Landscape genetics of a springtail endemic to Marion Island

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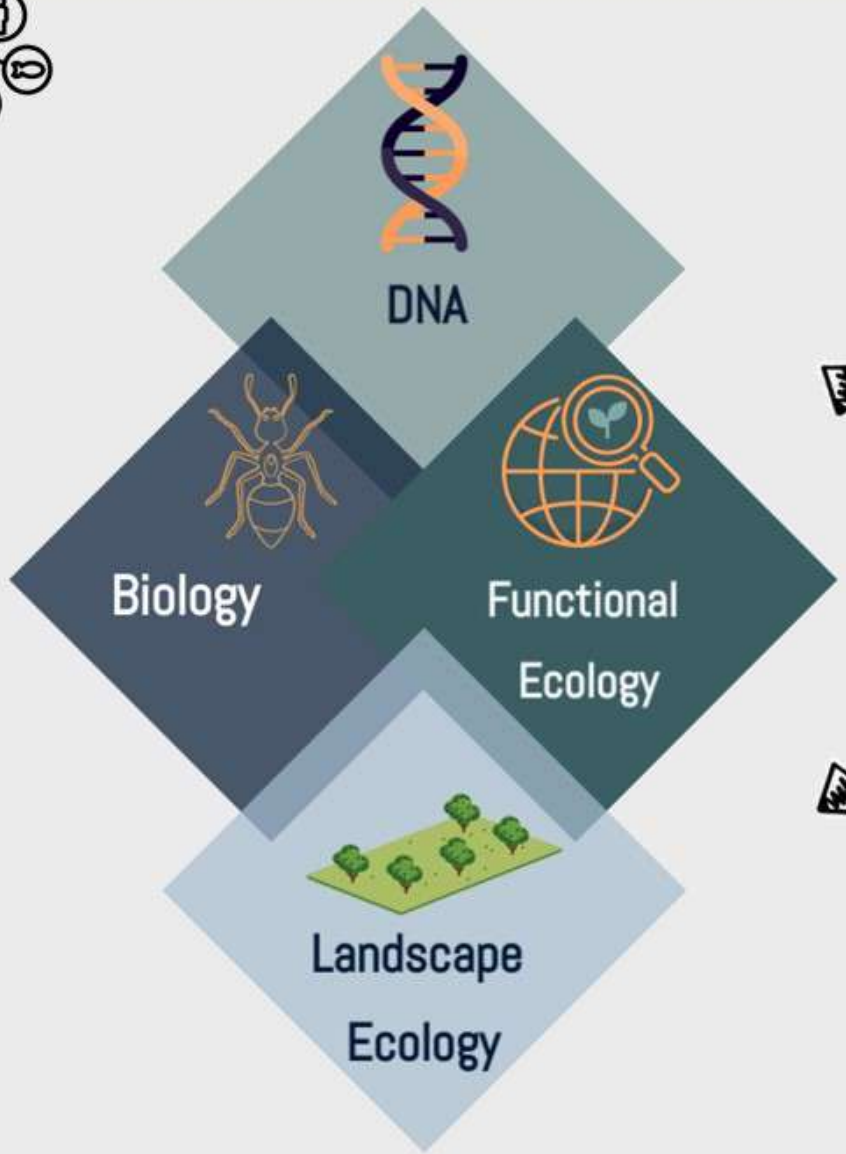
UNIVERSITY OF JOHANNESBURG

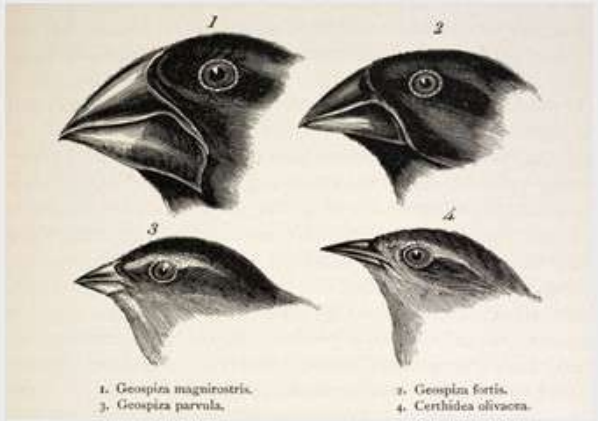
Ecological Genomics & Wildlife Conservation

NRF National Research Foundation

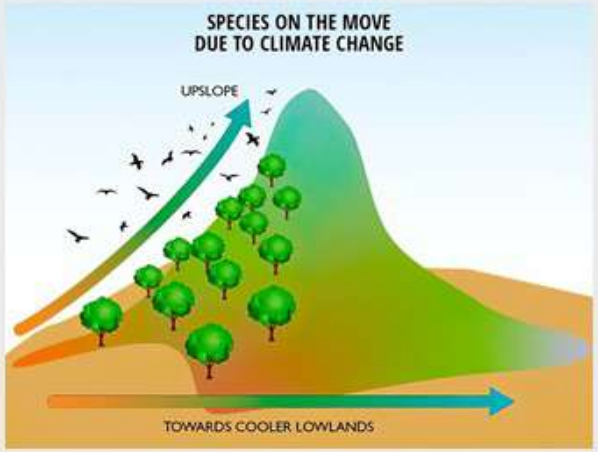
SANAP

EVOLUTIONARY BIOLOGY





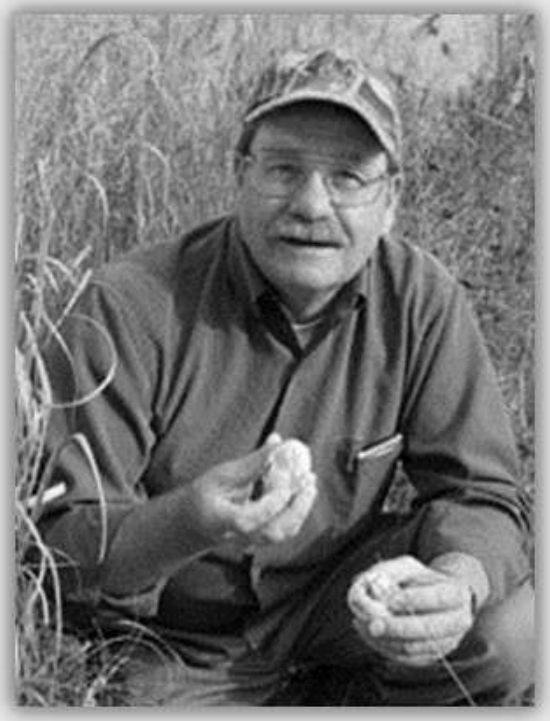
Historical (past speciation)



Contemporary (climate change)

INTRODUCTION

LANDSCAPE ECOLOGY



> Landscape ecology is the study of the **pattern and interaction between ecosystems** within a region of interest, and the way the **interactions affect ecological processes**, especially the unique **effects of spatial heterogeneity** on these interactions.
>
> William Clark (Prof Emeritus, Iowa State University)
> Principles of Landscape Ecology, Nature Education Knowledge, 2010

INTRODUCTION

LANDSCAPE ECOLOGY

White-plumed Honeyeater (Amos et al., 2012, 2014)

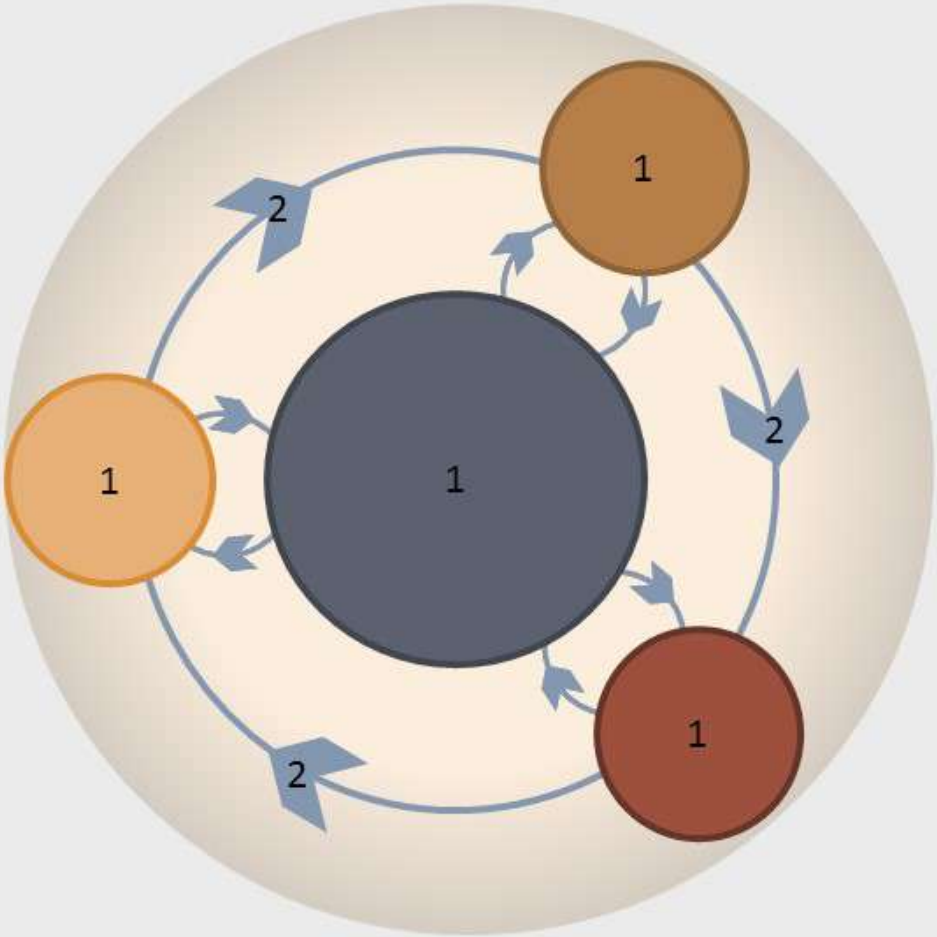
Eastern Fox Snake (Row et al., 2010)

Landscape heterogeneity
- Inter-habitat distance
- Matrix composition
- Barriers

Intrinsic characteristics
- Dispersal strategies
- Vagility through land-cover types
- Male vs female

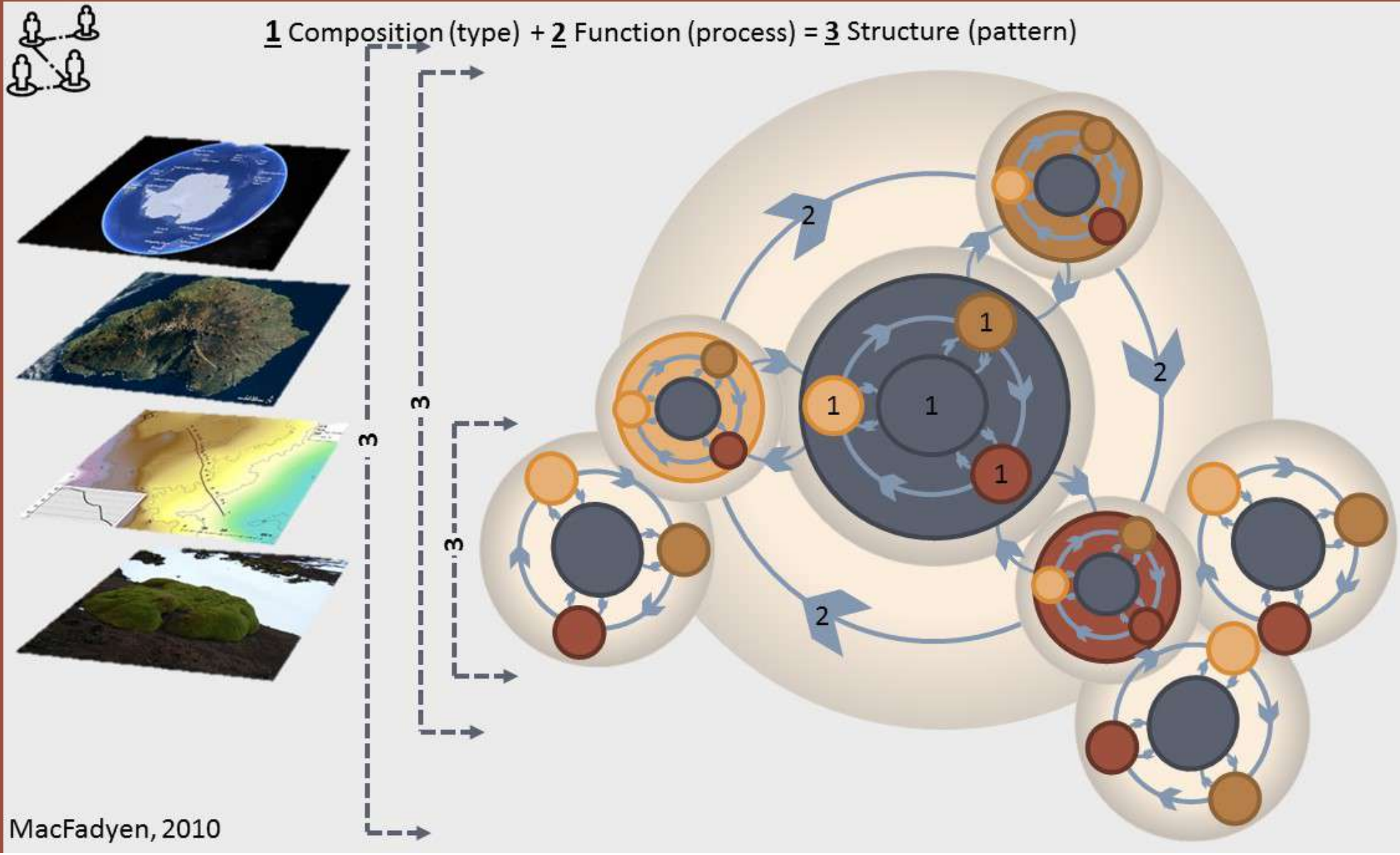
POPULATION DYNAMICS

1 Composition (type) + **2** Function (process) = **3** Structure (pattern)



MacFadyen, 2010

POPULATION DYNAMICS



INTRODUCTION

LANDSCAPE GENETICS

Review TRENDS in Ecology and Evolution Vol.18 No.4 April 2003 189

2003

Landscape genetics: combining landscape ecology and population genetics

Stéphanie Manel[1], Michael K. Schwartz[2], Gordon Luikart[1] and Pierre Taberlet[1]

Heredity (2007) 98, 128–142

www.nature.com/hdy

2007

REVIEW

Putting the 'landscape' in landscape genetics

A Storfer[1], MA Murphy[1], JS Evans[2], CS Goldberg[3], S Robinson[3], SF Spear[1], R Dezzani[4], E Delmelle[4], L Vierling[5] and LP Waits[3]

MOLECULAR ECOLOGY

Molecular Ecology (2010) 19, 3496–3514 doi: 10.1111/j.1365-294X.2010.04691.x

2010

Landscape genetics: where are we now?

ANDREW STORFER,* MELANIE A. MURPHY,† STEPHEN F. SPEAR,‡§ ROLF HOLDEREGGER¶ and LISETTE P. WAITS§

Review

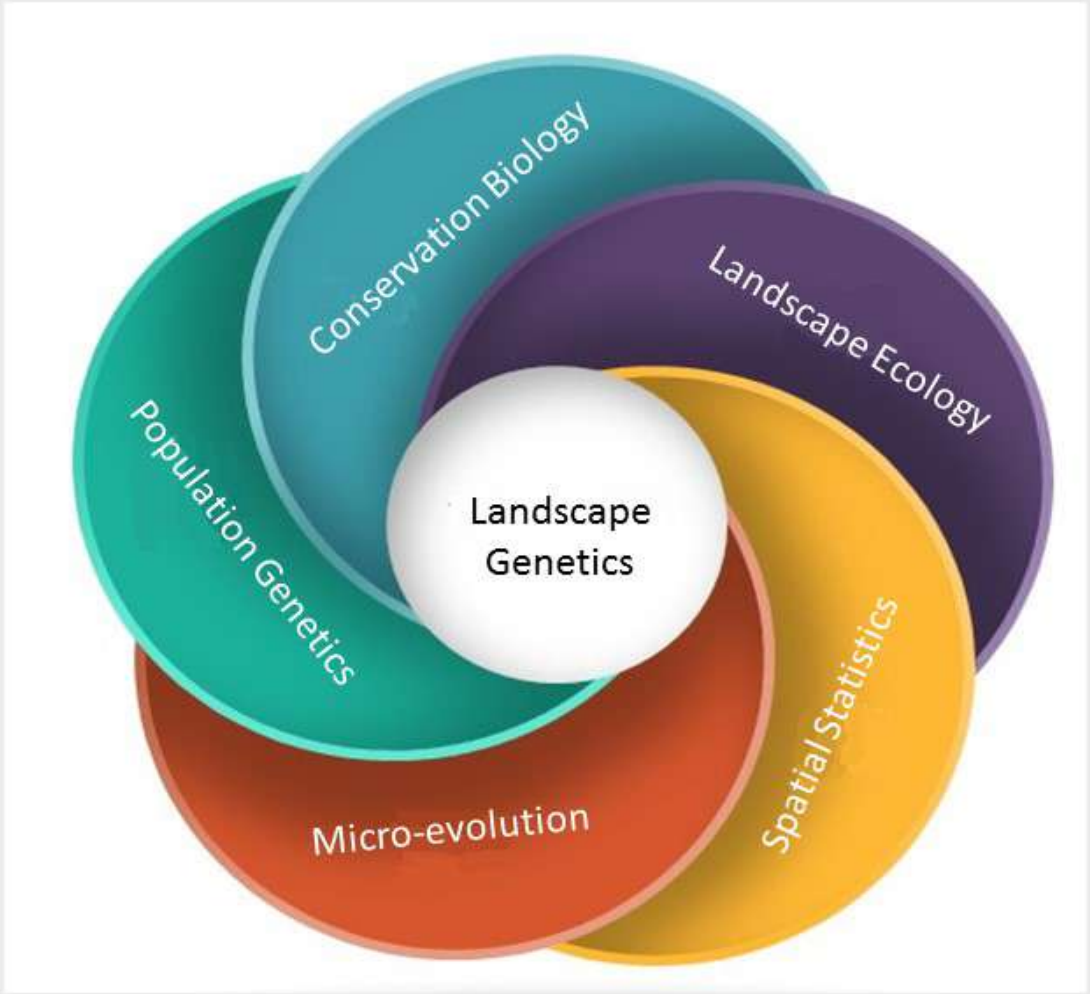
2013

Cell PRESS

Ten years of landscape genetics

Stéphanie Manel[1,2] and Rolf Holderegger[3,4]

LANDSCAPE GENETICS



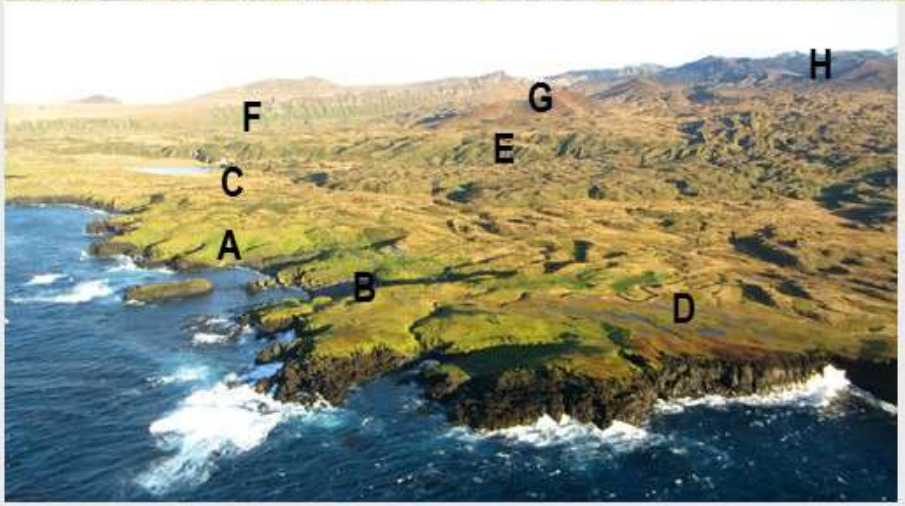
Adapted from Murphy and Evans, 2011

INTRODUCTION

WHAT SHAPES BIODIVERSITY PATTERNS ON MARION ISLAND?

1. Island history
2. Climate
3. Heterogeneous landscape
4. The organism

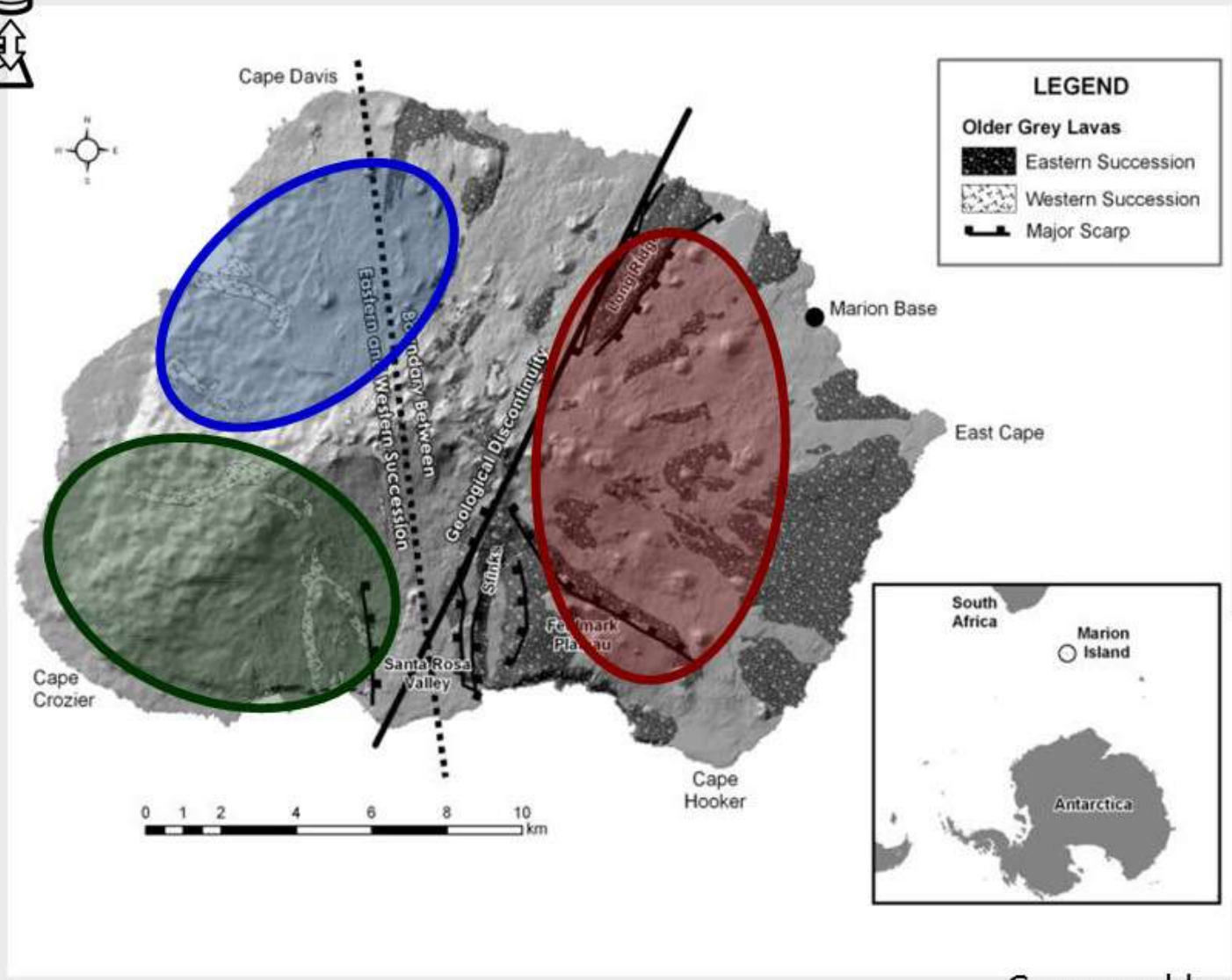
Cryptopygus antarcticus travei



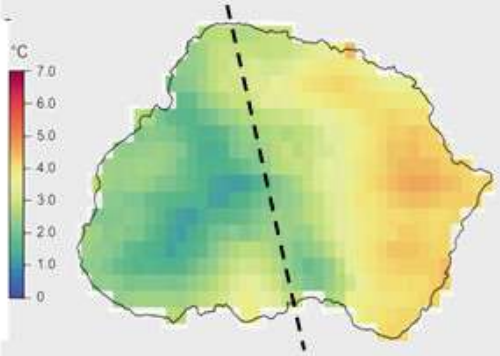
A – ST 1 sub-Antarctic Coastal Vegetation
B – ST 2 sub-Antarctic Biotic Herbfield and Grassland
C – ST 3 sub-Antarctic Mire
D – ST 4 sub-Antarctic Drainage Line and Spring Vegetation
E - ST 5 sub-Antarctic Fernbrake Vegetation
F - ST 6 sub-Antarctic Fellfield
G – ST 7 sub-Antarctic Cinder Cone Vegetation
H – PD 1 sub-Antarctic Polar Desert

SCALE

PREVIOUS RESEARCH - LARGE SPATIAL SCALES



Pringleophaga marioni



Groenewald, unpublished; Leihy et al., 2018

PREVIOUS RESEARCH - FINE SPATIAL SCALES

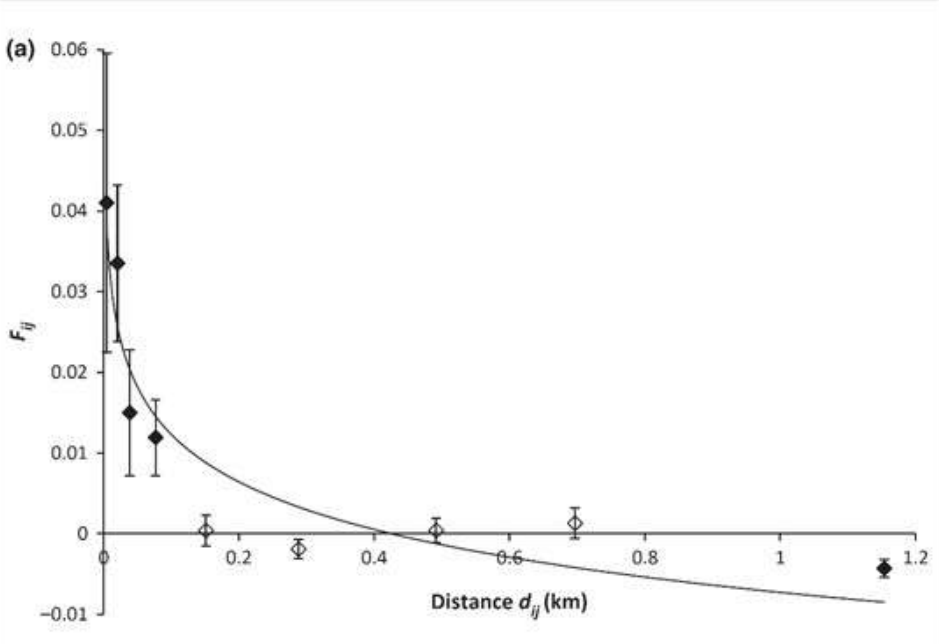
MOLECULAR ECOLOGY

Molecular Ecology (2012) 21, 184–194 doi: 10.1111/j.1365-294X.2011.05372.x

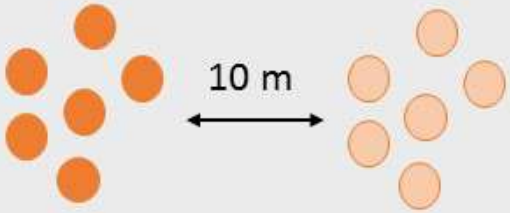
Plant dispersal in the sub-Antarctic inferred from anisotropic genetic structure

CÉLINE BORN,* PETER C. LE ROUX,†[1] COLIN SPOHR,* MELODIE A. McGEOCH†,‡ and BETTINE JANSEN VAN VUUREN*,†[2]

*Evolutionary Genomics Group, Department of Botany and Zoology, Stellenbosch University, Private Bag X1, Matieland 7602, South Africa, †Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University, Private Bag X1, Matieland 7602, South Africa, ‡Cape Research Centre, South African National Parks, PO Box 216, Steenberg 7947, South Africa

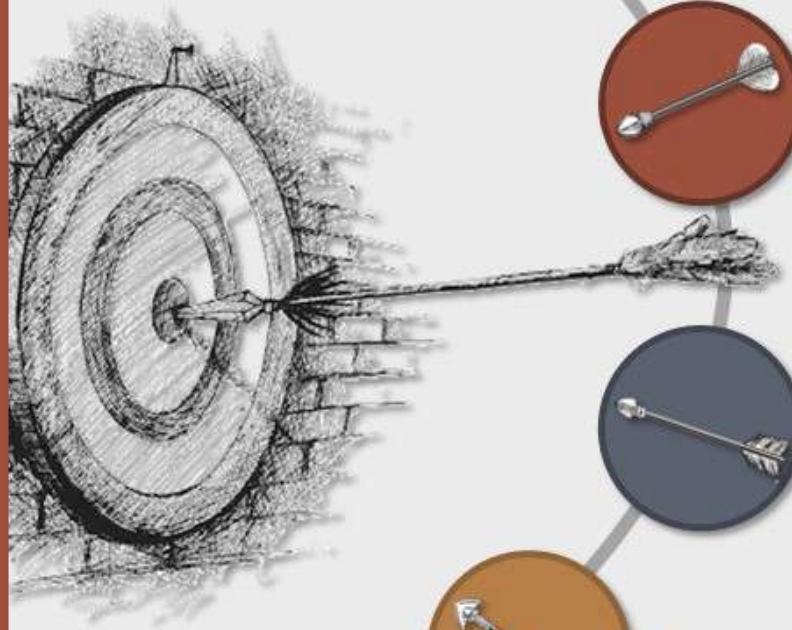


Azorella selago



RESEARCH AIMS

CURRENT STUDY - AIMS



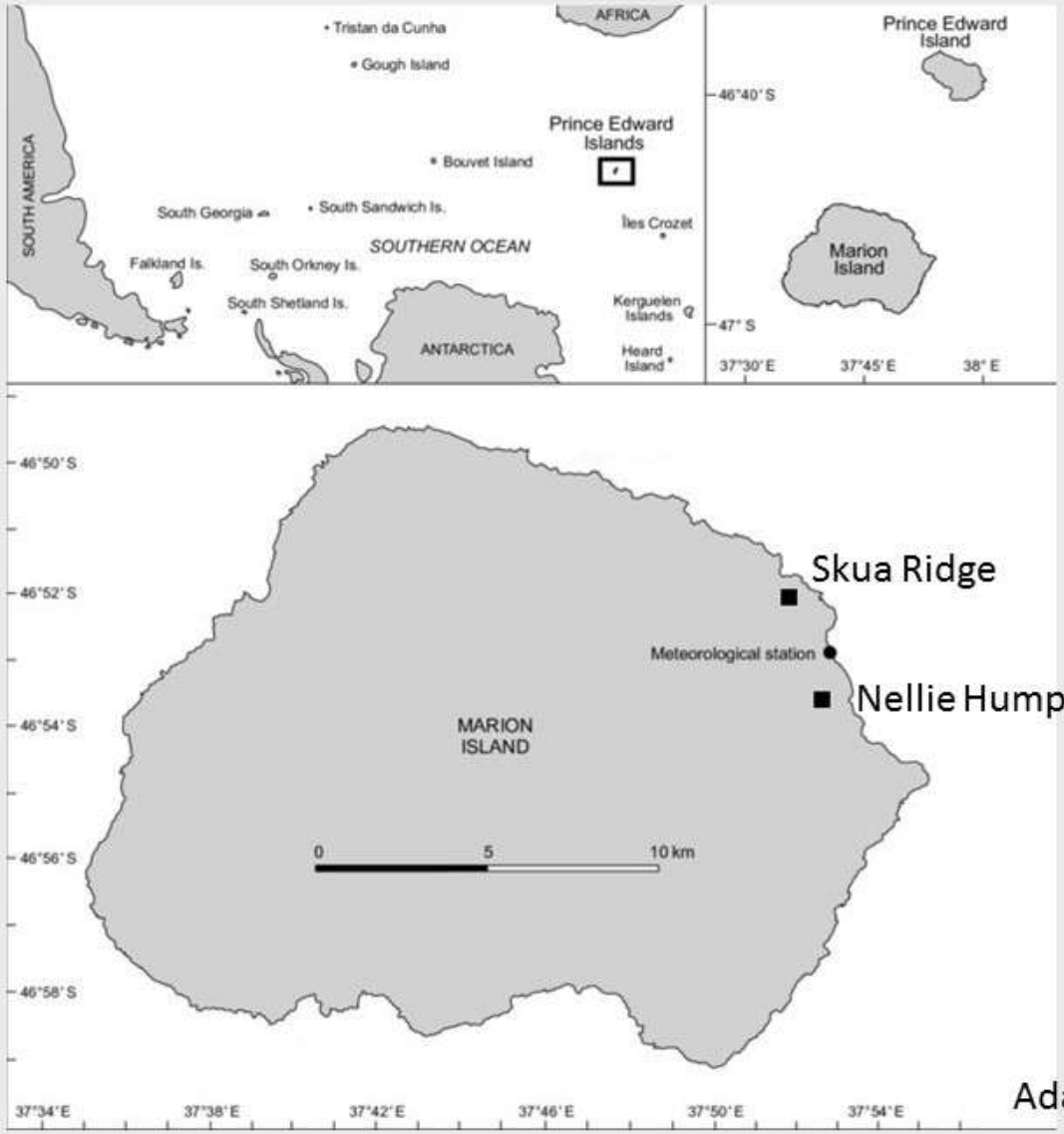
1. Explore genetic structure of a springtail endemic to Marion Island
2. Identify landscape features that facilitate or impede gene flow
3. Identify the role that the environment plays in shaping genetic structure
4. Determine the direction and drivers of gene flow

METHODS

CURRENT STUDY - WORKFLOW

METHODS

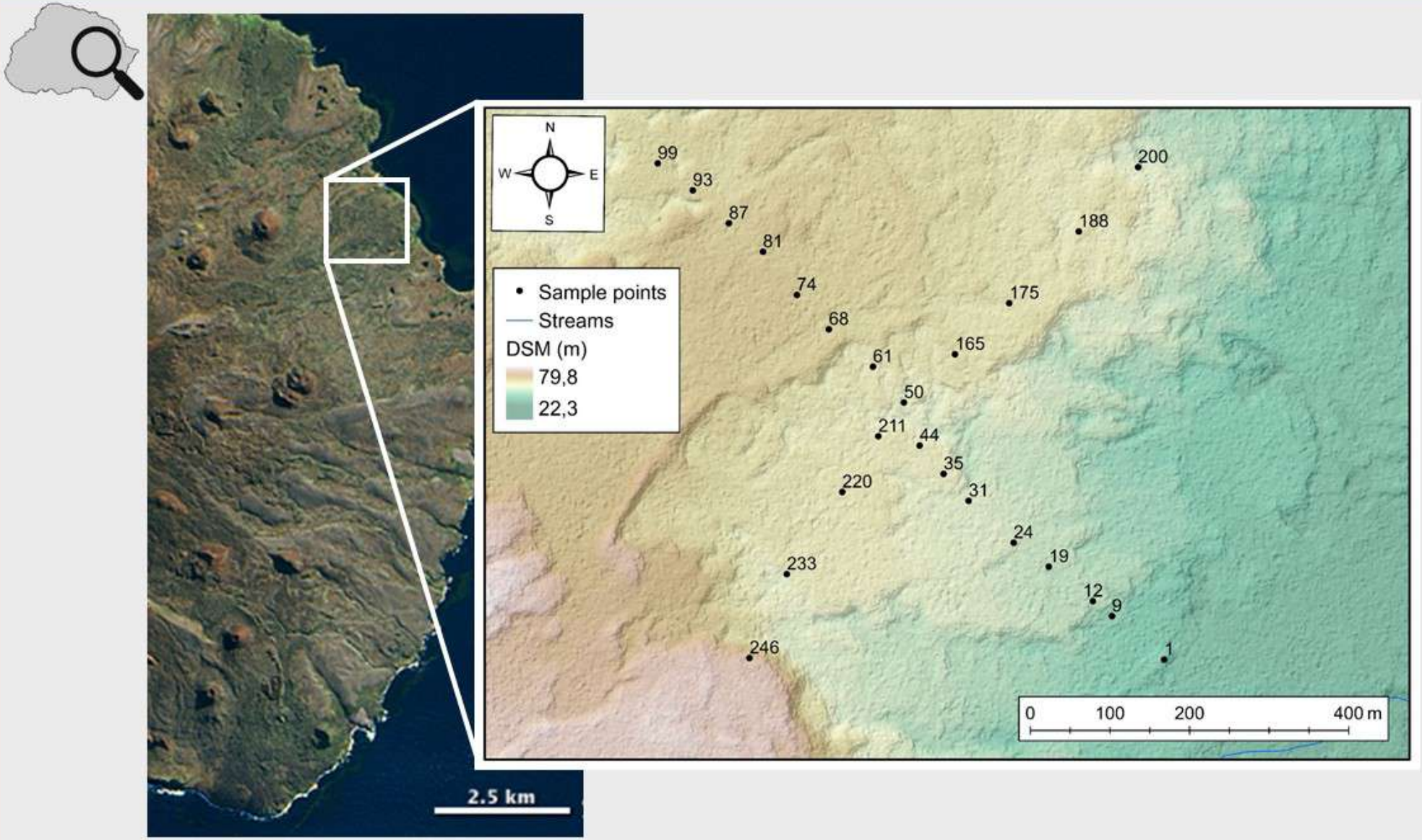
STUDY SITES



Adapted from Pistorius et al., 2011

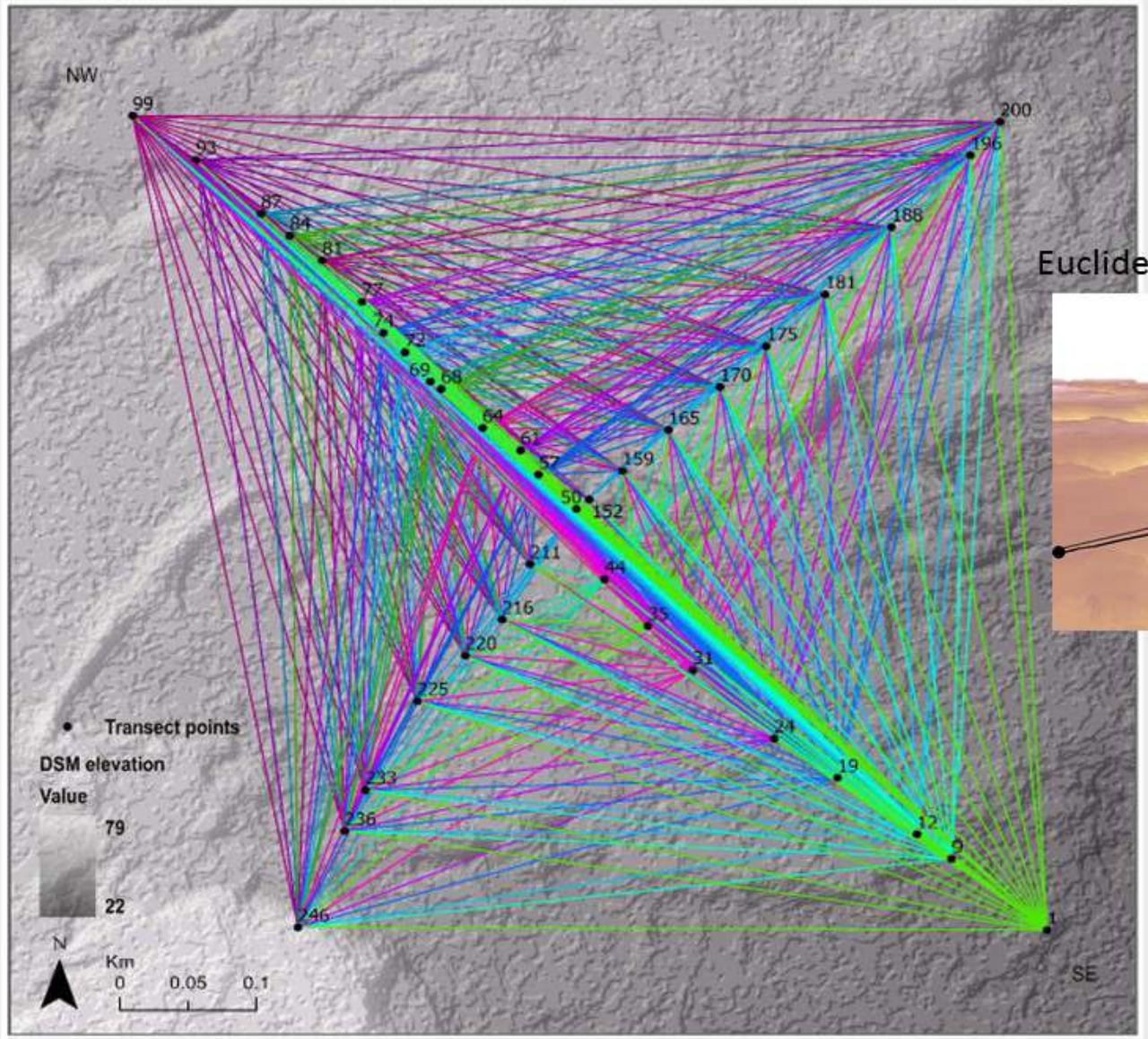
METHODS

NELLIE HUMPS TRANSECT

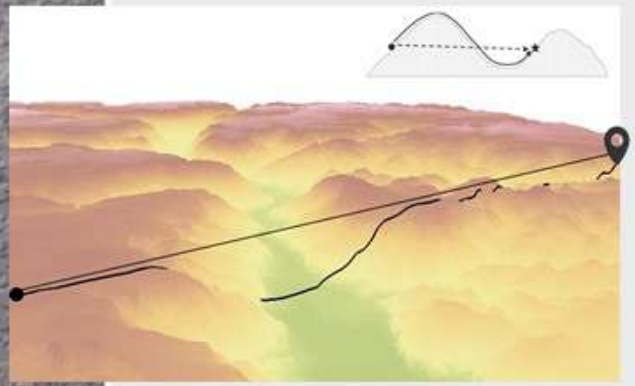


METHODS

CURRENT STUDY - WORKFLOW

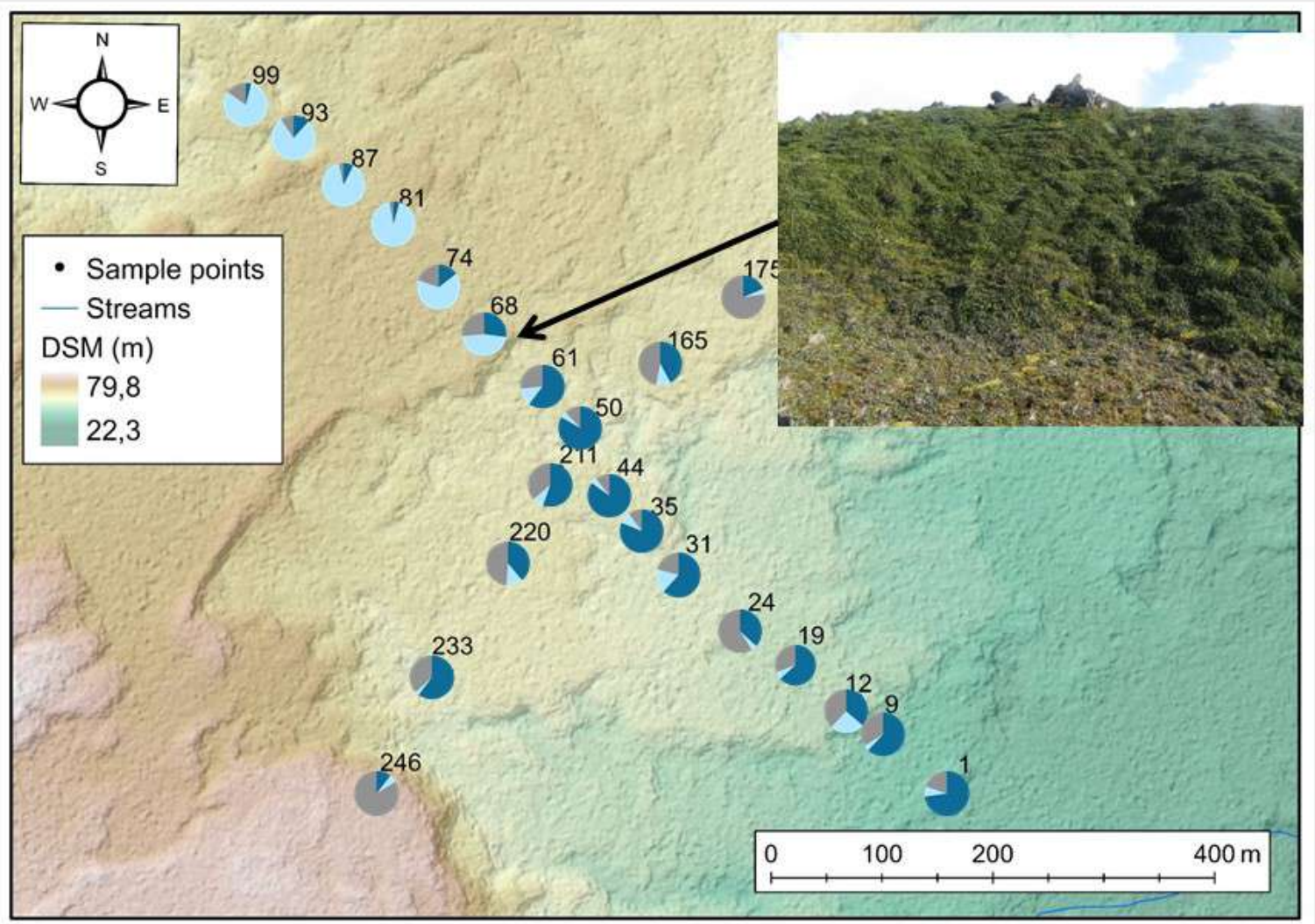


Euclidean distance vs surface distance



RESULTS

NELLIE HUMPS TRANSECT

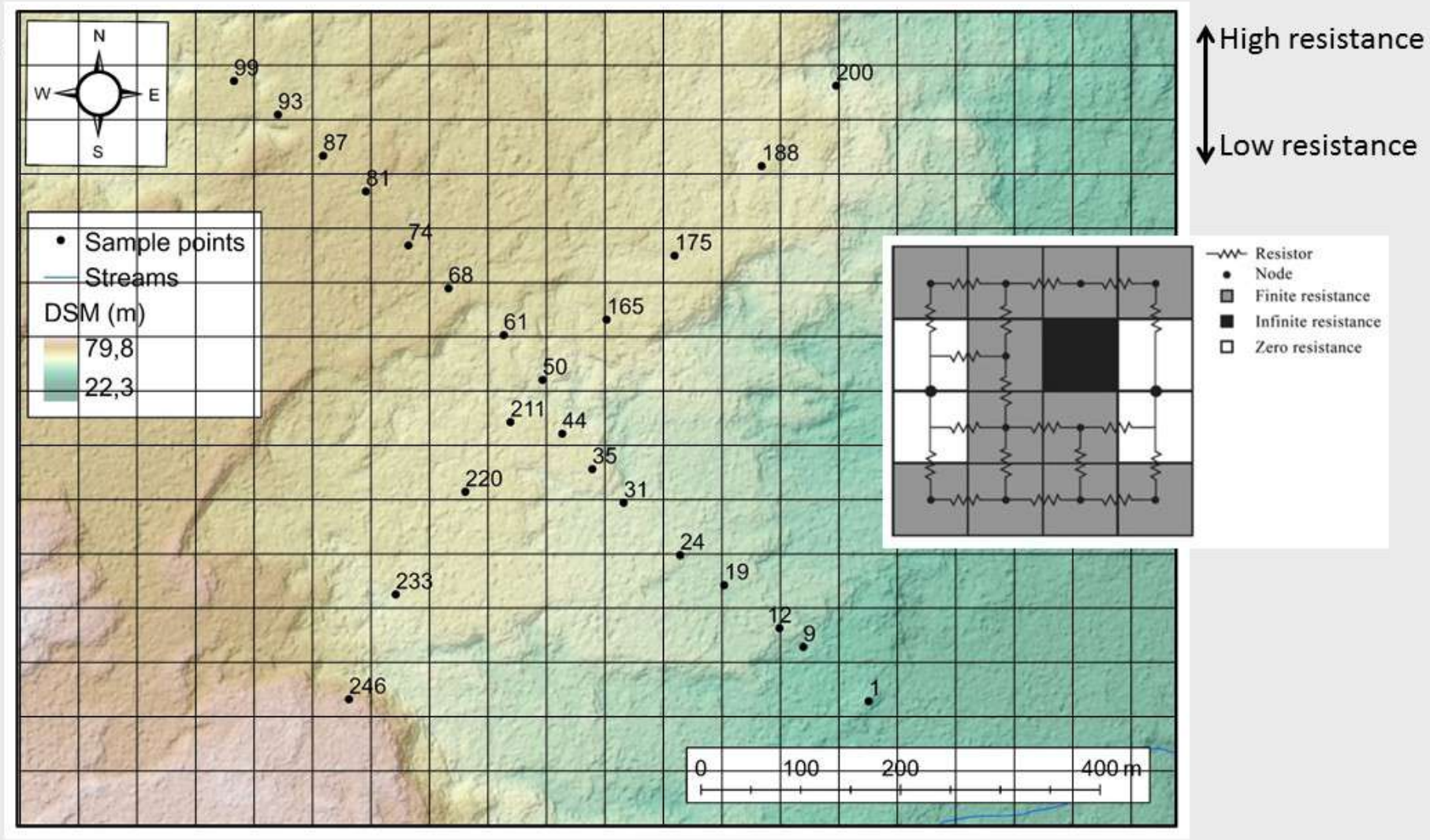


RESULTS

NELLIE HUMPS TRANSECT

RESULTS

NELLIE HUMPS TRANSECT



RESULTS

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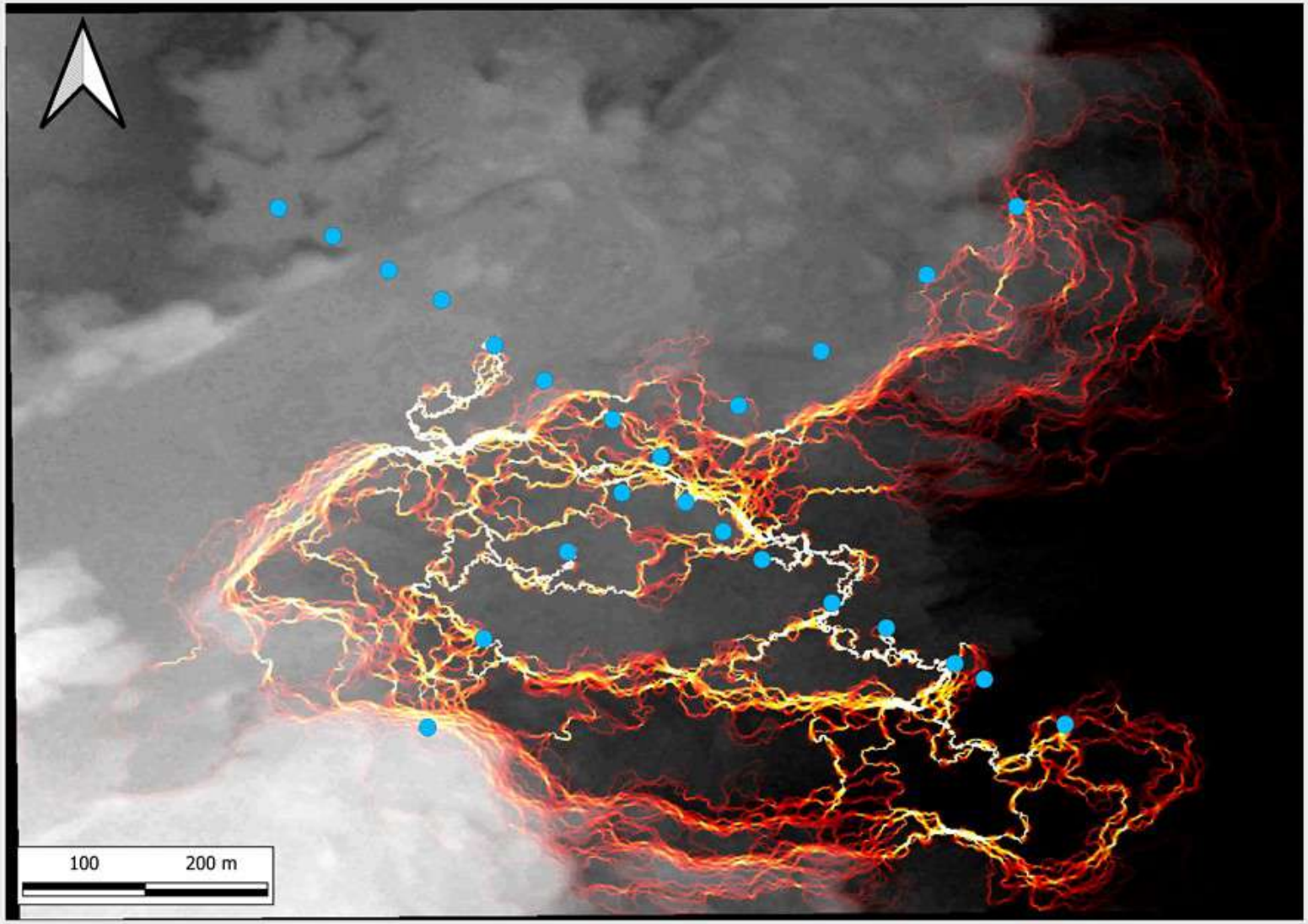


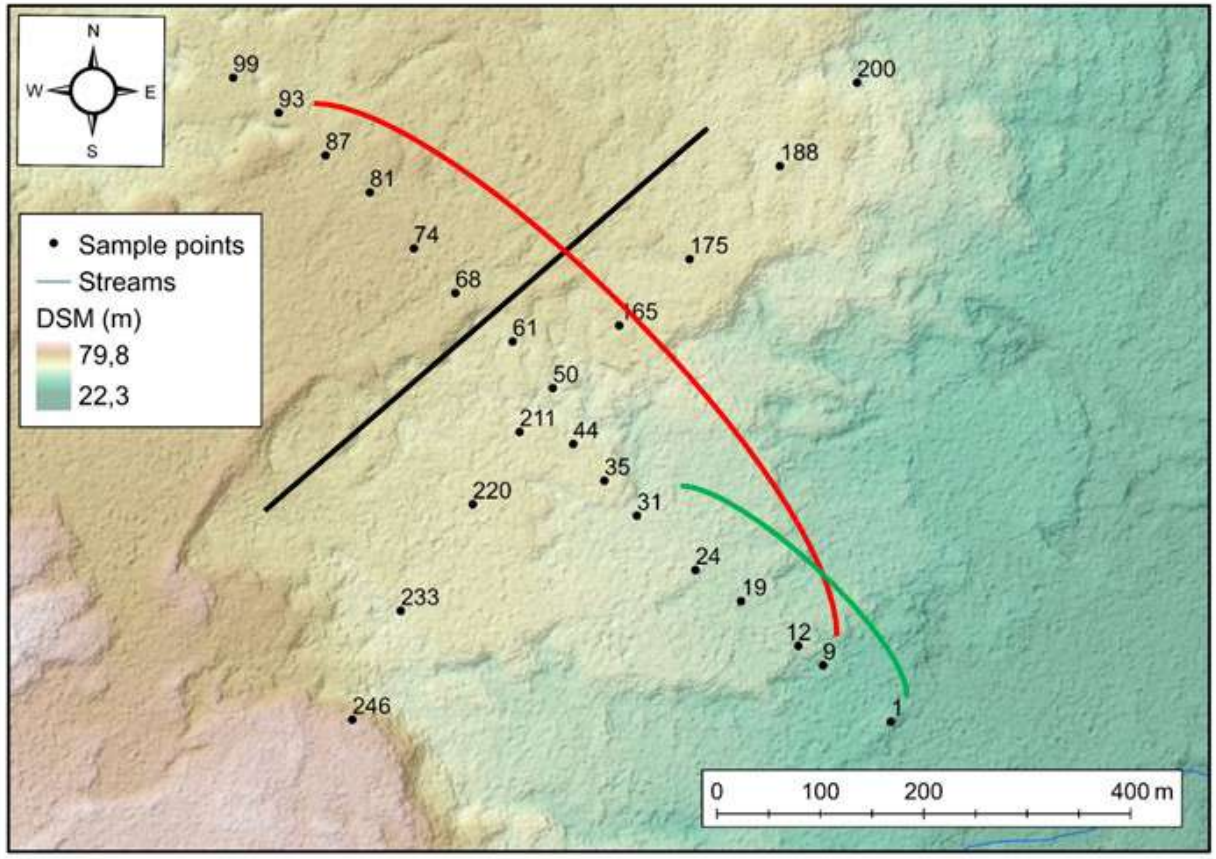
RESULTS

NELLIE HUMPS TRANSECT

Binary variable:

0 – No Barrier

1 – Barrier

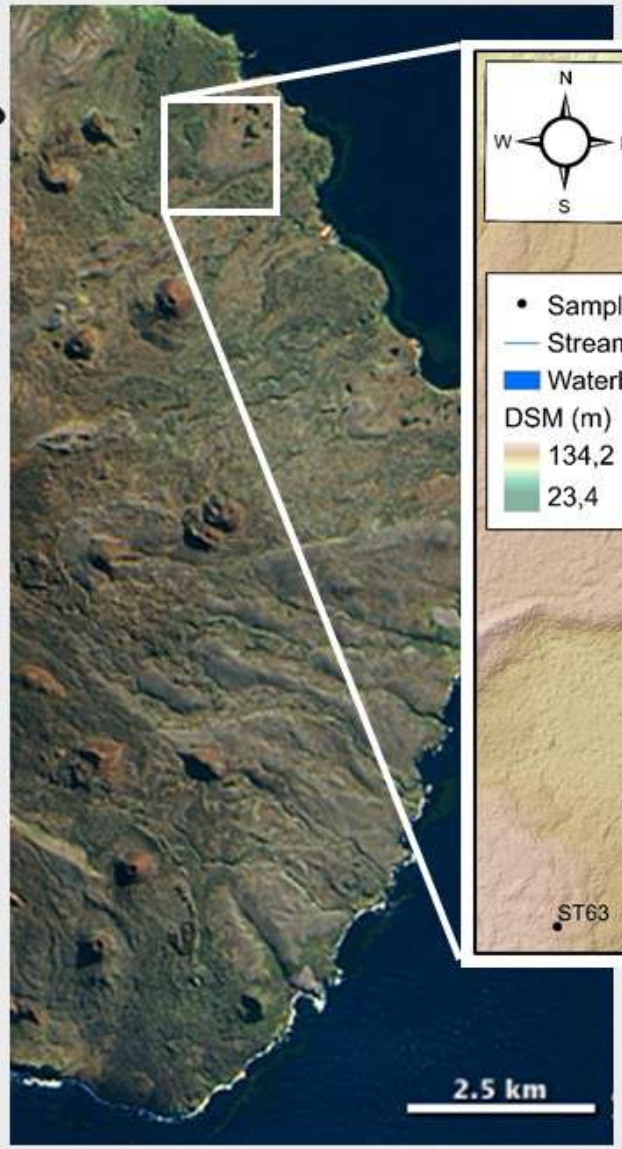


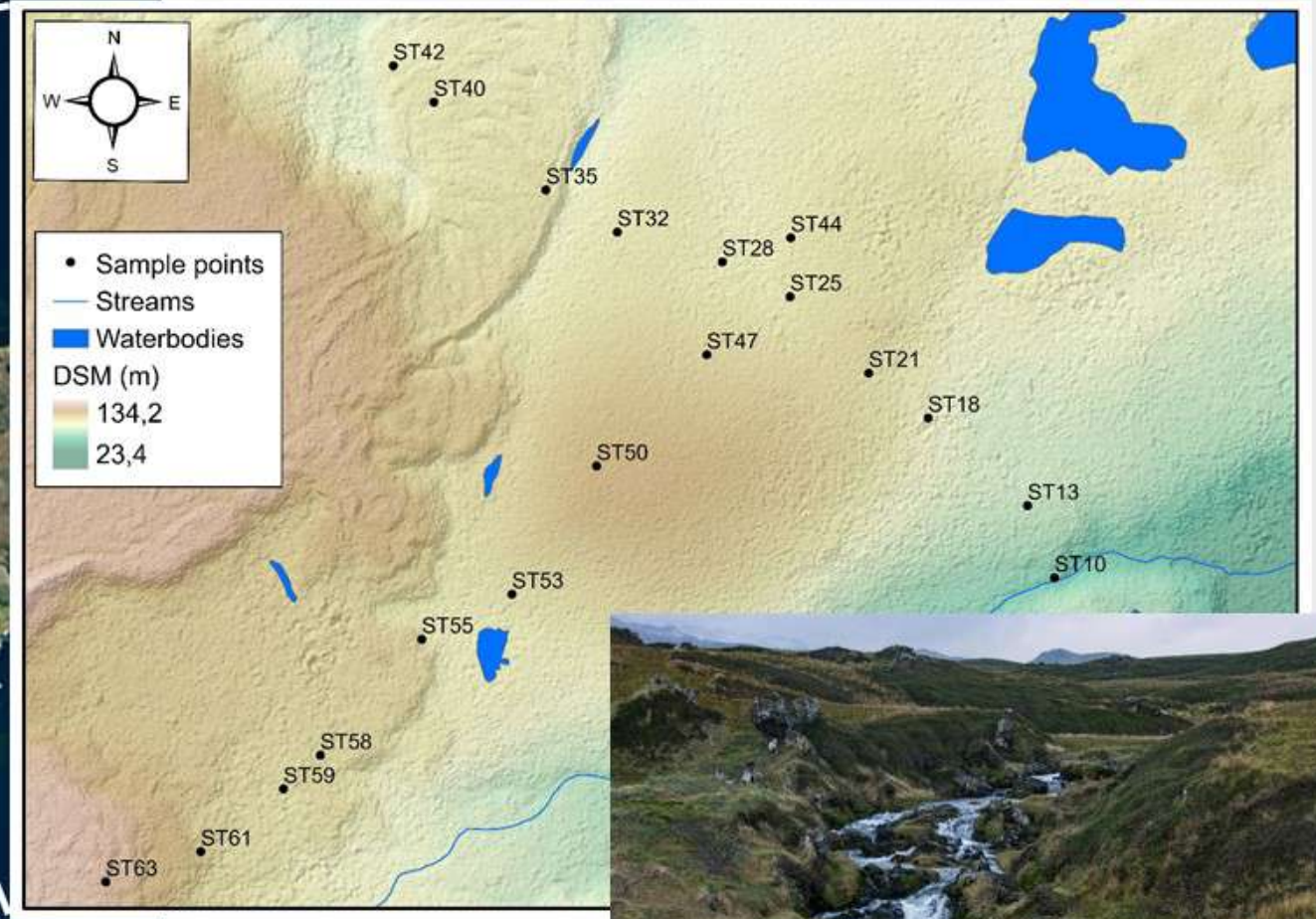
Generalized Linear Models

Model	AIC
Fij ~ Euclidean distance	-134232.5
Fij ~ Surface distance	-134232.8
Fij ~ Landscape resistance	-131806.8
Fij ~ barriers	-134090.3
Fij ~ Euclidean distance + Landscape resistance	-134234.6
Fij ~ Euclidean distance + Barriers	-135153.1
Fij ~ Surface distance + Landscape resistance	-134234.6
Fij ~ Surface distance + Barriers	-135155.8
Fij ~ Landscape resistance + barriers	-134152.0

RESULTS

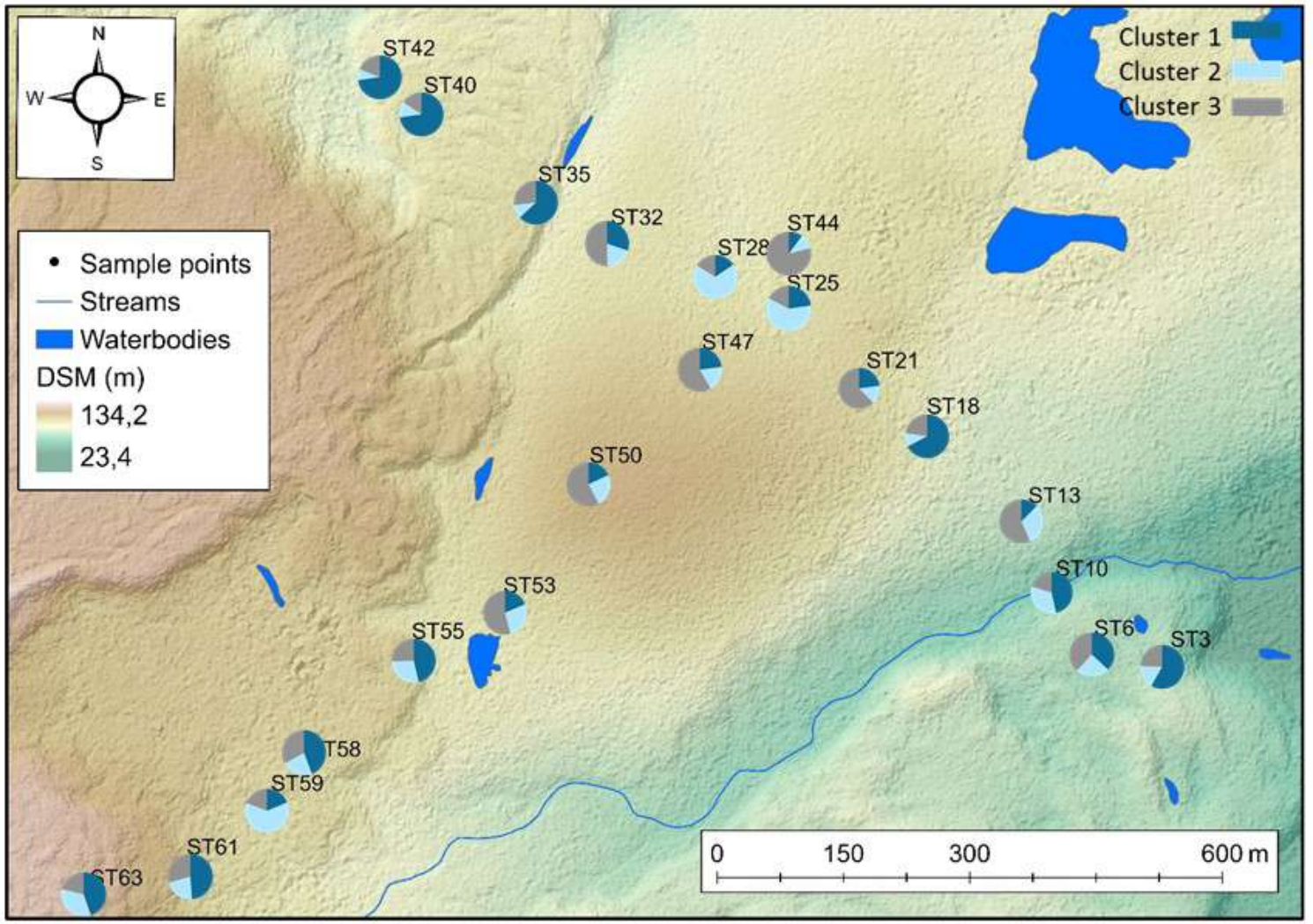
SKUA RIDGE TRANSECT

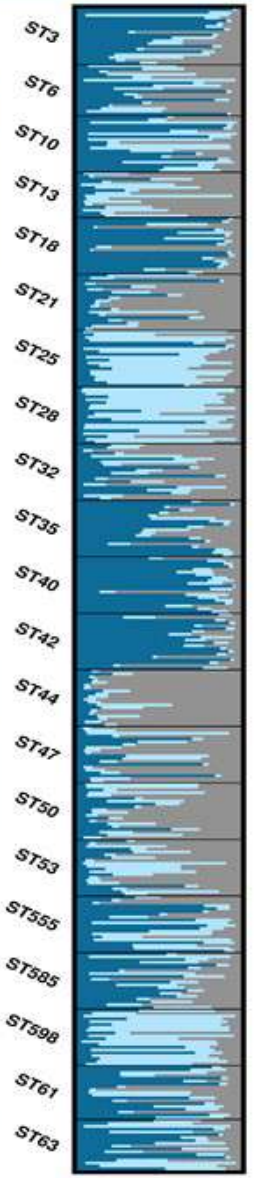




RESULTS

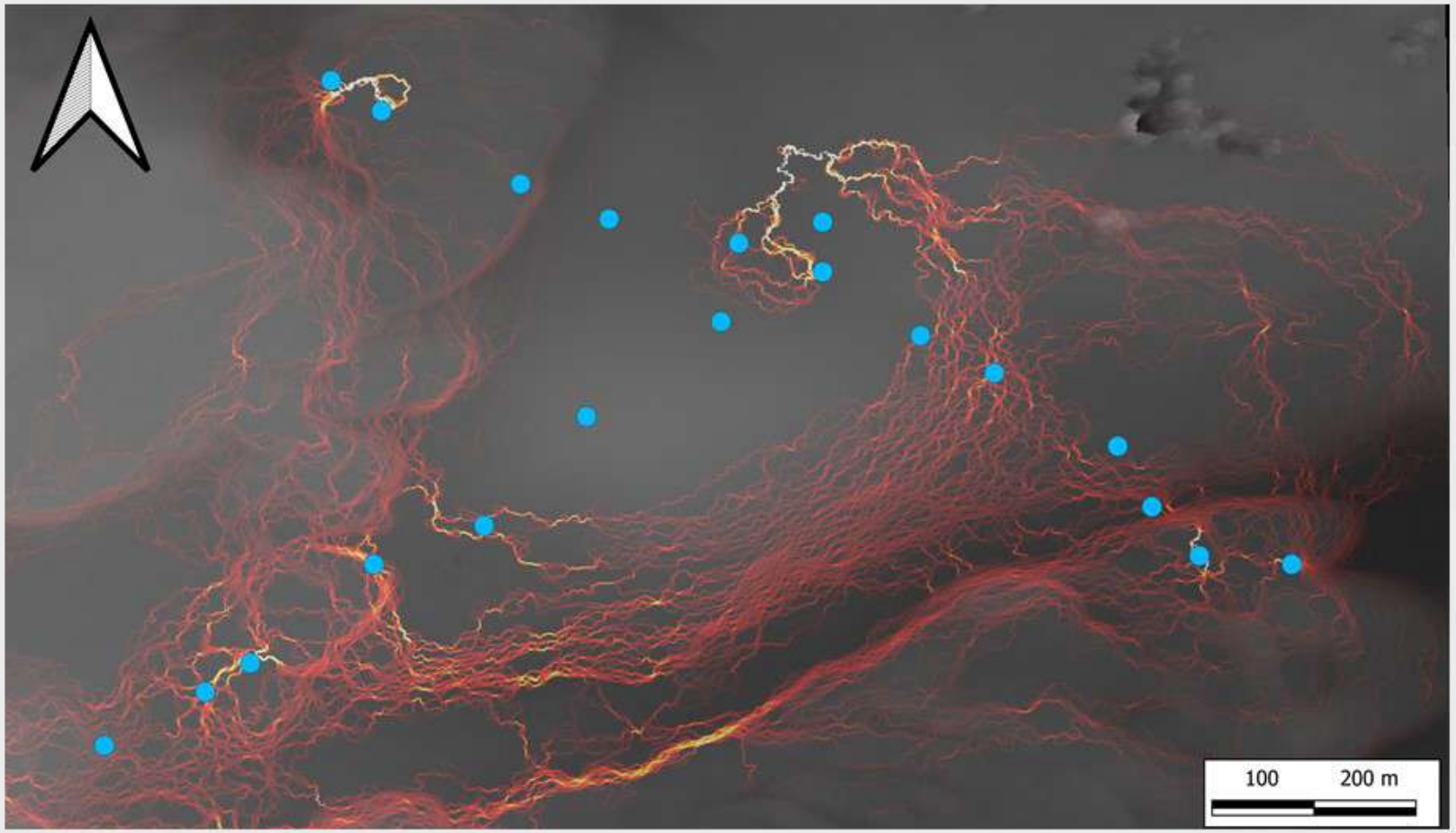
NELLIE HUMPS TRANSECT





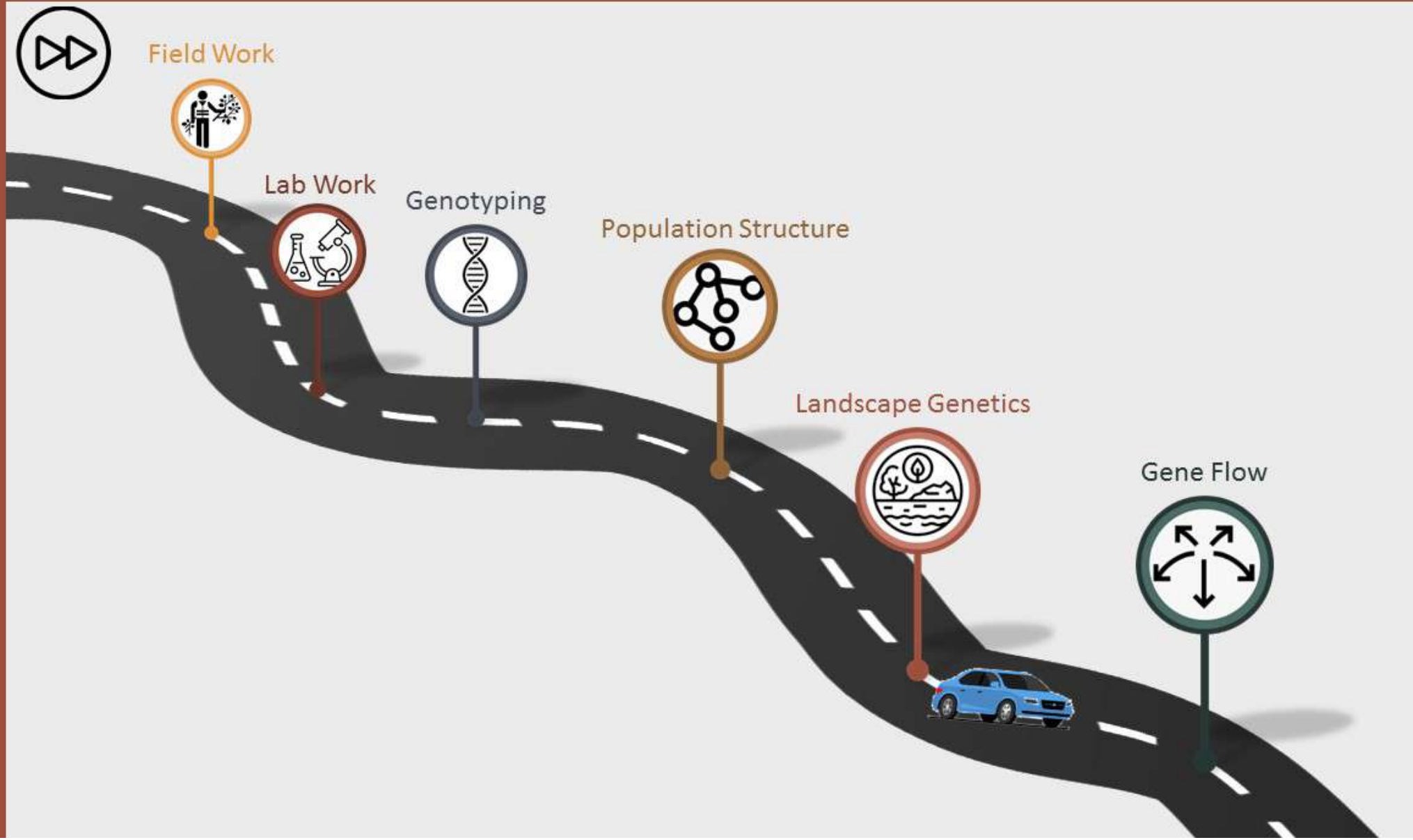
RESULTS

SKUA RIDGE TRANSECT



COMING SOON

WHAT'S NEXT?



COMING SOON

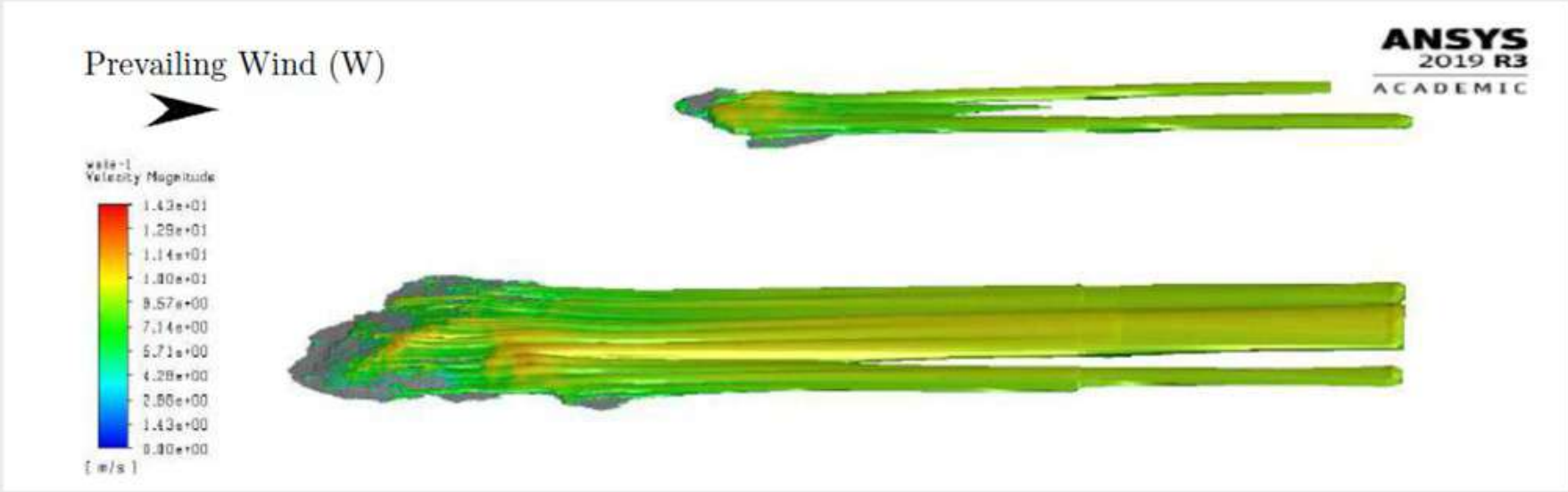
WHAT'S NEXT?

ELSEVIER

Ecological Modelling
Volume 464, February 2022, 109827

Investigation of ecologically relevant wind patterns on Marion Island using Computational Fluid Dynamics and measured data

K.A. Goddard [a], K.J. Craig [a], J. Schoombie [a], P.C. le Roux [b]



CONCLUSION

WHAT DOES THIS MEAN?

- Complex landscape = complex genetic patterns
- Utility of GIS-based landscapes
- Landscape distance and barriers shape structure
- Springtails as proxies to study landscape genetics
- Fine-scale work can inform us about:
  - Migratory patterns (gene flow)
  - Genetic neighbourhood
  - The biology of the species
  - Conservation

ACKNOWLEDGEMENTS

THANK YOU

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Ecological Genomics & Wildlife Conservation

Shilpa Parbhu

Matthew Adair

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