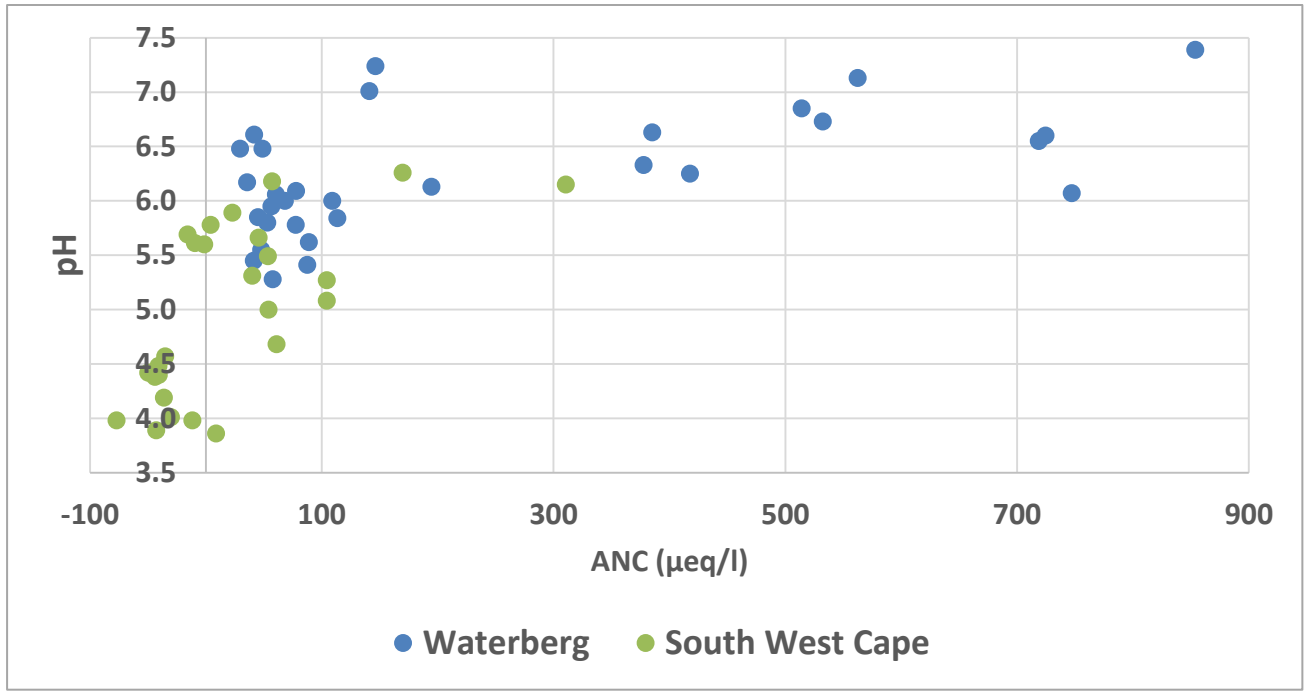
Waterberg region

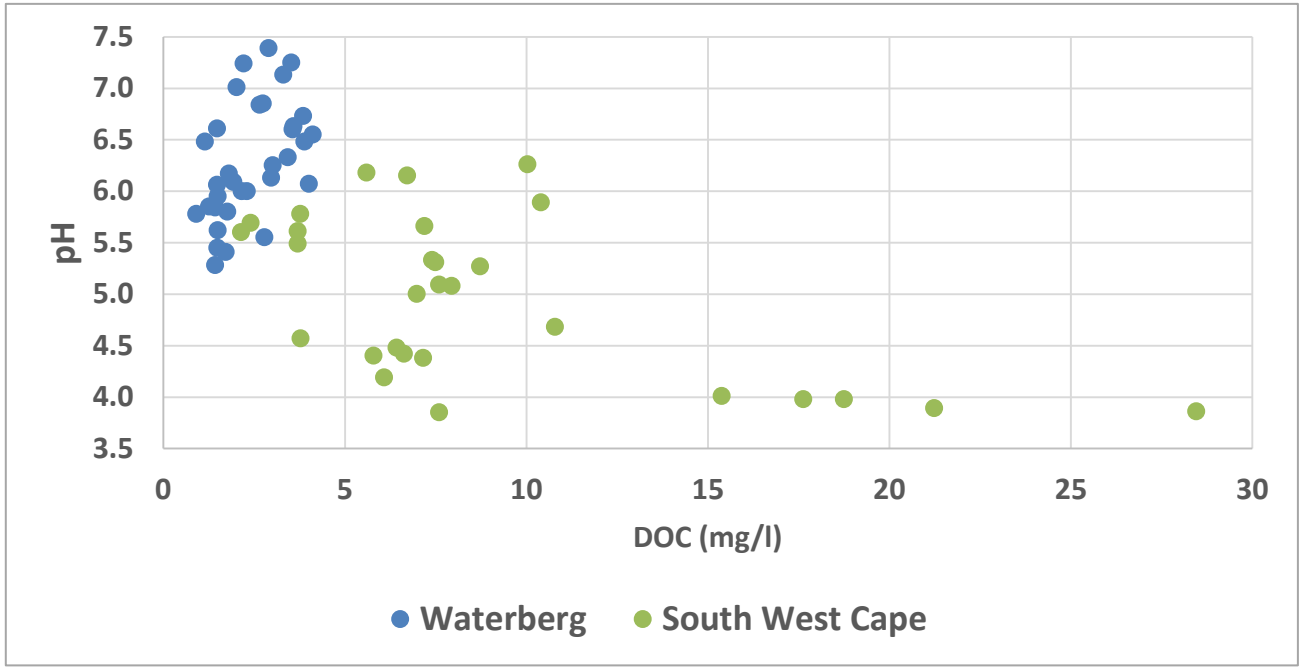
- Least studied area of the three regions
- Consists of acidic and basic streams
- Largely dominated by uncommon
  Mayfly species that are sparsely distributed

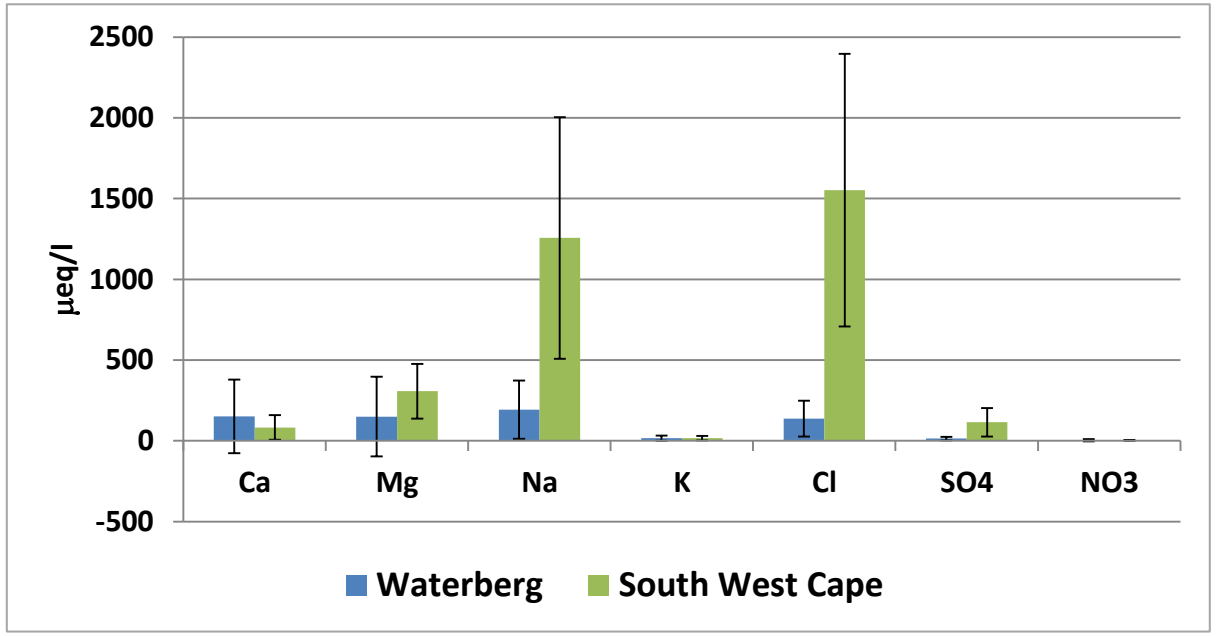
South-western Cape region

- Most studied area in aquatic sciences
- Naturally acidic streams
- High degree of diversity and endemism
  - World's 200 significant Freshwater Ecoregions

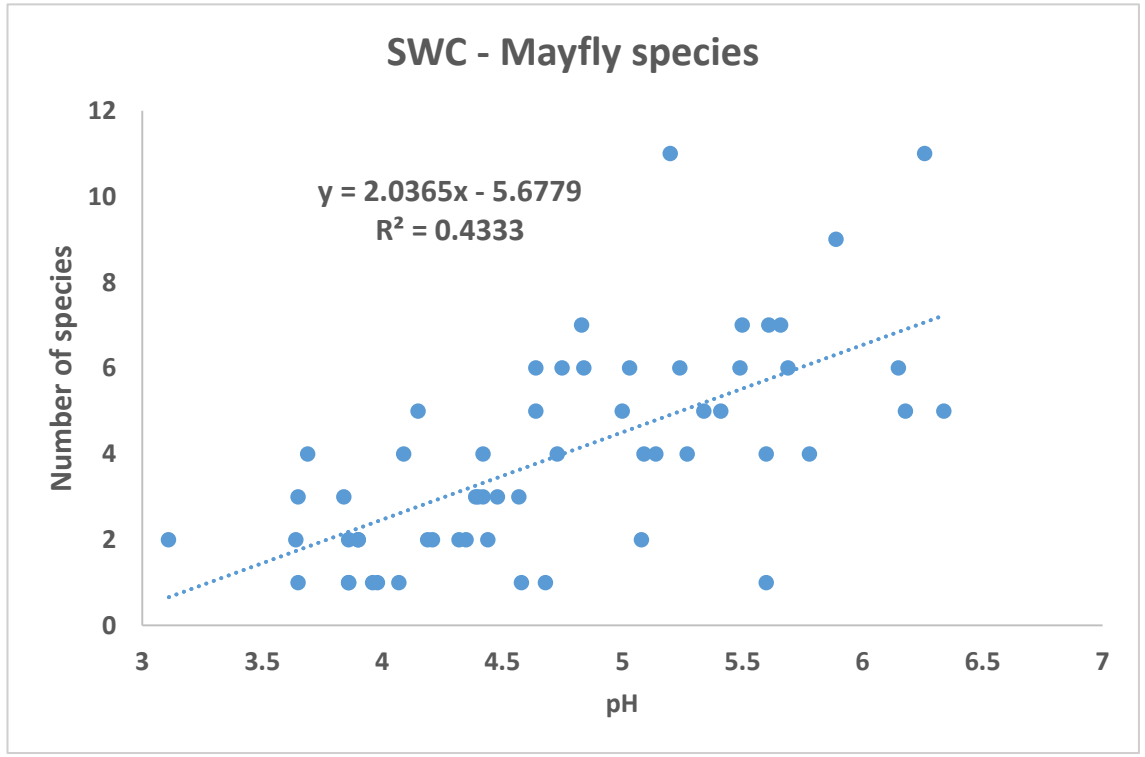
Chemistry results

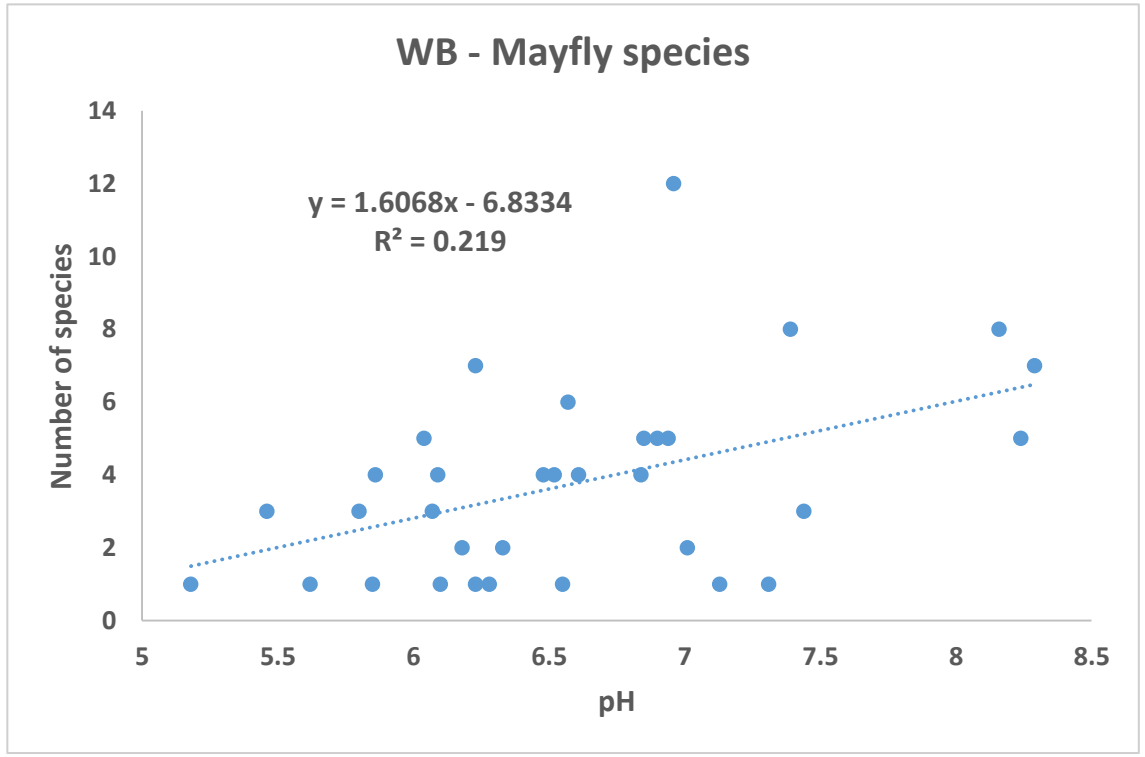






The effects of pH concentration on species numbers





Visit to Norway

- Chemistry
  - Q & A
  - Summarising and analyzing data
- Relationship between chemistry and biology
  - Individual species
  - Potential indices
- Critical loads

THANK YOU

South African NATIONAL PARKS

NILU Norsk institutt for luftforskning Norwegian Institute for Air Research

ALBANY MUSEUM

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

WITS UNIVERSITY

The Research Council of Norway

NIVA Norwegian Institute for Water Research

CZECH GEOLOGICAL SURVEY 1919

NRF National Research Foundation

UMGENI WATER • AMANZI

The overall project addresses the theme “Environment” with a specific interest in the effects of air pollution on the aquatic ecosystem as well as predicting future scenarios of climate change and changes in sulphur and nitrogen emissions into the atmosphere.

South African indices

- There are several indices that are available in South Africa and are used to assess the integrity of the aquatic ecosystem
  - Index of habitat integrity (IHI)
  - Fish assemblage integrity index (FAII)
  - South African scoring system (SASS5)
  - Macro-invertebrate response assessment index (MIRAI)
  - Fish response assessment index (FRAI)
  - Riparian vegetation index (RVI)

- SASS5 and MIRAI are specific to macroinvertebrates and they assess the overall health of the aquatic ecosystem and identification is done at family level

- In this study we tried to investigate the feasibility of establishing a South African scoring system specific to acidification using macroinvertebrates