# Predictive Distribution Modeling as an Environmental Management Tool:

## A Case Study of *Cherax quadricarinatus* in Jamaican Rivers

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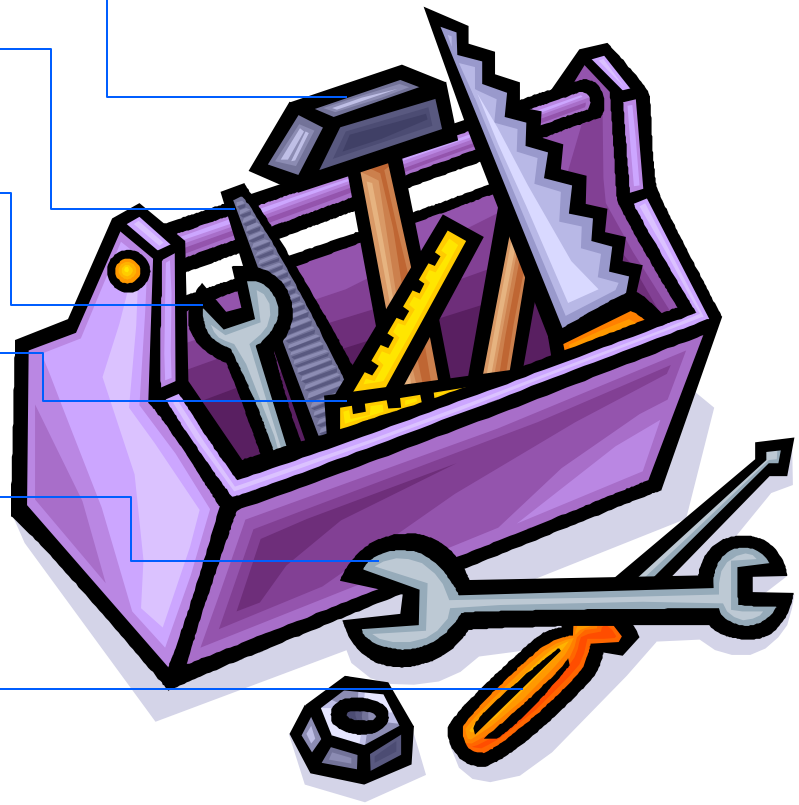
# Tools available to an Environmental Manager

- Quantitative Data
- Local Knowledge
- Past Experience
- Expert Opinion
- Simulated Models
- **SDMs**
- Etc.



# Species distribution model (SDM)

*(SDMs or 'ecological niche', 'environmental niche', 'habitat suitability' and 'bioclimate envelope' modeling)*

A model which uses a species' observed distribution and/or biological characteristics to predict its actual (or potential) distribution

- Observed : range within which species has been sighted
- Actual : species' current distribution
- Potential : range within which the species could be found

*Term is widespread but somewhat misleading since **it is actually the distribution of suitable environments that is being modelled**, **rather than the species' distribution per se***

# Why model species distributions?

- Important component of conservation planning
- Improve our understanding of species-habitat relationships in space and time
- Predict patterns of biodiversity
- Identify areas of conservation significance
- **Predict species invasions and identify areas at risk**
- Identify suitable areas for reintroducing species
- Locating study sites……etc

# Determining Invasive Potential

- Islands susceptible to invasion owing to small size and geographical isolation (see Sax & Brown, 2000)

- Jamaica - long history of species introductions (see Espeut & Grant, 1990; Mahon & Aiken, 1977)

# *Cherax quadricarinatus*

(redclaw crayfish)

# Research Questions

- Which environmental variables are more important in the determination of redclaw distribution?
- Which of the modelling methods performed better at analysing redclaw distribution in the rivers selected?

# Methodology

- Statistical modeling (Generalized Linear Model, GLM)
  - Models the behavior of a random process
  - Utilizes samples of output data to construct a representation of the process
  - Predicts the future behavior of the process

Vs

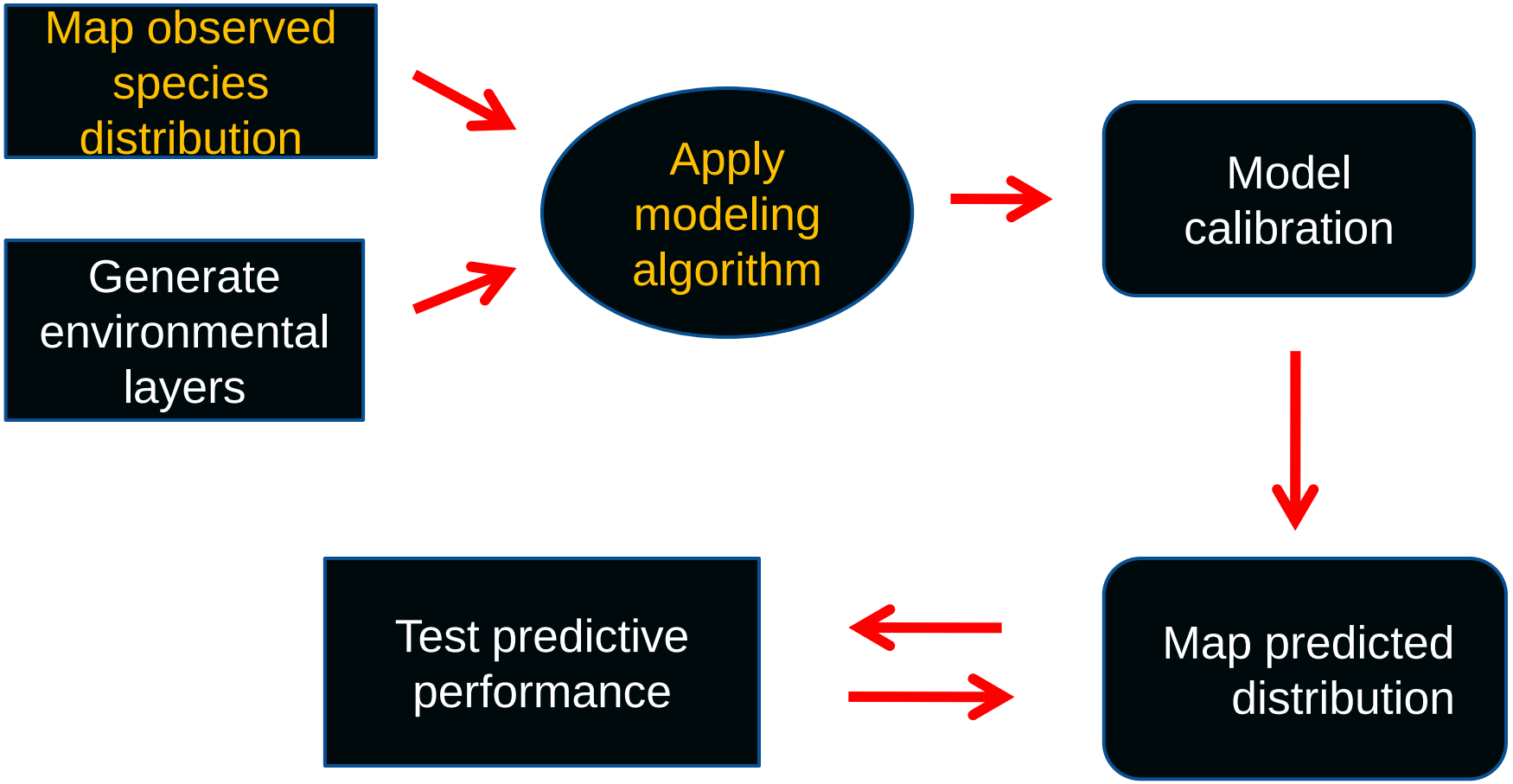
- Maximum Entropy Models (Maxent)
  - A family of distributions within the class of exponential models for statistical modeling

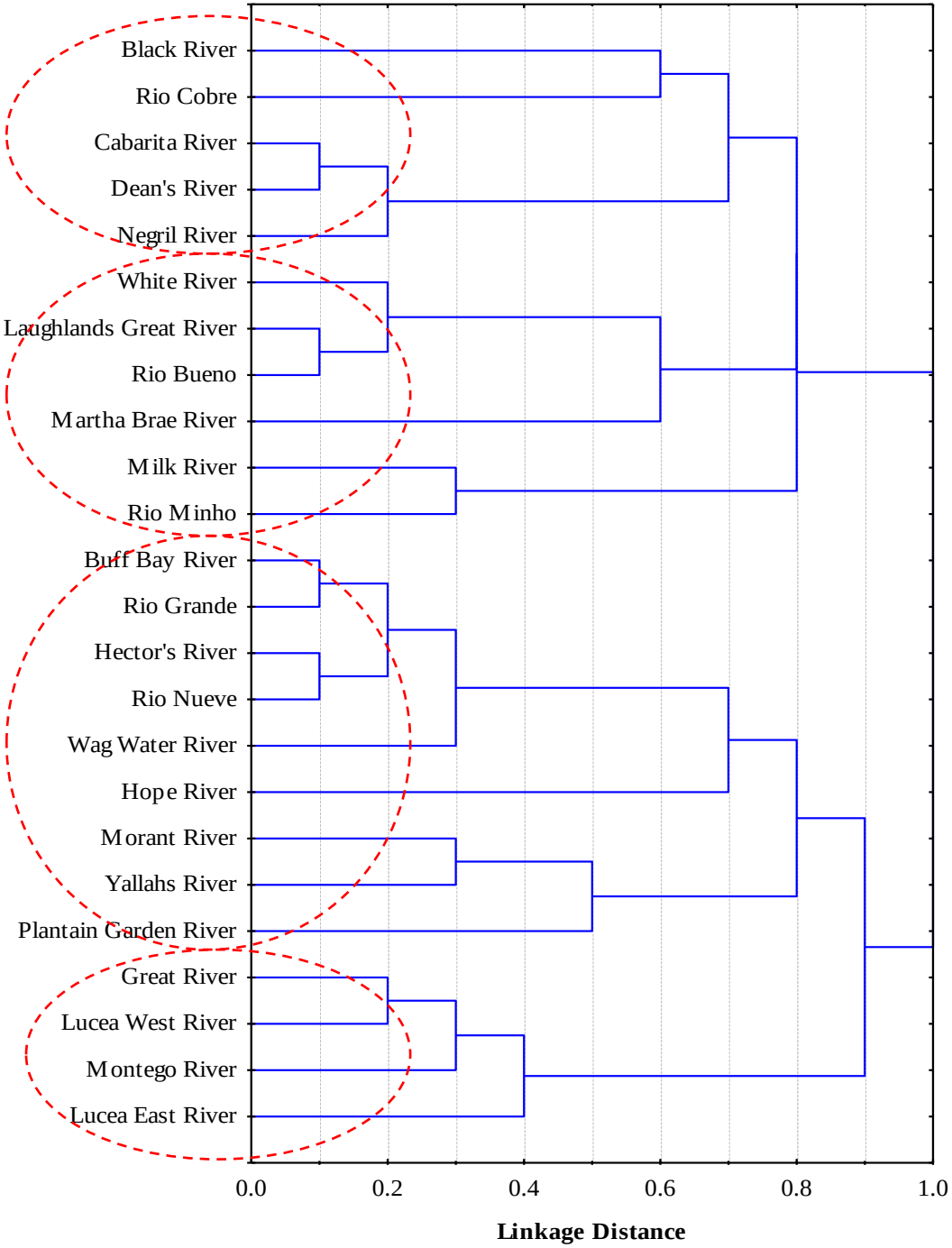
# SDMs

Assume the following knowledge and skills:

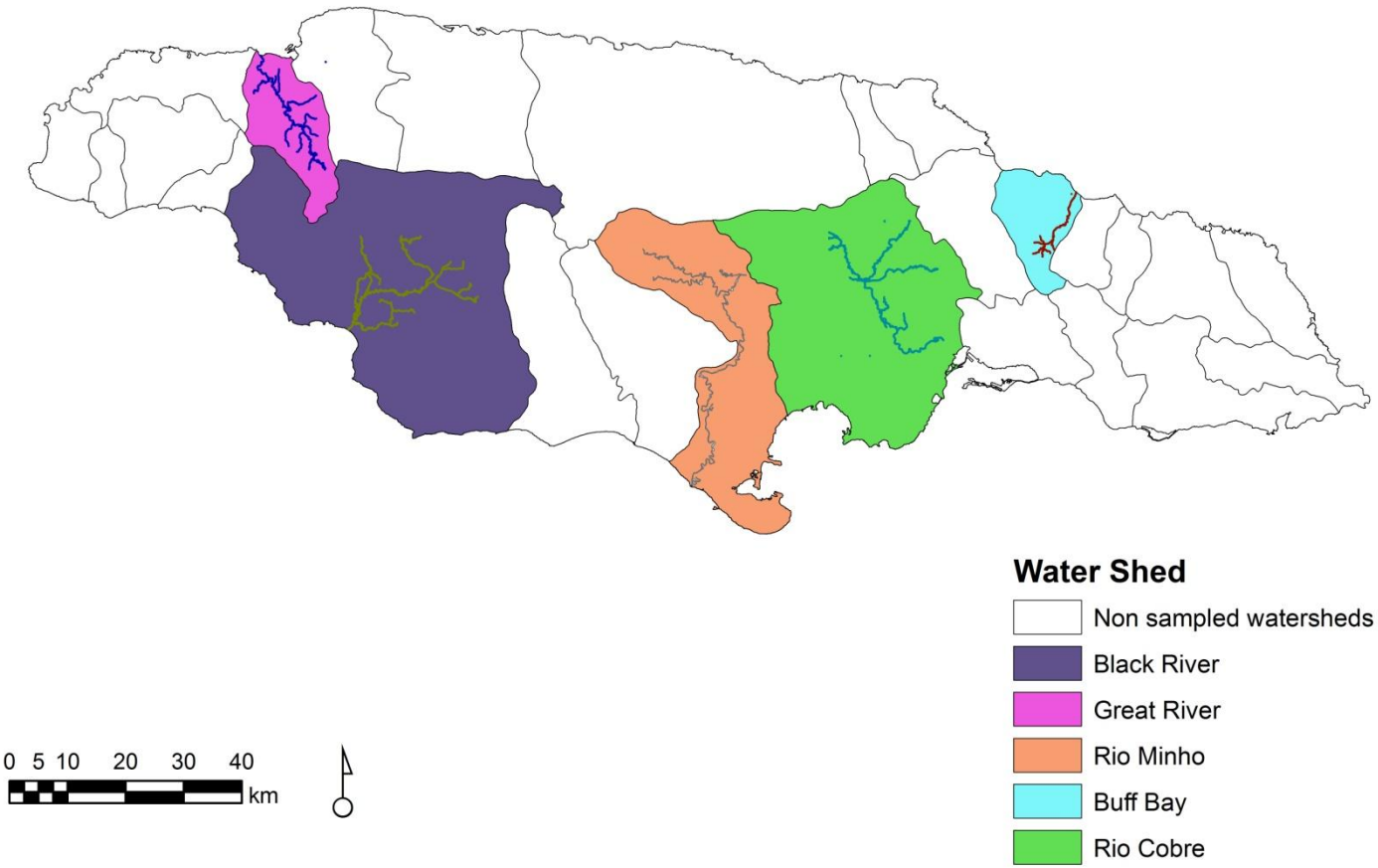
1. **Ability to use GIS** (e.g. manipulate raster & ASCII files)
2. **Statistical skills**
3. **Understanding the ecological principles** of species' geographical range limits in order to carry out and interpret the modelling appropriately

# Logic flow for correlative SDMs

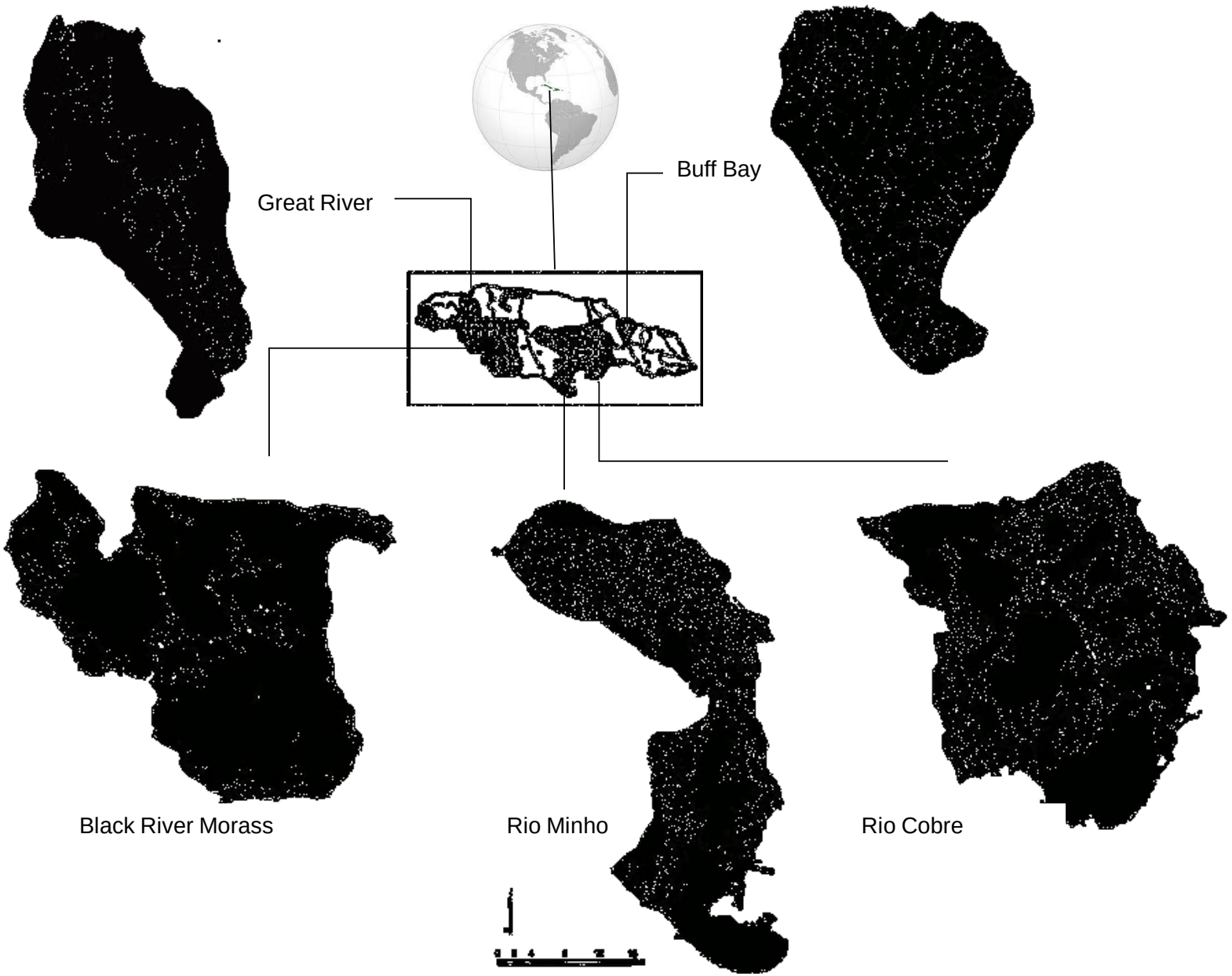



Black River
Rio Cobre
Cabarita River
Dean's River
Negril River
White River
Laughlands Great River
Rio Bueno
Martha Brae River
Milk River
Rio Minho
Buff Bay River
Rio Grande
Hector's River
Rio Nueve
Wag Water River
Hope River
Morant River
Yallahs River
Plantain Garden River
Great River
Lucea West River
Montego River
Lucea East River
0.0
0.2
0.4
0.6
0.8
1.0
Linkage Distance

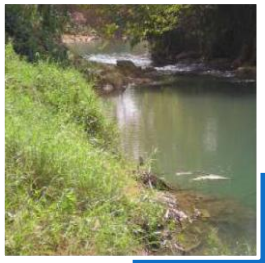
# Samplied rivers in their respective watersheds



# Model Sites



# Physicochemical parameters used

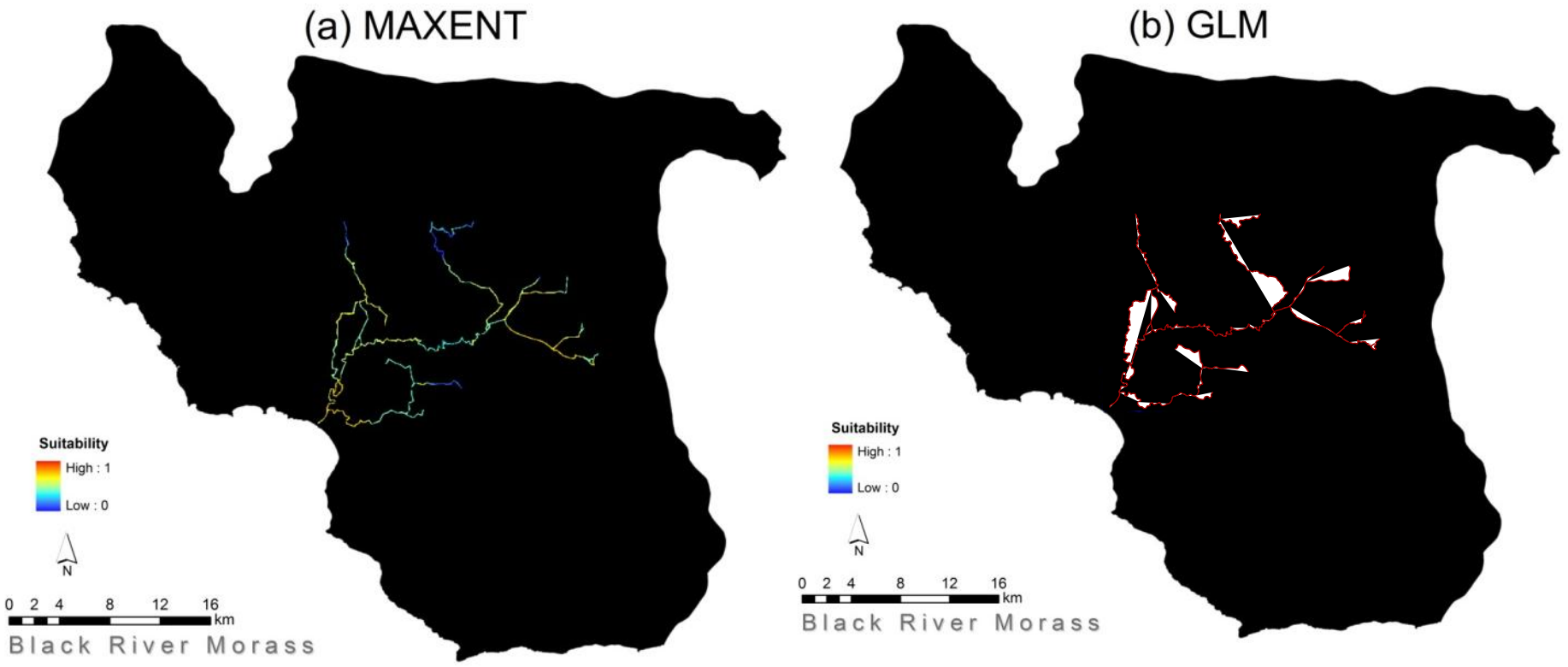


- Total dissolved oxygen (mg $L^{-1}$)
- Dissolved oxygen (% saturation)
- pH
- Conductivity (µS $cm^{-1}$)
- Redox potential/ORP
- Temperature ($^0$C)
- Flow rate (m/s)
- Salinity (pps)
- Turbidity
- Hardness (mgCaCo3)
- Nitrates
- Water velocity ($ms^{-1}$)
- Water depth (m)

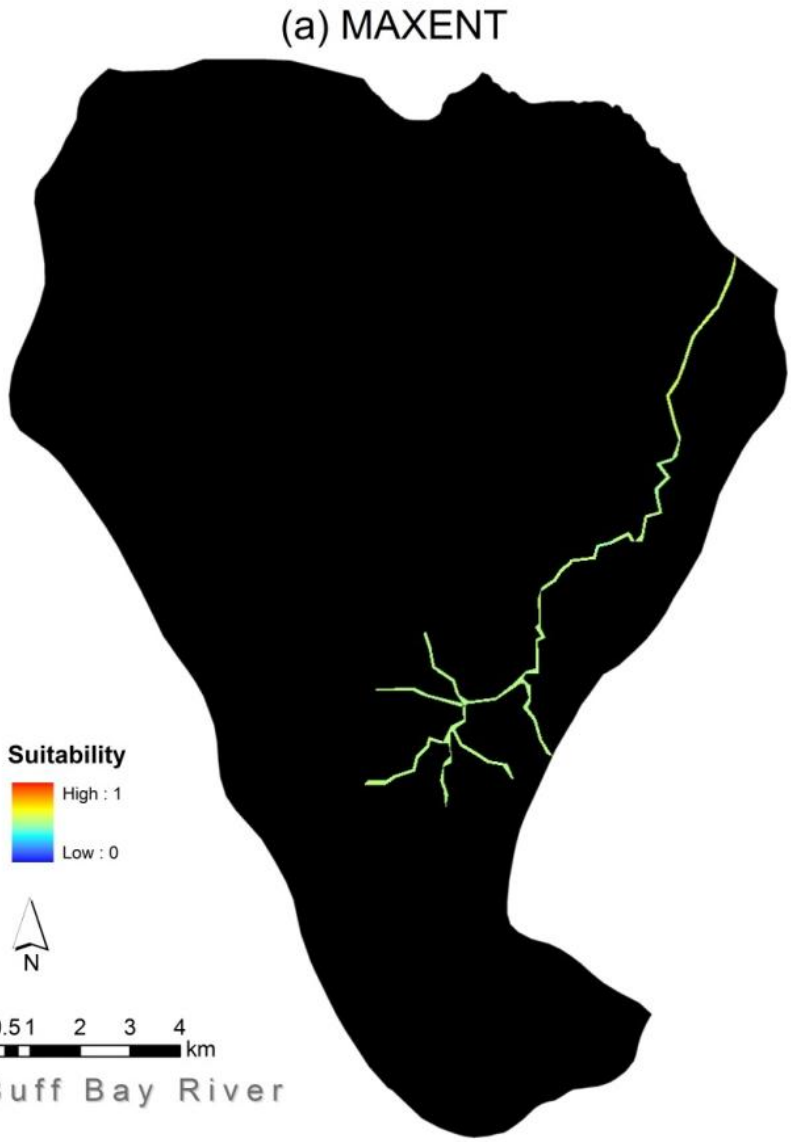
- Elevation (m)
- Climate
- Hydrogeology
- Soil texture

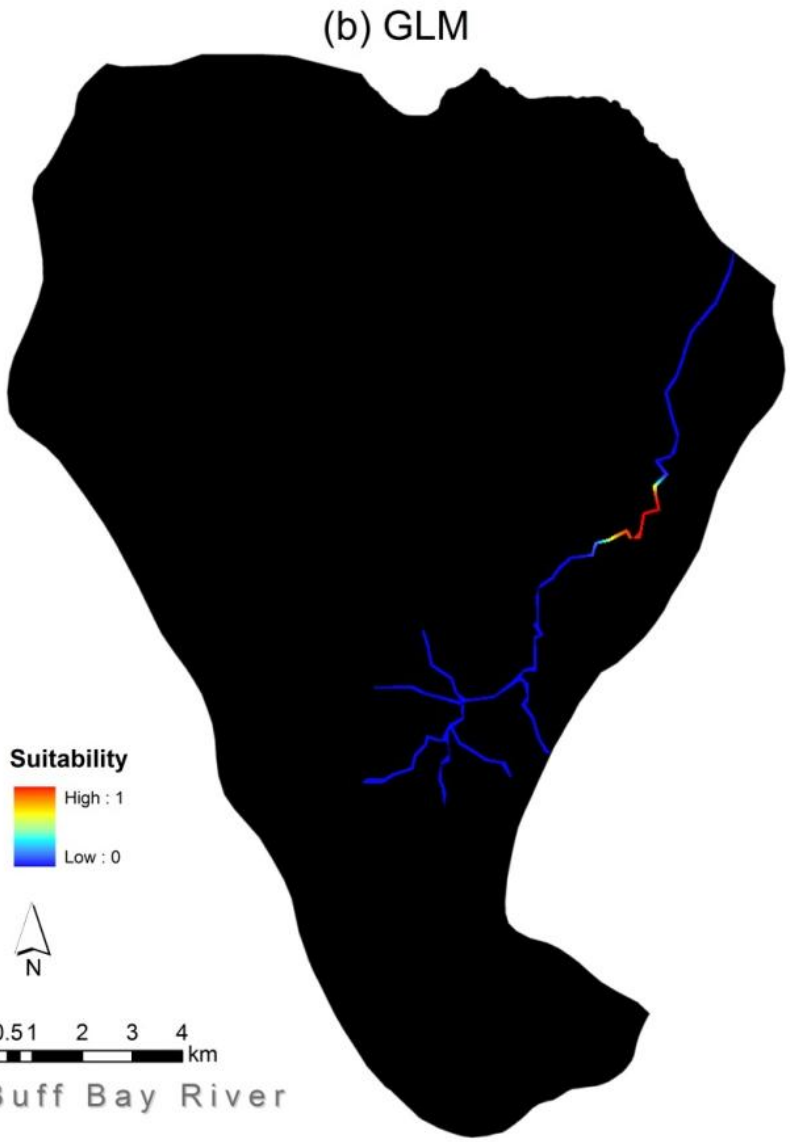
# Results

# Predictive models of *Cherax quadricarinatus* distribution in the Black River

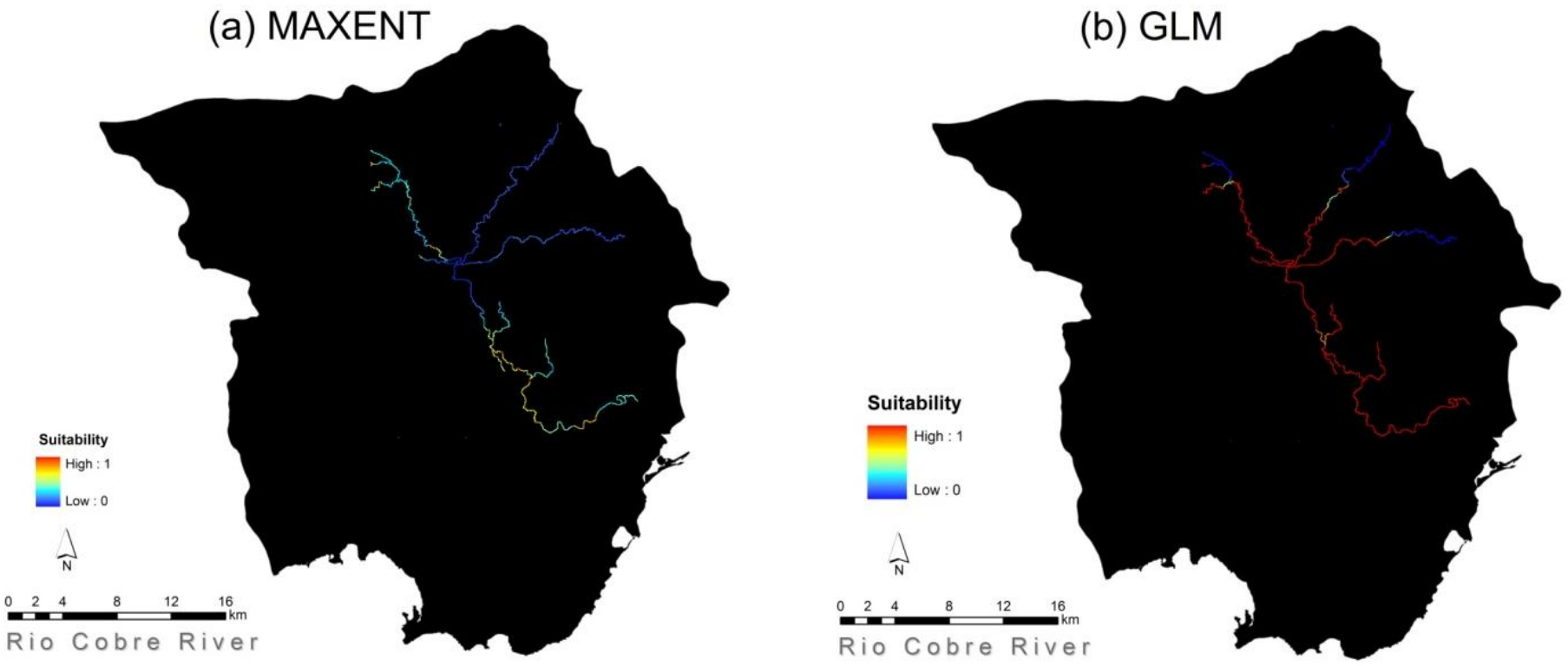


# Predictive models of *Cherax quadricarinatus* distribution in the Buff Bay River

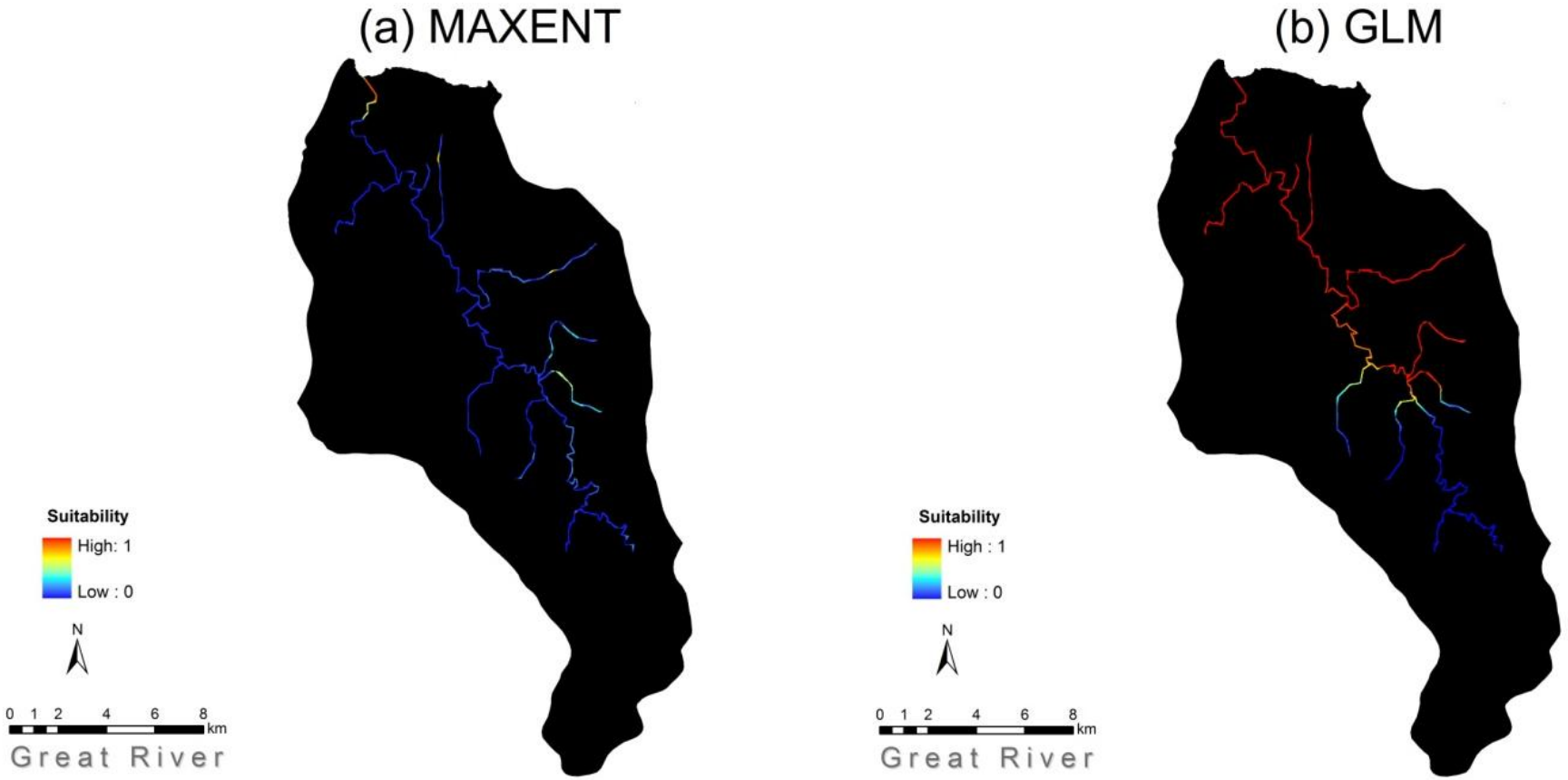


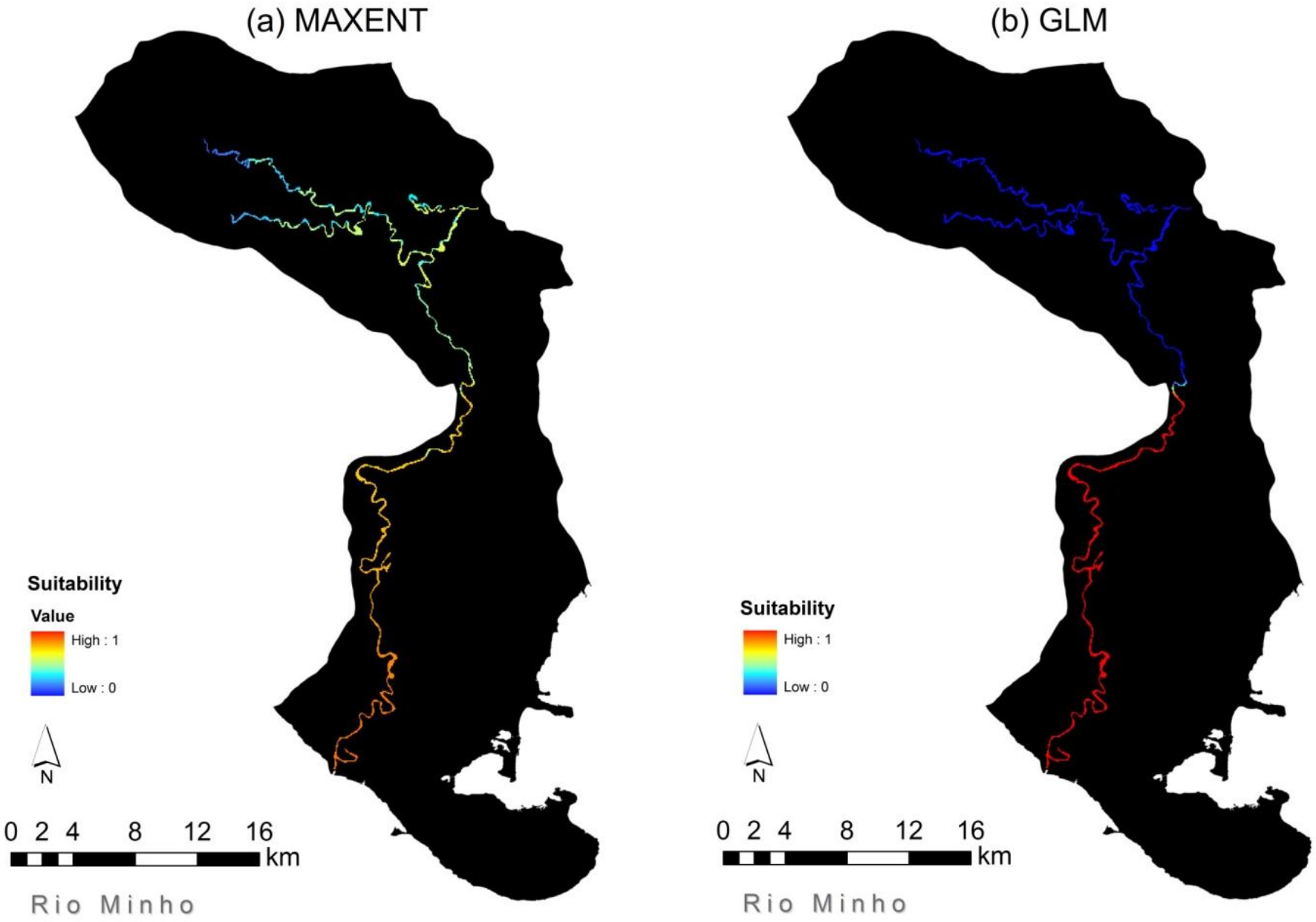
# Predictive models of *Cherax quadricarinatus* distribution in the Rio Cobre



# Predictive models of *Cherax quadricarinatus* distribution in the Great River



# Predictive models of *Cherax quadricarinatus* distribution in the Rio Minho



# Habitat Suitability

- The red-claw has wide tolerance limits with respect to water quality
- Hydrogeology and soil texture, water velocity, elevation and nitrate most important predictors
- Irrespective of the classification, it appears that all Jamaican rivers are vulnerable to invasion by *Cherax quadricarinatus*

# Classification useful in predicting the extent of the distribution of crayfish throughout river

- Low gradients and altitude - South and South-Western rivers vulnerable along entire lengths
- North-western, North-central and South-central rivers vulnerable at lowland stretches and close to coast
- North-eastern rivers least suitable

# SDMs for Invasive Species

**Applications**

- Risk assessment
- Pre-screening for proposed introduced species

**Challenges**

- Baseline data availability
- Data quality
- Adoptability (Interpreting results for management & policies)

# General Model Shortfalls

- A premise of SDMs is that the species is in equilibrium with its environment (Elith & Graham, 2009)
  - Difficult to ascertain for invasive species
- Does not deal with confounders
- "*Garbage in garbage out*"
- Model performance based on computed statistics (ROC, AUC, Kappa, etc)

# Acknowledgments

Special thanks to the

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- Water Resources Authority
- Forestry Department

# References


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- Mahon, R & Aiken K., 1977. Establishment of North American Bullfrogs, *Rana catesbeiana* (Amphibia, Anura, Ranidae) in Jamaica. Journal of Herpetology. 11: 197-199.

# Thank you!