The world in a grain of sand

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UNIVERSITY OF THE
FREE STATE
UNIVERSITEIT VAN DIE
VRYSTAAT
YUNIVESITHI YA
FREISTATA

UFS·UV
NATURAL AND
AGRICULTURAL SCIENCES
NATUUR- EN
LANDBOUWETENSKAPPE

Dedication

My Lord and saviour

My family

My mentors

My colleagues

My students

A grain of sand

Kruger National Park (2013)

Introduction

Humans classify their environment to:

- **create order**
- **make it more understandable**
- **aid recollection**
- **communicate**

Soil Classification

International systems:

- **USDA Soil Taxonomy**
- **World Reference Base for Soil Resources**

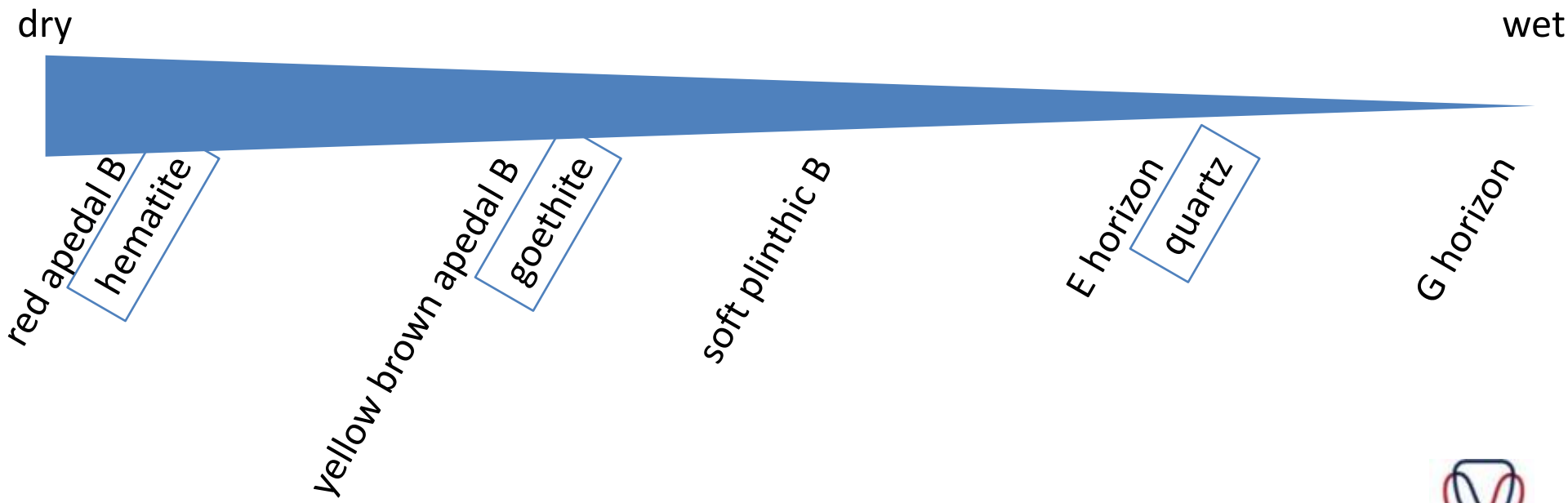
National system:

- **Soil Classification: A Taxonomic System for South Africa**
  - **Colour defined horizons:**
    - **grey E horizon**
    - **yellow brown apedal B horizon**
    - **red apedal B horizon**

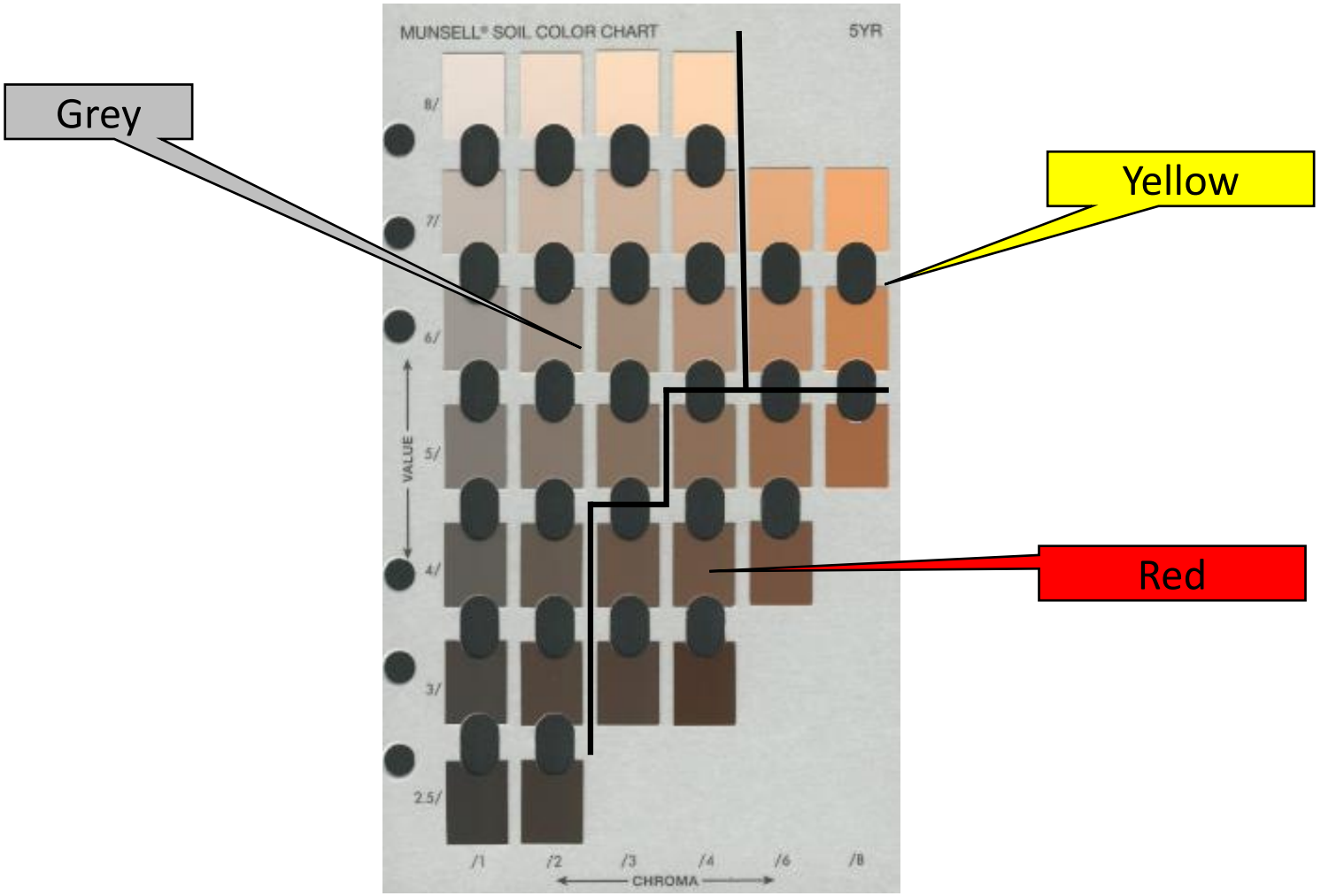
Colour defined horizons

Perceived hydrological order:

- **red → driest**
- **yellow → intermediate**
- **grey → wettest**



Colour definitions



Soil forms

P210 (Bloemdal)

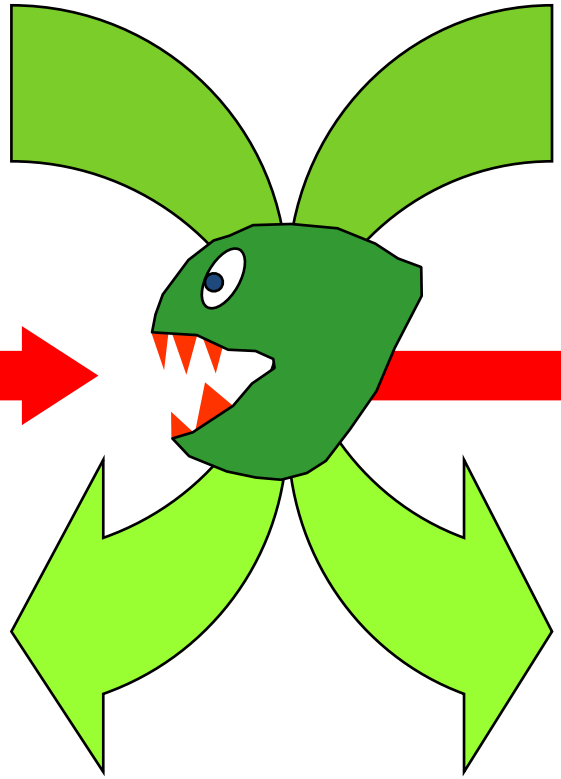
P204 (Longlands)

P226 (Kroonstad)

Aerobic respiration

$CH_2O + H_2O$

$O_2 + 4e^- + 4H^+$



organic matter

energy

$CO_2 + 4e^- + 4H^+$

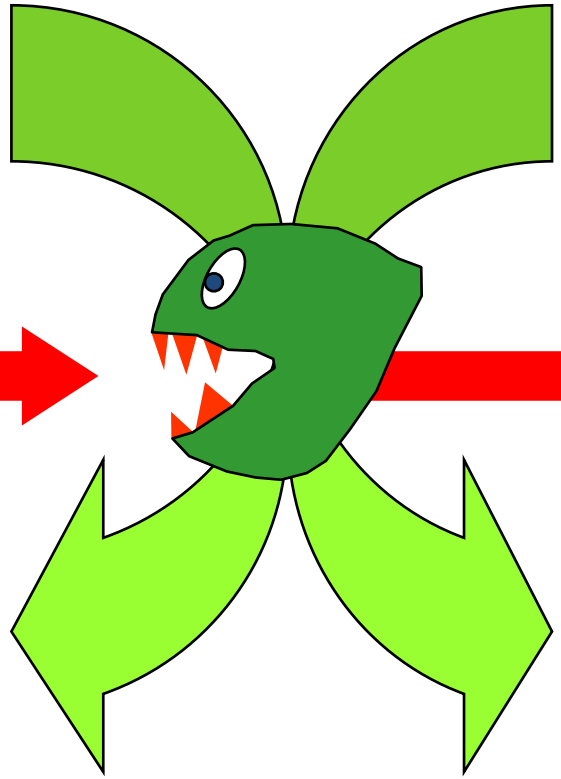
$2\ H_2O$

Anaerobic respiration

$CH_2O + H_2O$

$Fe_2O_3 + 2e^- + 6H^+$

(insoluble)



organic matter

less energy

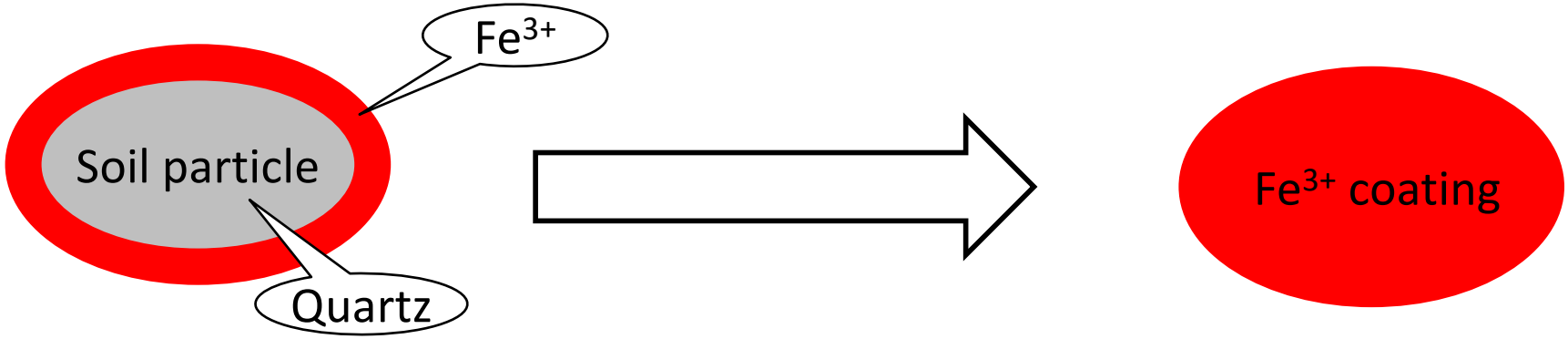
$CO_2 + 4e^- + 4H^+$

$2Fe^{2+} + 3H_2O$

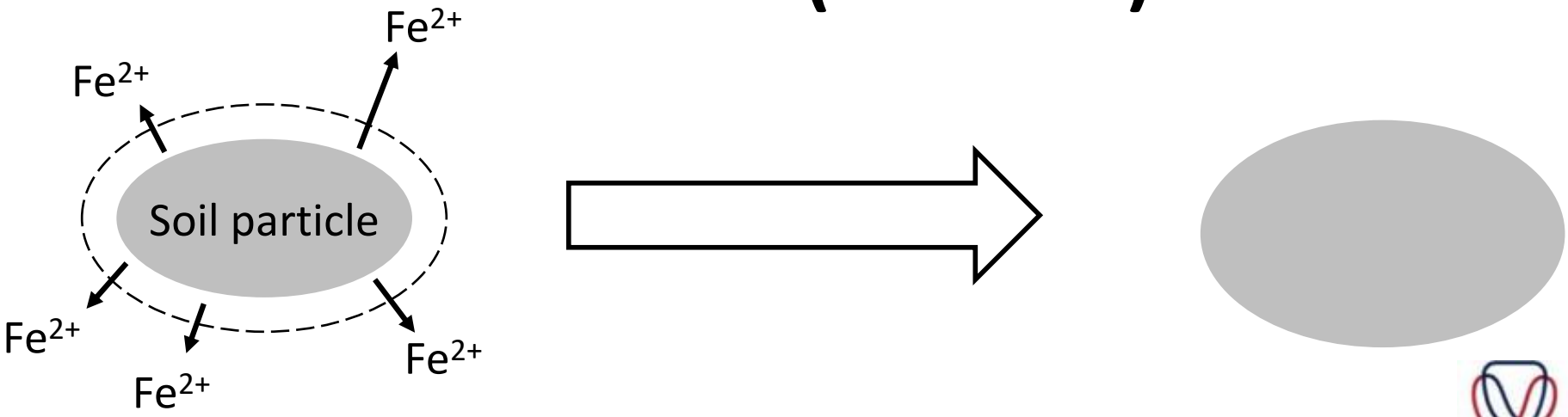
(soluble)

Fe determines colour

Aerobic (oxidised)



Anaerobic (reduced)



Fe determines colour

Fluvisol in Hungary (2011)

Reduction sequence

Oxygen reduction

$$4e^- + 4H^+ + O_2 \leftrightarrow 2H_2O \qquad (+500\ mV)$$

Denitrification

$$10e^- + 12H^+ + 2NO_3^- \leftrightarrow N_2 + 6H_2O \qquad (+350\ mV)$$

Manganese reduction

$$2e^- + 4H^+ + MnO_2 \leftrightarrow Mn^{2+} + 2H_2O \qquad (+300\ mV)$$

Iron reduction

$$2e^- + 6H^+ + Fe_2O_3 \leftrightarrow 2Fe^{2+} + 3H_2O \qquad (+200\ mV)$$

Sulphate reduction

$$8e^- + 10H^+ + SO_4^{2-} \leftrightarrow H_2S + 4H_2O \qquad (-75\ mV)$$

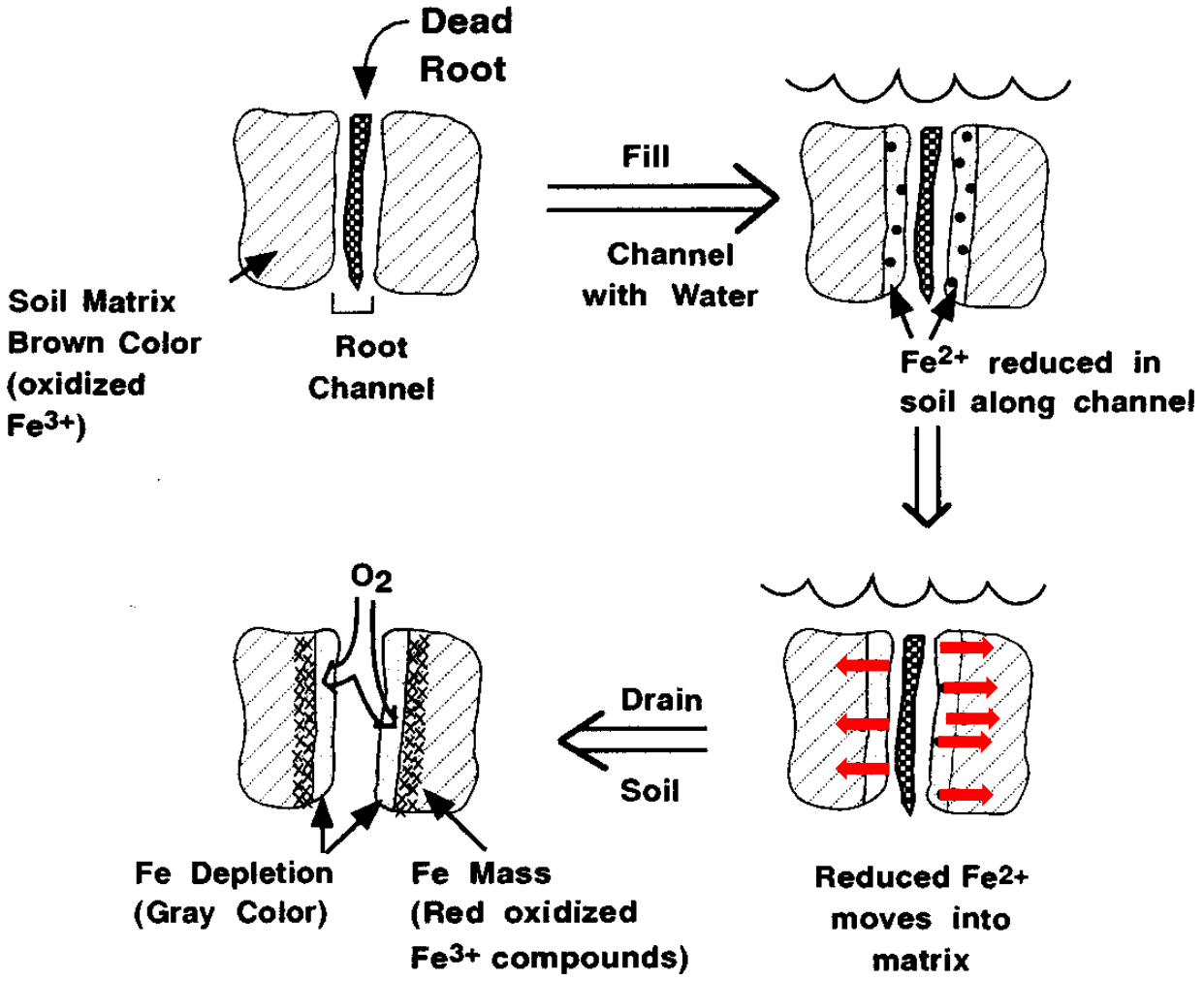
Swamp gas production

$$8e^- + 8H^+ + CO_2 \leftrightarrow CH_4 + 2H_2O \qquad (-185\ mV)$$

H_2 formation

$$2e^- + 2H^+ \leftrightarrow H_2 \qquad (-185\ mV)$$

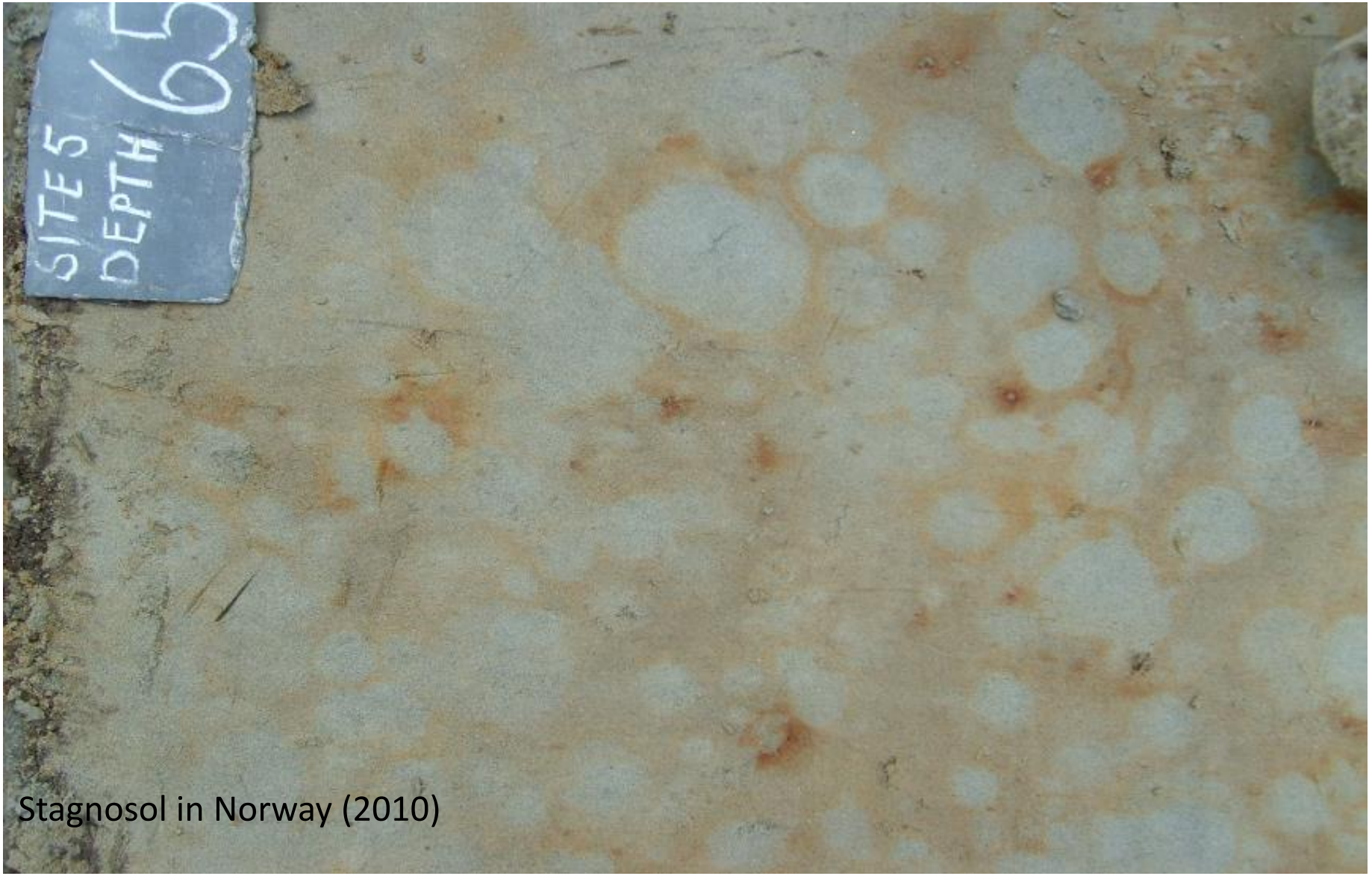
Stagnic colour pattern



Stagnic colour pattern

Stagnosol in Norway (2010)

Stagnic colour pattern

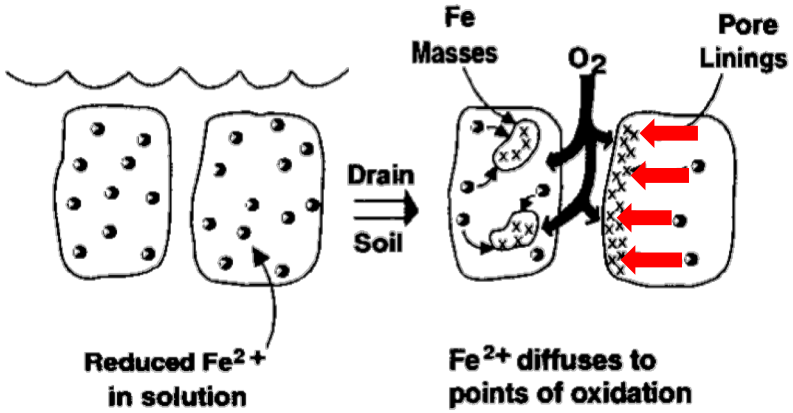


Stagnosol in Norway (2010)

Stagnic colour pattern

Stagnosol in Norway (2010)

Gleyic colour pattern

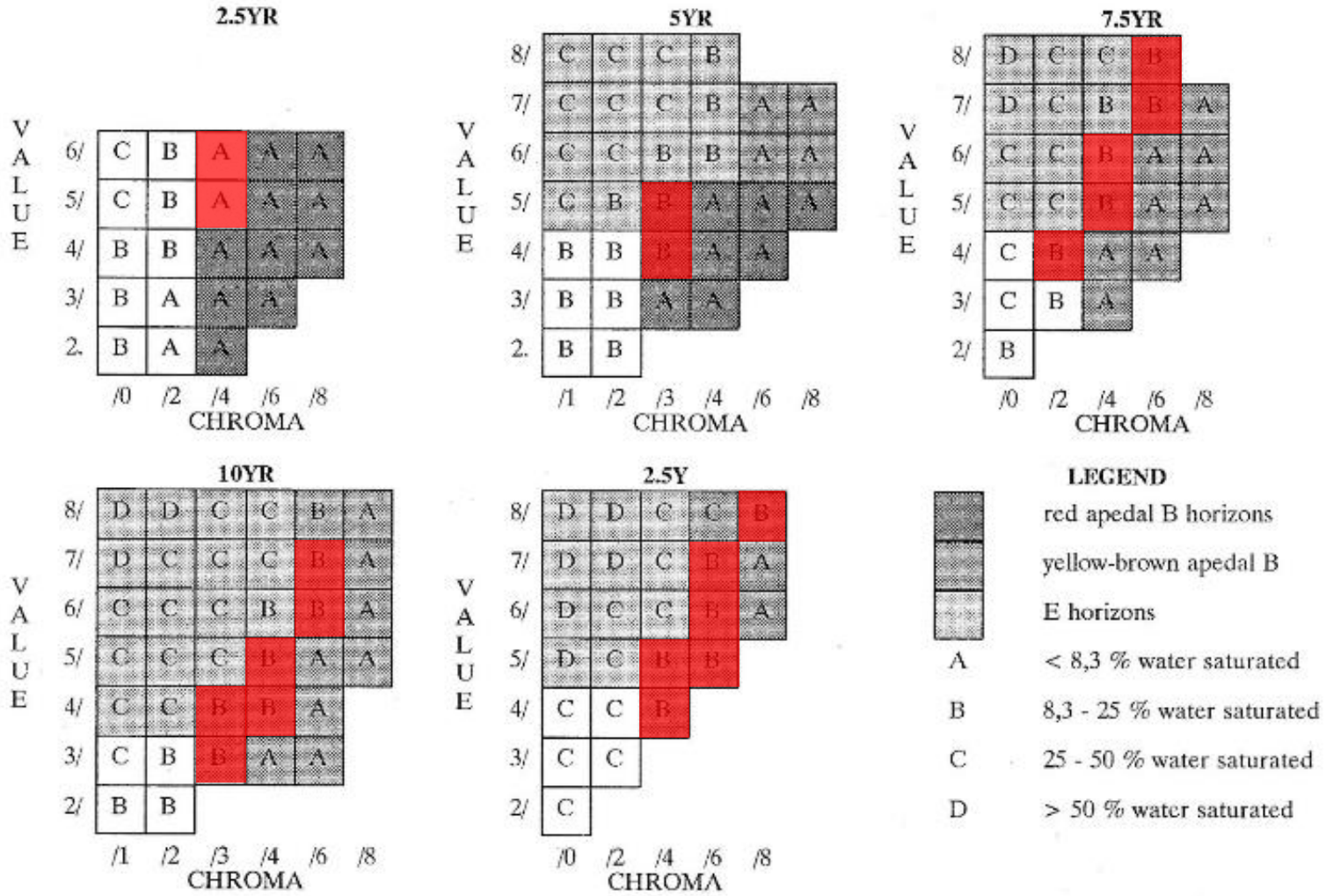


Gleyic colour pattern

Gleysol in Poland (2011)

Gleysol in Hungary (2011)

Munsell colour definitions



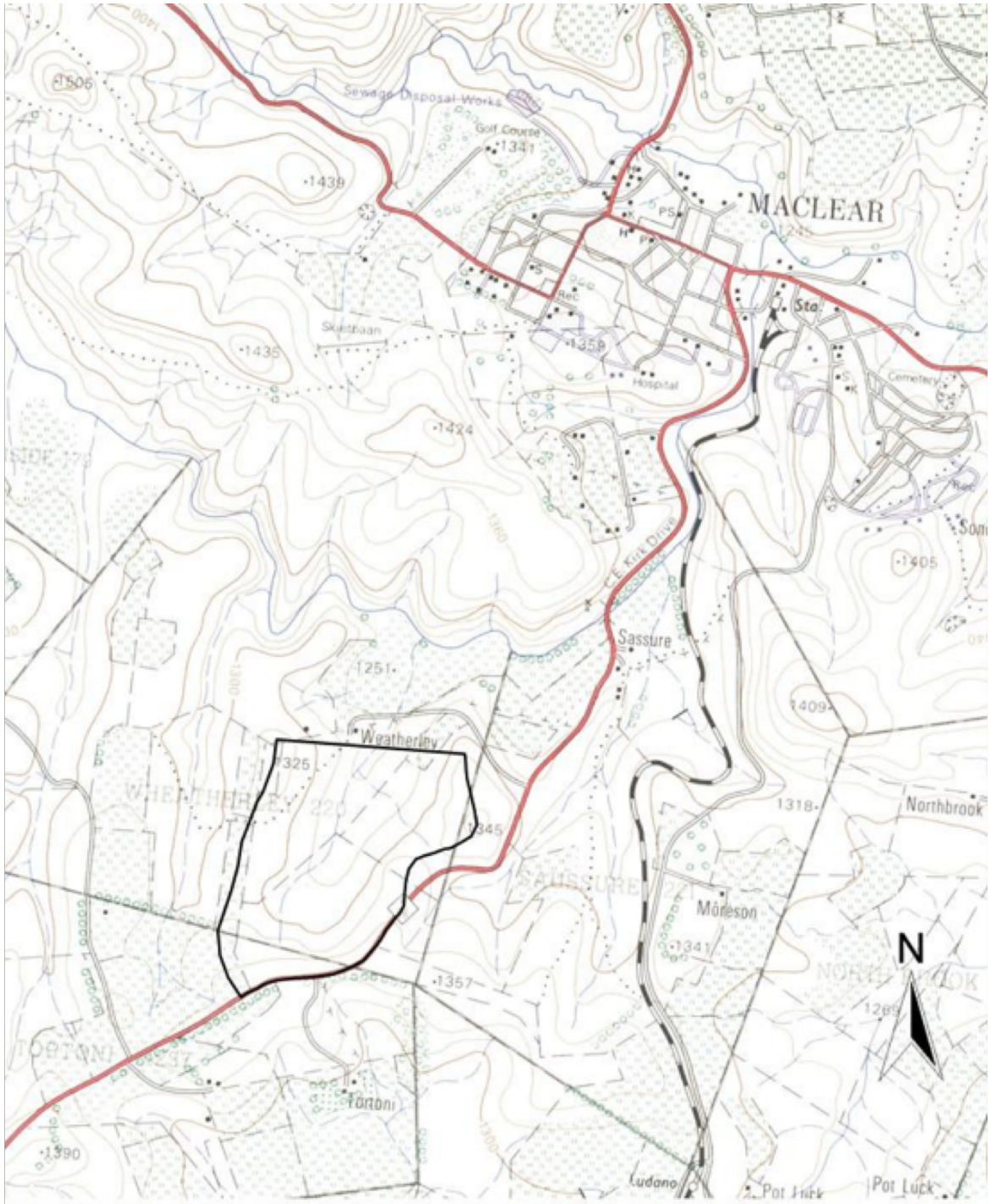
Duration of free water (%) = 2,35 x Hue_{dry} + 5,79 x $Value_{dry}$ - 7,31 x $Chroma_{dry}$ - 27,89

Weatherley

METHODOLOGY:

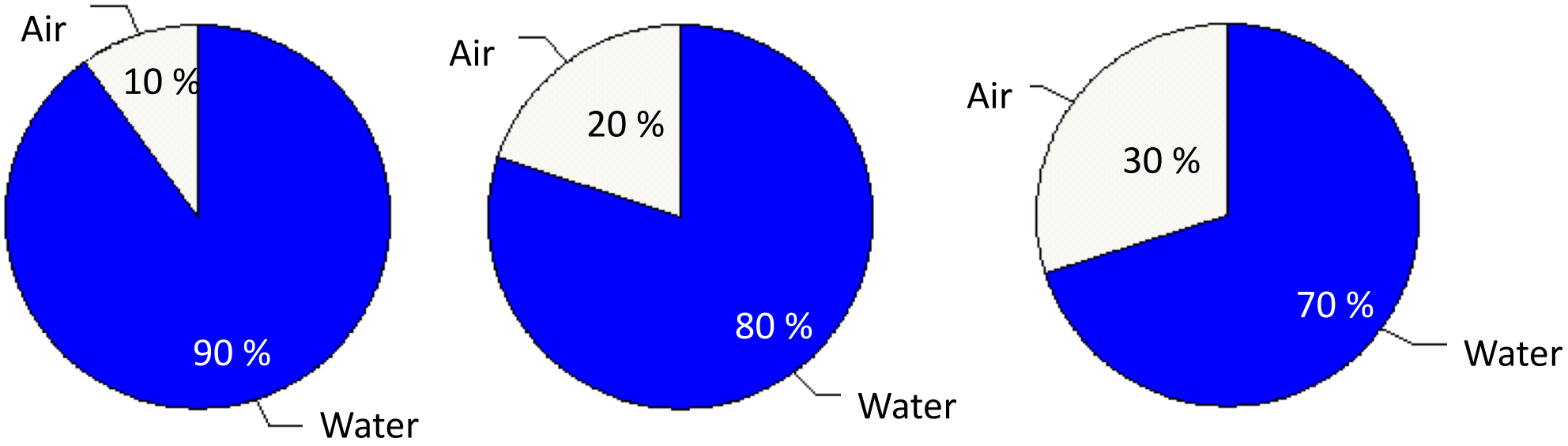
- **28 profiles**
  - **described in detail**
  - **sampled & analysed in 100 mm intervals**
  - **bulk density & porosity**

- **Neutron water meter measurements**
  - **weekly for six years (1997 - 2002)**

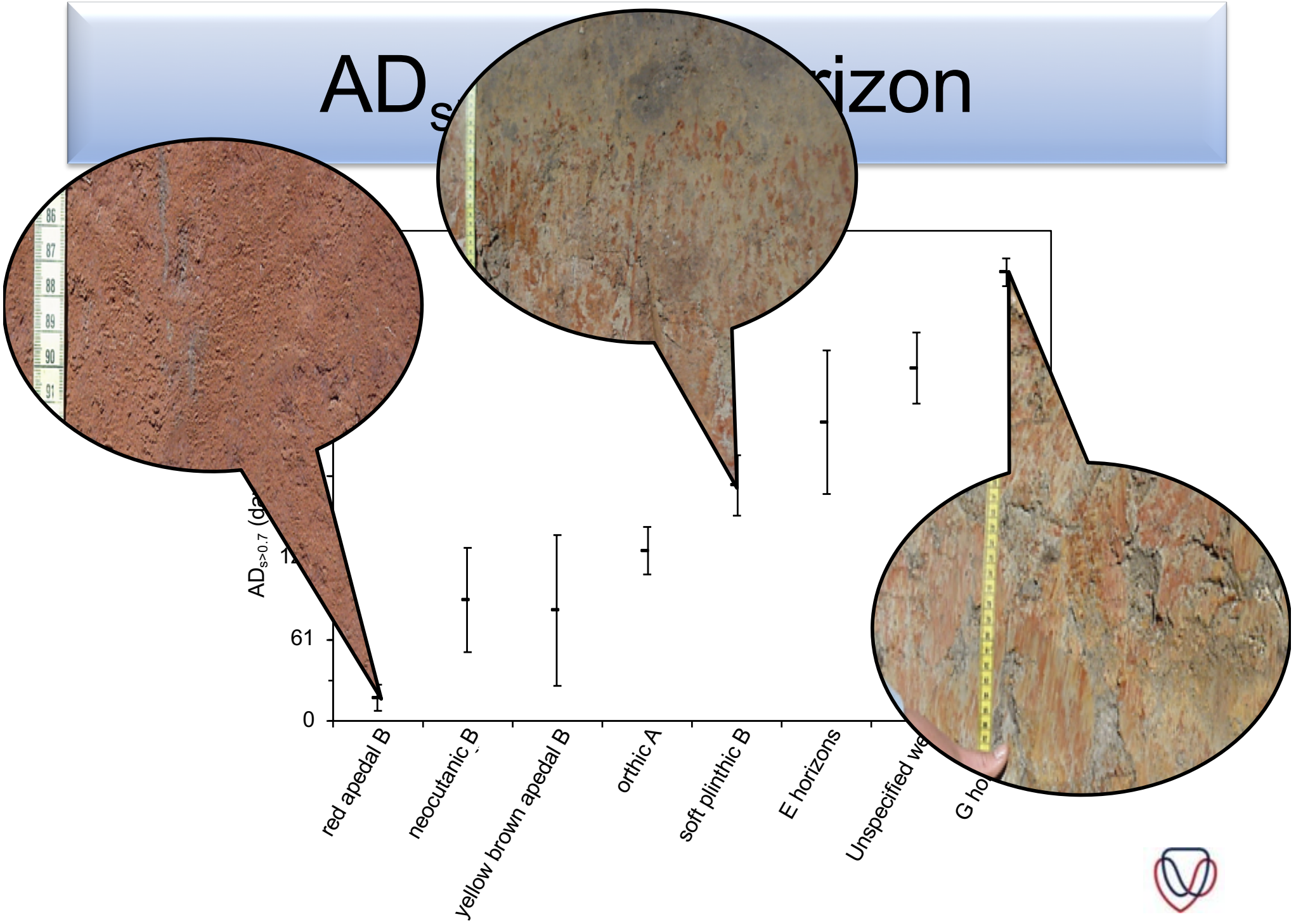


UFS UV

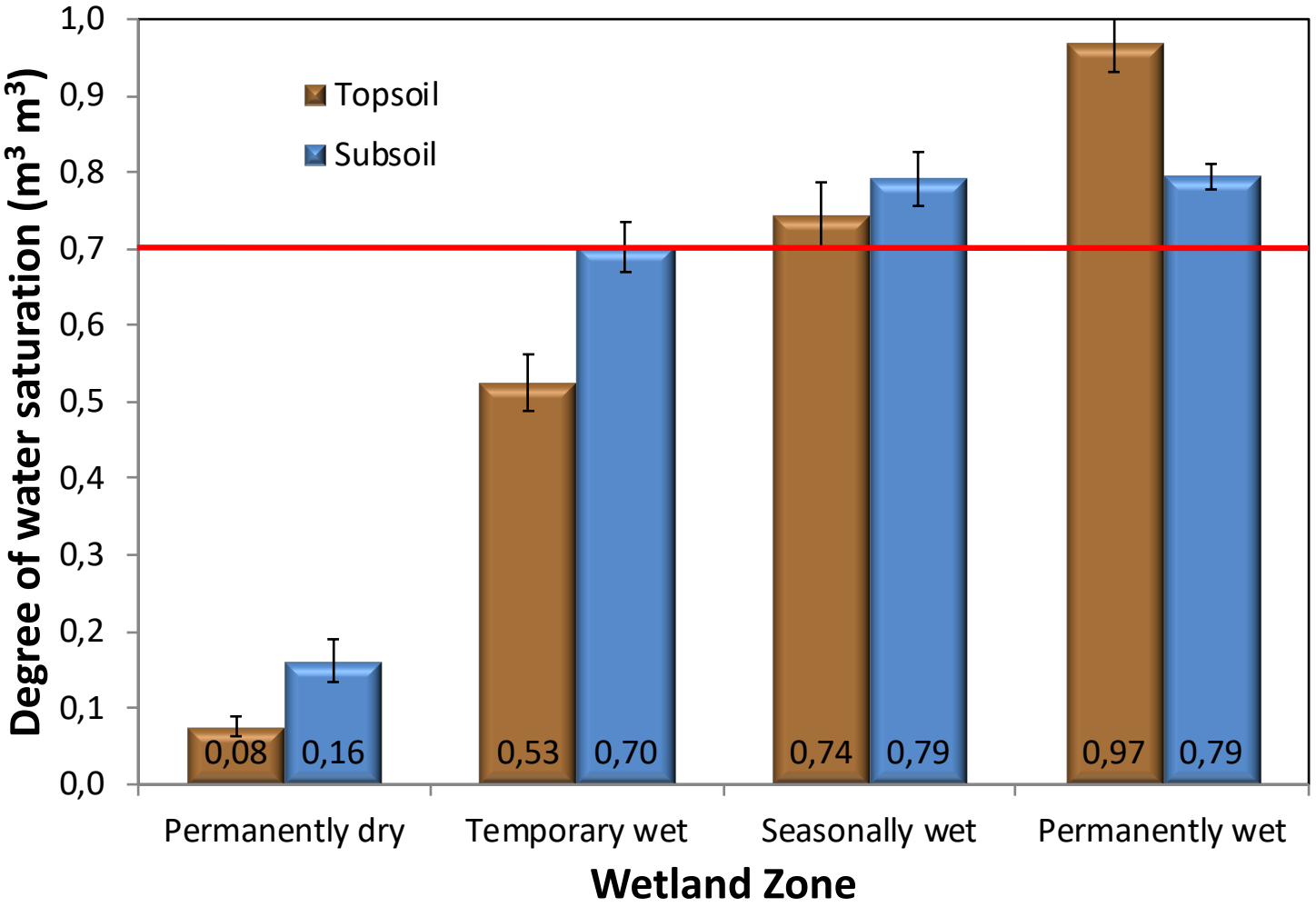
Degree of water saturation ($S_{0.7}$)



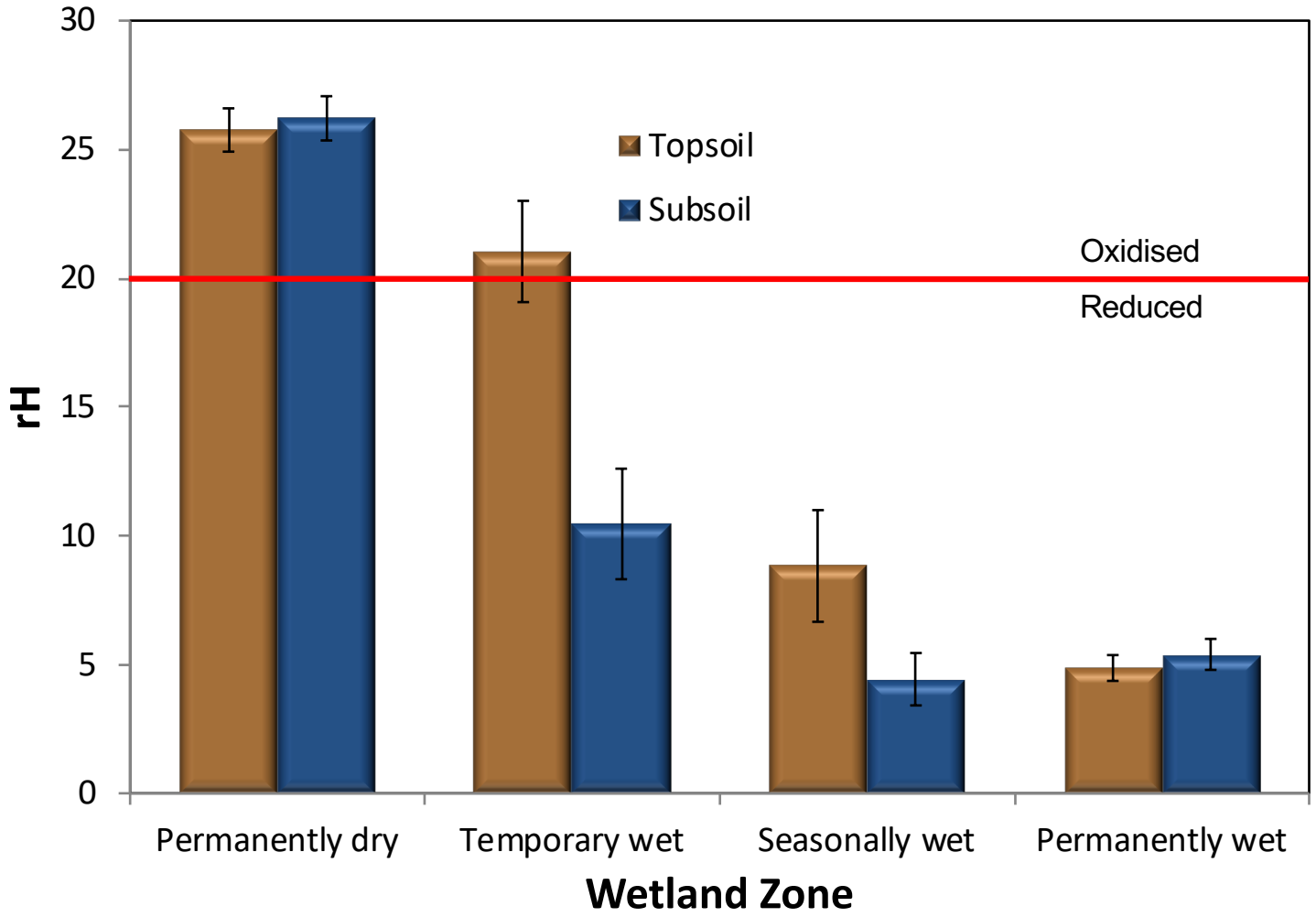
AD$_s$ rizon


AD$_{s>0.7}$ (d
61
0
red apedal B
neocutanic B
yellow brown apedal B
orthic A
soft plinthic B
E horizons
Unspecified we
G ho

Florisbad


Degree of water saturation (m³ m³)
1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0,0
Topsoil
Subsoil
0,08
0,16
0,53
0,70
0,74
0,79
0,97
0,79
Permanently dry
Temporary wet
Seasonally wet
Permanently wet
Wetland Zone

Florisbad

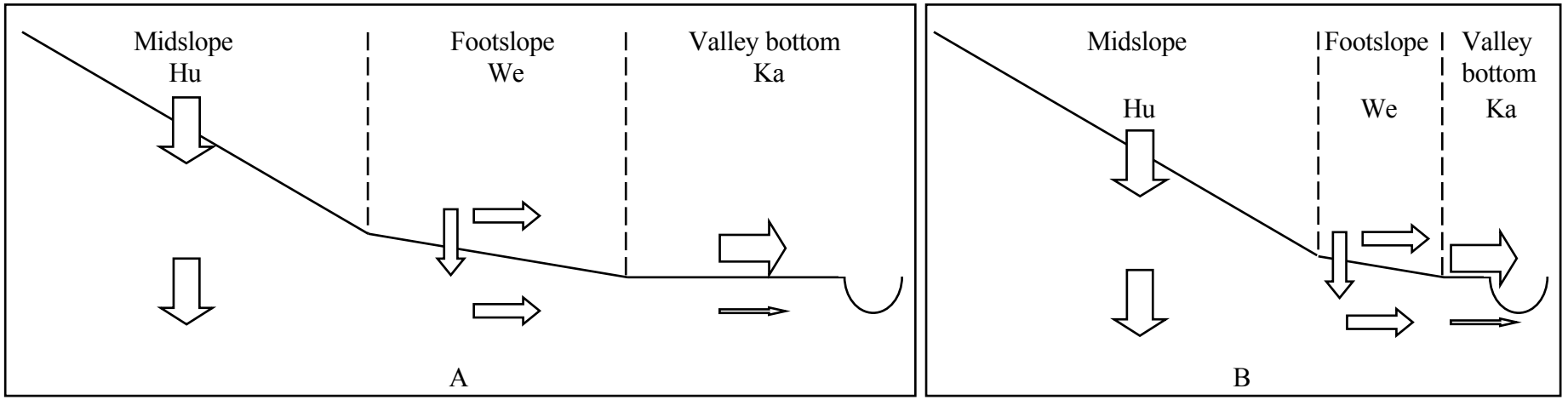


rH = 2(Eh/59 + pH)

Application

- **Hydropedology**
- **Wetland delineation**
  - **Urban development**
  - **Mining EIAs**
- **Irrigation scheduling**
- **Water table soils**
- **Soil classification**

Hydropedology



Wetlands

- **Saturated with water in growing season**
  - **Determines vegetation type**
  - **Leads to distinct soil morphology**
    - **Termed redox morphology**
  - **Evidence of saturation in rooting depth**
    - **Grey soil matrix colours**
    - **Mottling**

Rift valley fever

Viral zoonotic disease

Affects domestic and wild animals and humans

Outbreaks every ca. 10 years

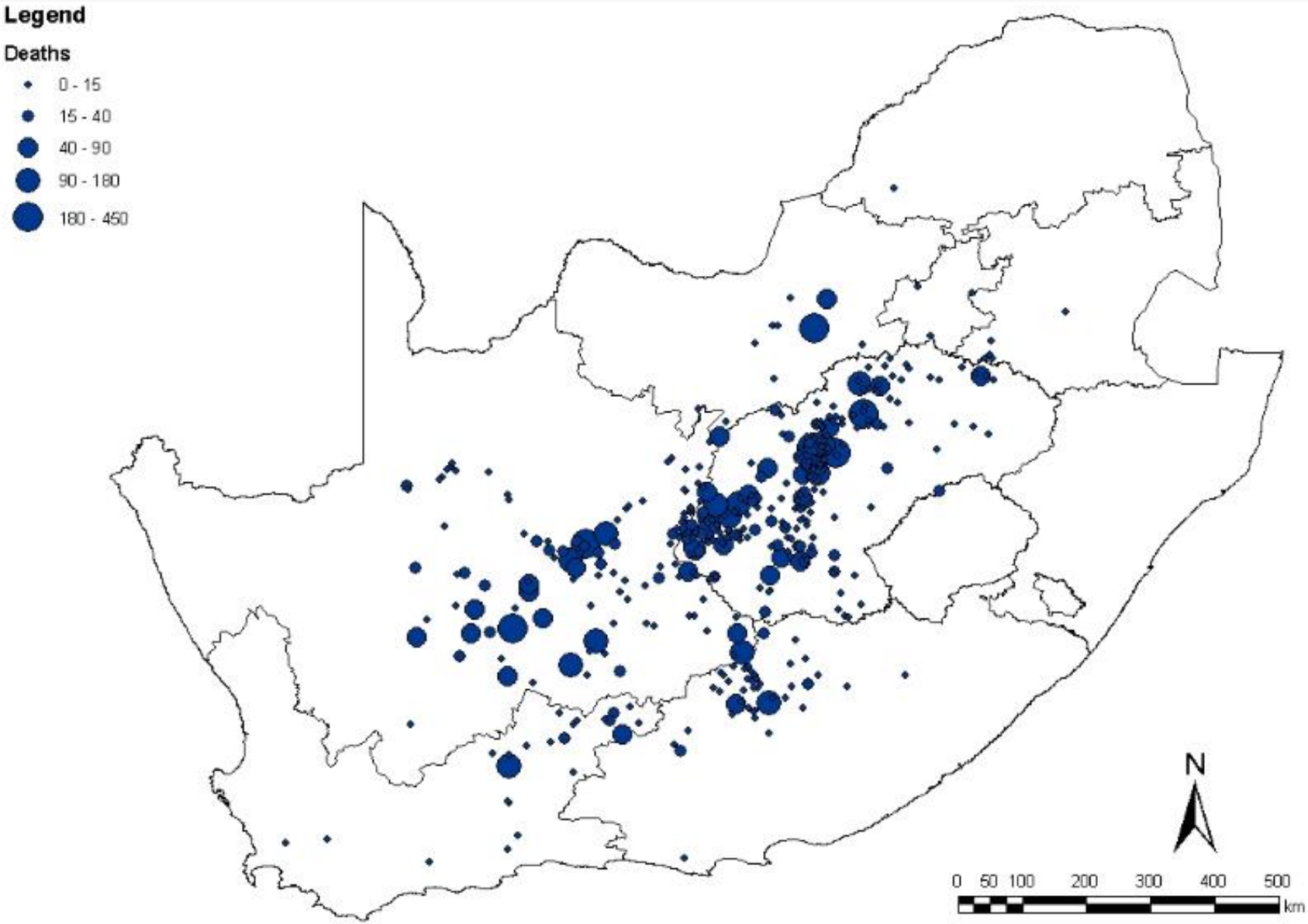
- **Aligned to rainfall cycle?**

Transmitted by infected *Aedes* mosquitos

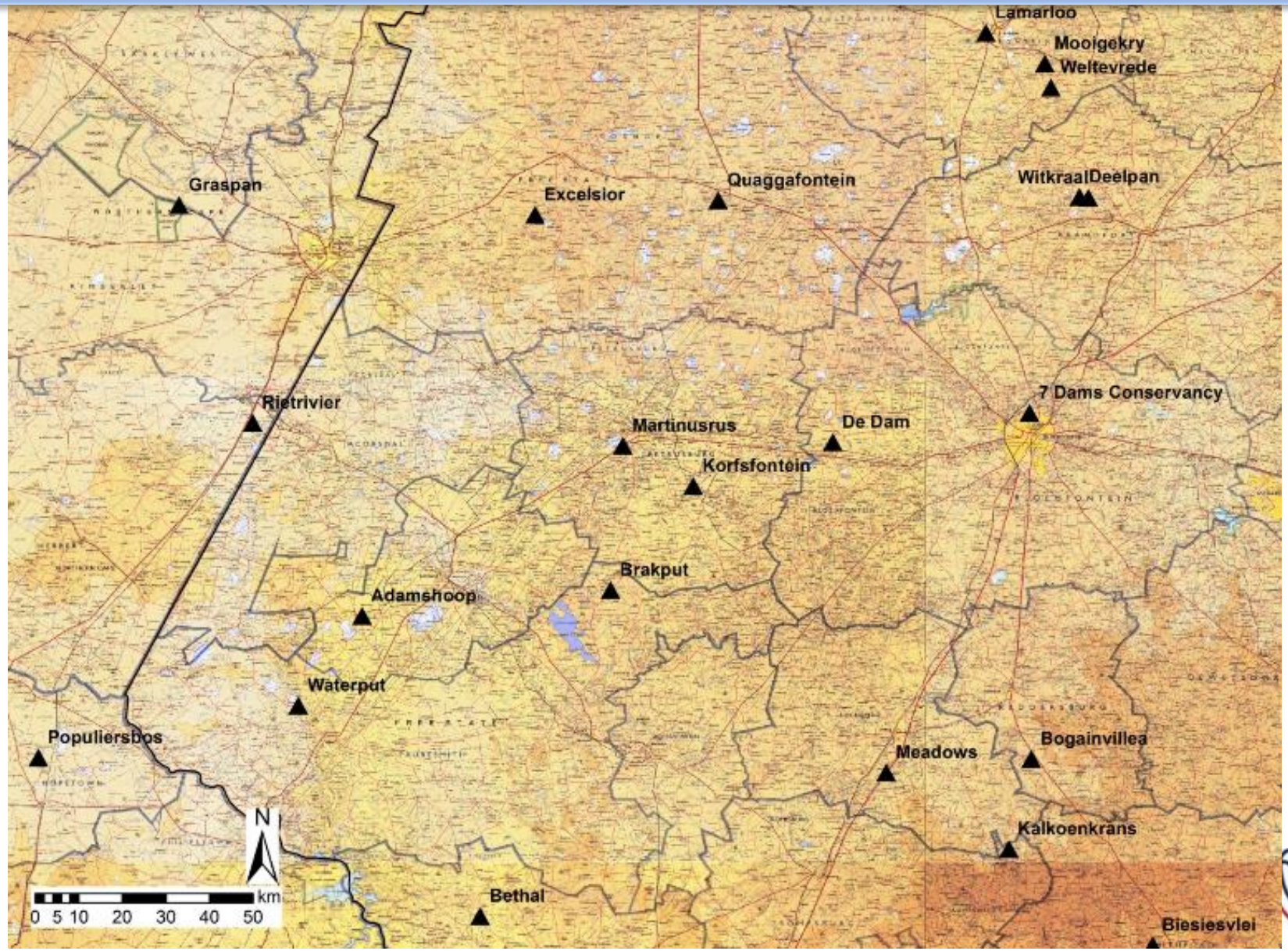
High abortion and mortality rates in livestock

Virus estivates in mosquito larvae in wetlands?

RVF sheep mortality (2010)



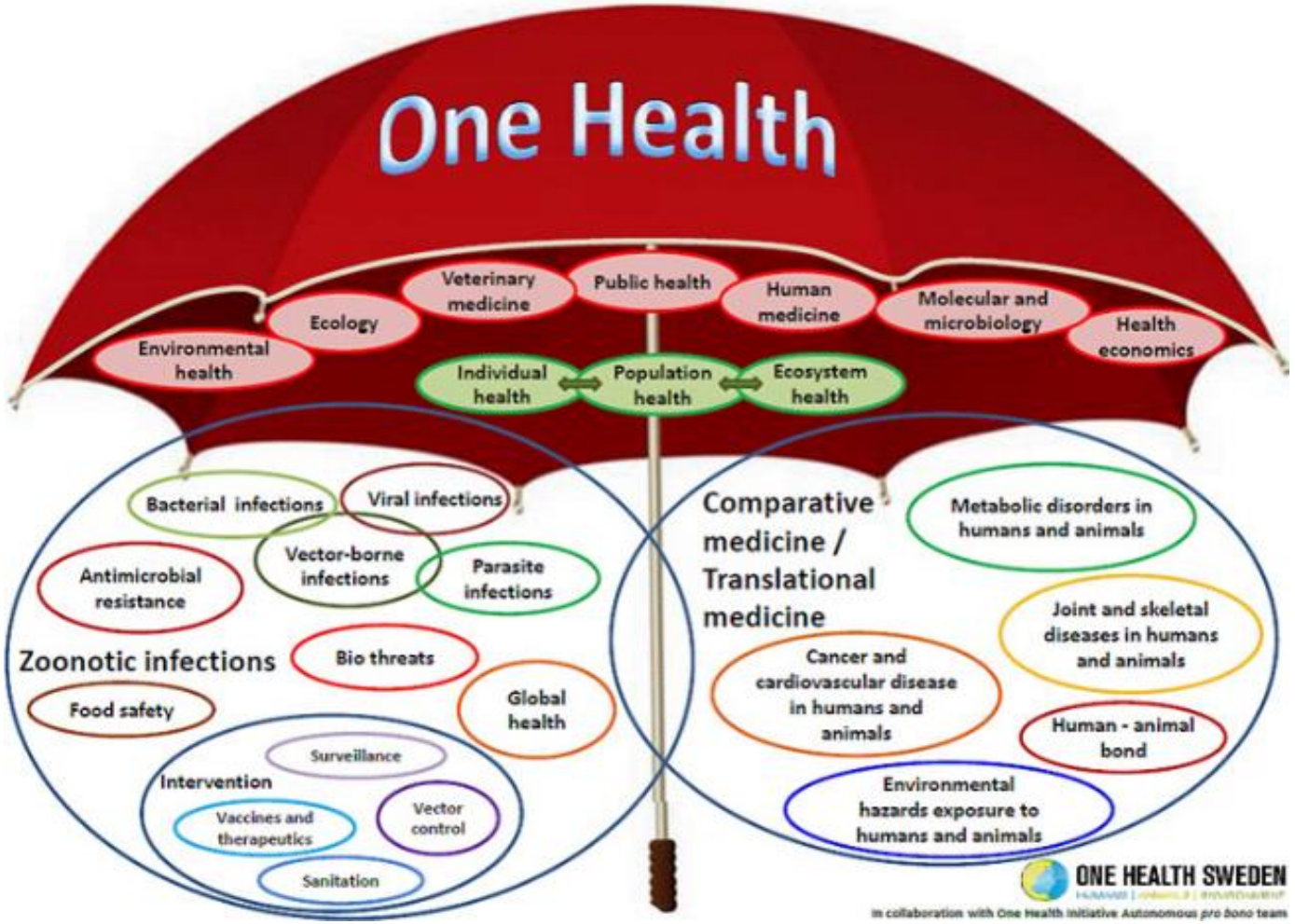
RFV study sites



Prediction of RVF outbreak site

- $D_g^2(x_i) = -2 \cdot \left(x_i' Q_g x_i + x_i' L_g + C_g\right)$
  - i – Location
  - x_i - Vector of dimension 3
    - **log (sol. Ca), square root (exch. K), square root (med. sand)**
    - From stepwise procedure
  - Q_g - Matrices
  - L_g - Vectors
  - C_g - Constants
  - $g = 1,2$ (1: Group 1 – Outbreak, 2: Group 2 – Control)
- $D_1^2(x_i) > D_2^2(x_i)$ – Outbreak site
- $D_1^2(x_i) < D_2^2(x_i)$ – Control site

One Health


One Health
Veterinary medicine
Public health
Human medicine
Molecular and microbiology
Ecology
Health economics
Environmental health
Individual health
Population health
Ecosystem health
Bacterial infections
Viral infections
Vector-borne infections
Parasite infections
Antimicrobial resistance
Zoonotic infections
Bio threats
Food safety
Global health
Surveillance
Intervention
Vaccines and therapeutics
Vector control
Sanitation
Comparative medicine / Translational medicine
Metabolic disorders in humans and animals
Joint and skeletal diseases in humans and animals
Cancer and cardiovascular disease in humans and animals
Human - animal bond
Environmental hazards exposure to humans and animals
ONE HEALTH SWEDEN
In collaboration with One Health Initiative Autonomous pro bono team

RVF partners

NATIONAL INSTITUTE FOR COMMUNICABLE DISEASES
Division of the National Health Laboratory Service

University of Pretoria

UFS UV
UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

EcoHealth Alliance

the detea
the department of economic development, tourism and environmental affairs
FREE STATE PROVINCE

defence
Department:
Defence
REPUBLIC OF SOUTH AFRICA

USRA

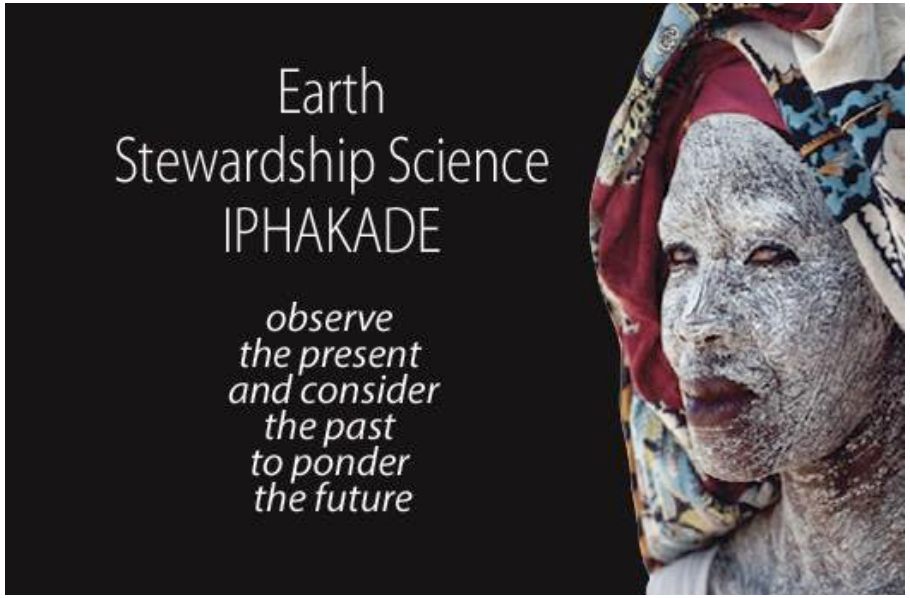
NASA

South African NATIONAL PARKS

This project is sponsored by the U.S. Department of Defense, Defense Threat Reduction Agency. The content of the information does not necessarily reflect the position or the policy of the federal government, and no official endorsement should be inferred.

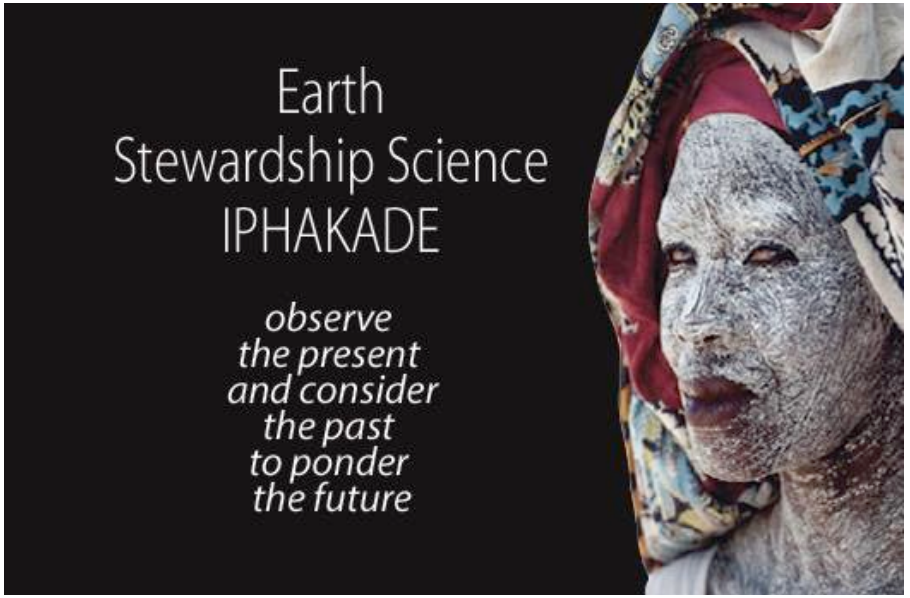
Iphakade at the UFS

- Since 2009
- Initiated at UFS by Marian Tredoux
- Initially collaboration between Germany & SA
- Funded in SA by DST
- Administrated by Prof. Maarten de Witt (NMU)
- Disbursed to various university collaborators



Iphakade totals at UFS

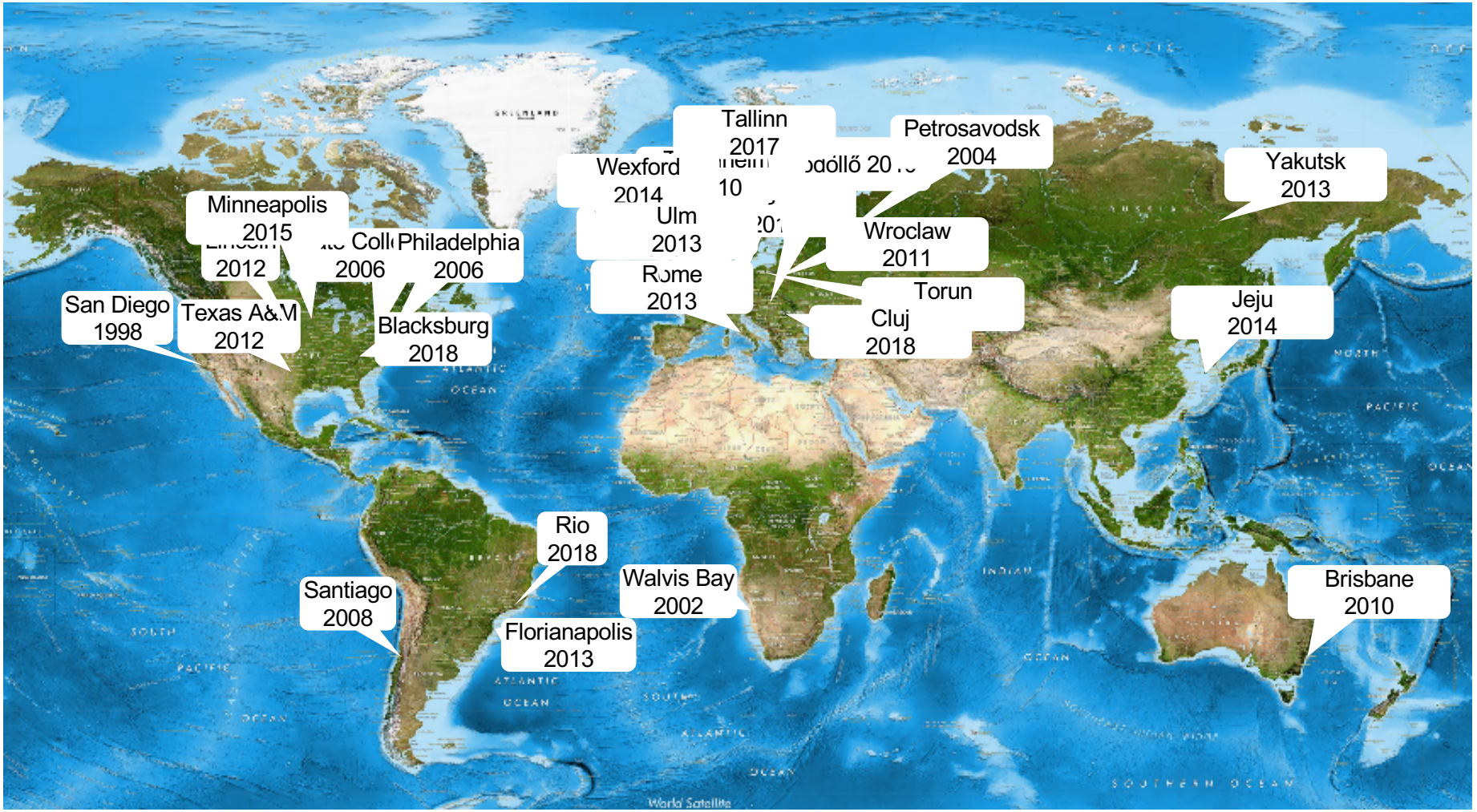
- ca. **R14 100 000 over 10 years**
- **6 Departments**
- **17 Lecturers**
- **180 students**
- **Focus on Hons., M.Sc. & Ph.D. students**
- **Approximately:**
  - **50% black; 50% white**
  - **40% female; 60% male**



The Future

- **To propose ancillary criteria to relate SAT to WRB**
- **To modify SAT diagnostics to better relate to WRB**
- **To propose morphological diagnostics for the WRB**

The world


Tallinn
2017
Petrosavodsk
2004
Wexford
2014
Yakutsk
2013
Minneapolis
2015
Ulm
2013
Wroclaw
2011
Philadelphia
2006
2012
2006
Rome
2013
Torun
San Diego
1998
Texas A&M
2012
Blacksburg
2018
Cluj
2018
Jeju
2014
Rio
2018
Walvis Bay
2002
Brisbane
2010
Santiago
2008
Florianapolis
2013
World Satellite

Conclusion

Soil colour:

- reflects soil hydrology
- can therefore be used to infer water behaviour
- applied in:
  - hydropedology
  - wetland delineation
  - irrigation scheduling
  - water table soils
  - soil classification

Must be willing to see the world in a grain of sand

Thank you!