

# Subdivision Susceptibility:

## Modelling Change in the Rural-Urban Interface

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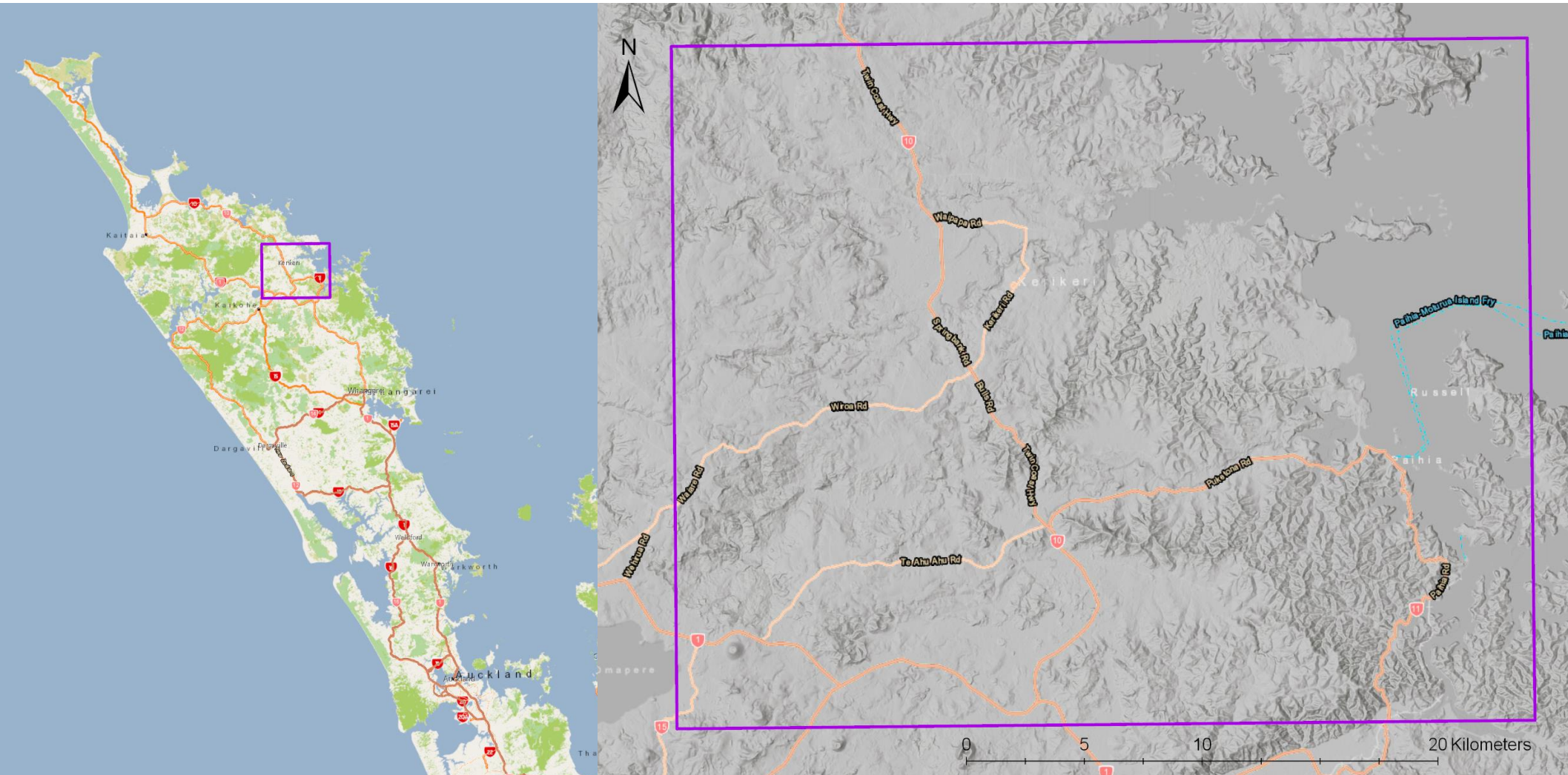
**VISION CONSULTING**  
Engineers & Planners

New Zealand Esri Users Conference  
Auckland  
August, 2019

## Project Scope:

- Evaluate the application of Land Change Modelling for subdivision in the **Kerikeri- Bay of Islands** area
- Gain insights into past **change drivers** for the **rural/urban interface**
- Highlight areas of potential **future subdivision** and the implications

## Kerikeri-Bay of Islands Study Area:



## Software

- Data cleaning and preparation
  - ArcMap 10.6**
- Analysis
  - Clark Labs, Land Change Modeller 2.0**
    - Extension for ArcMap 10.2+
- Presentation
  - ArcGIS Pro 2.3**



## What is land change modelling?

- **Raster Analysis**
- Combines **transitions in land cover** with **driver variables** to explain and predict land change
- Often applied to **physical aspect**:
  - land cover (eg. forest to plains) or
  - land use (eg. farm to urban)
- Typically applied to large areas (Region to Country)
  - large cells (25m to 50m)

## How is this project different?

- Focused on sub-district area
- 8m cells
- non-categorical criteria
  - **non-physical** elements, change to **Legally designated** parcel size
- Two analysis performed

## **Where can it be applied?**

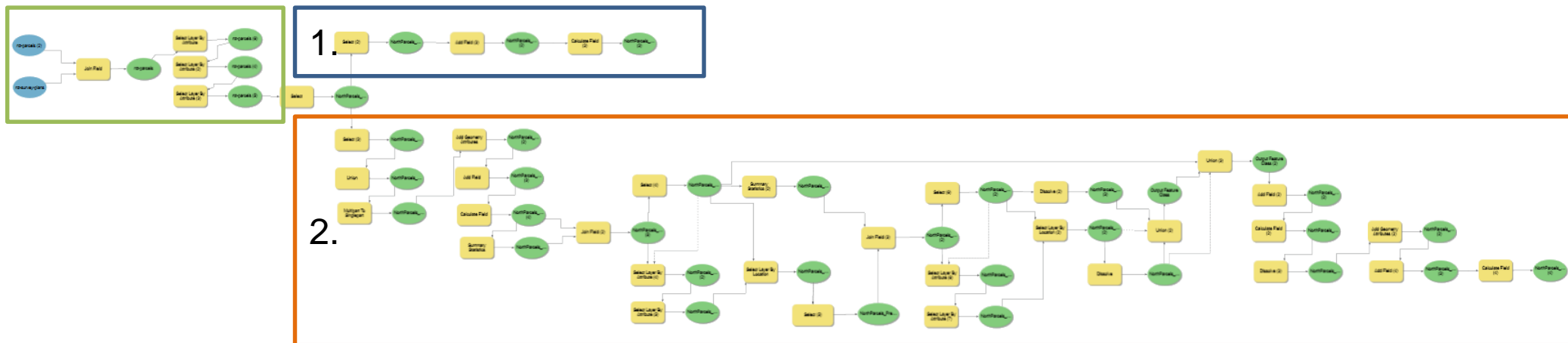
- **Urban Planning**
- **Transportation Planning**
- **Environmental and Sustainability Research**
- **Market Research**
- **Hazards and Reverse-sensitivity**

## **Modelling Process**

- 1. Data Preparation**
- 2. Measuring Land Change**
- 3. Modelling Drivers and Susceptibility**
- 4. Predicting Future Change**

## 1. Data Preparation

- **Change Layers (aprx. 15 years)**
  1. 2003 Parcels (before Jan 2004)
  2. 2018 Parcel (before Jan 2019)





## 1. Data Preparation

### •Model Driver Layers

#### ○Distance from:

- Primary Roads
- Secondary Roads
- Waste Water Lines
- Urban/Town Land cover
- Coast
- Primary Township

#### ○Coverage by:

- Slope
- Elevation
- Population Density
- Land Cover Data Base
- District Plan Zoning

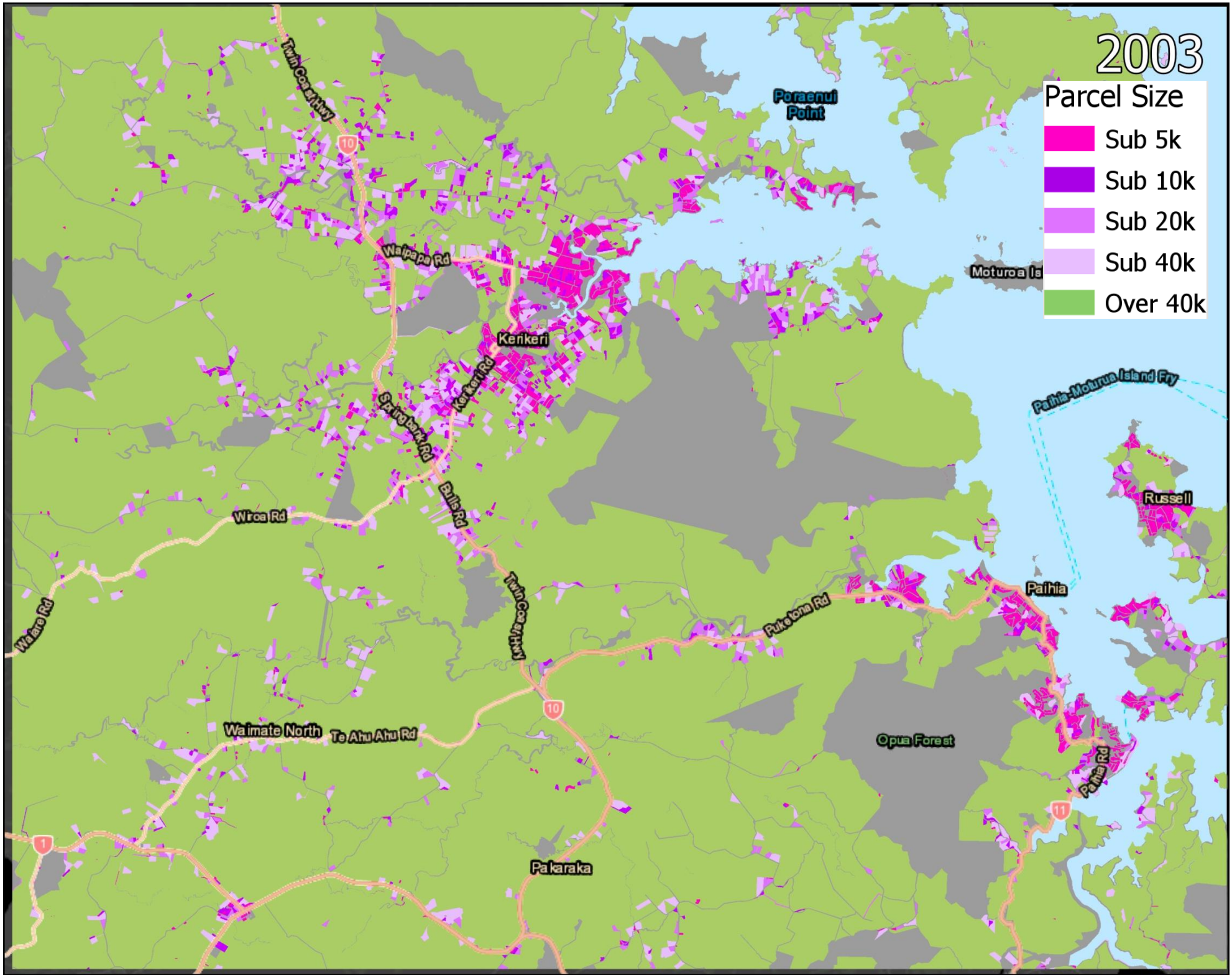
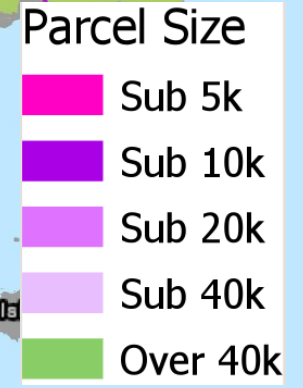
### •Requirements for all layers:

- Raster format, integer or continuous
- Same extent, cell size, background value, CRS

## 2. Measuring Change

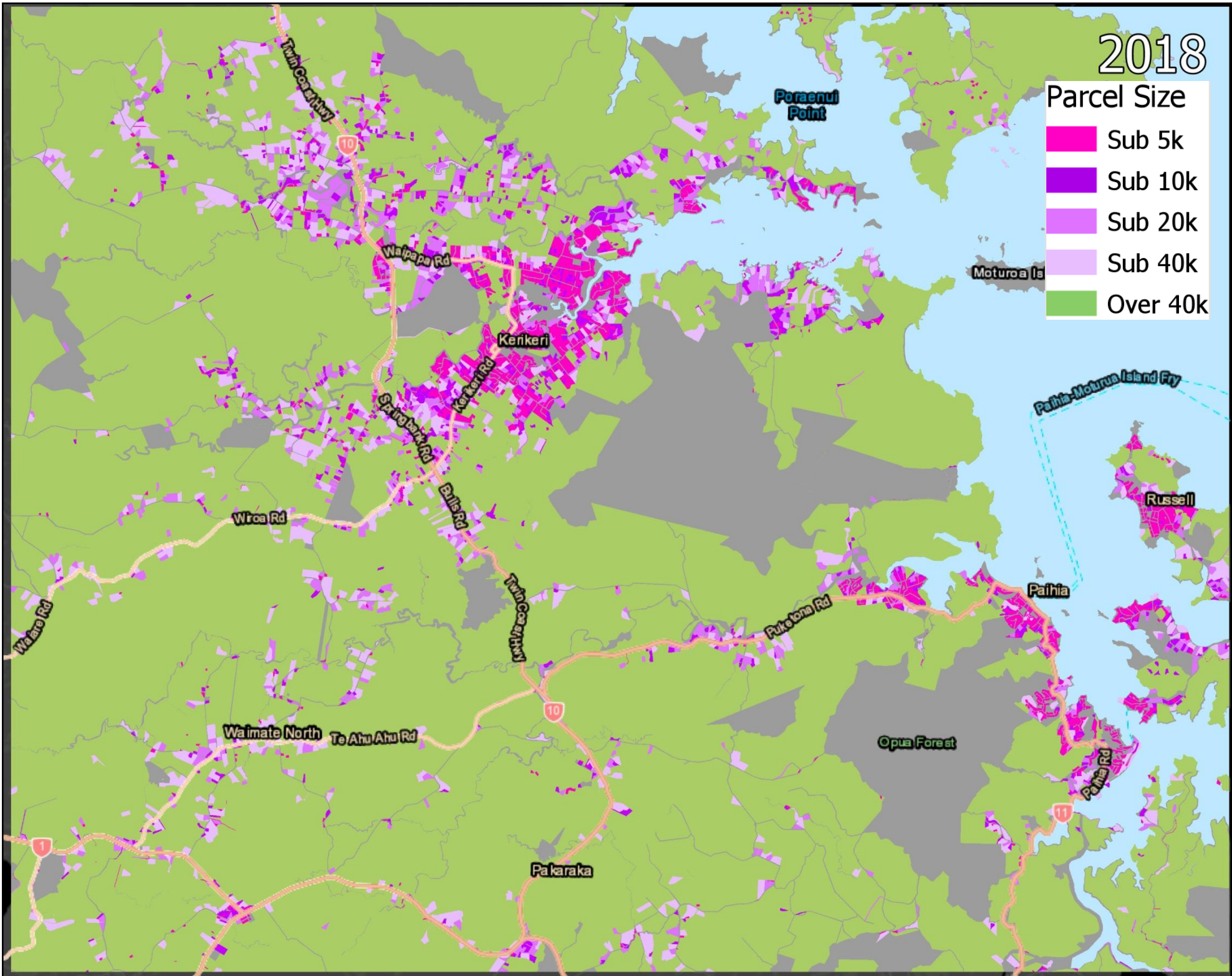
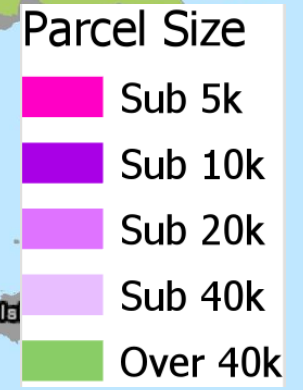
- Change measured across four size thresholds:
  - 5,000 m<sup>2</sup> (infrastructure dependence)
  - 10,000 m<sup>2</sup>
  - 20,000 m<sup>2</sup>
  - 40,000 m<sup>2</sup> (minimum size for DP RP zone)
- Change maps produced to model **transition** and **persistence**

2003





2018

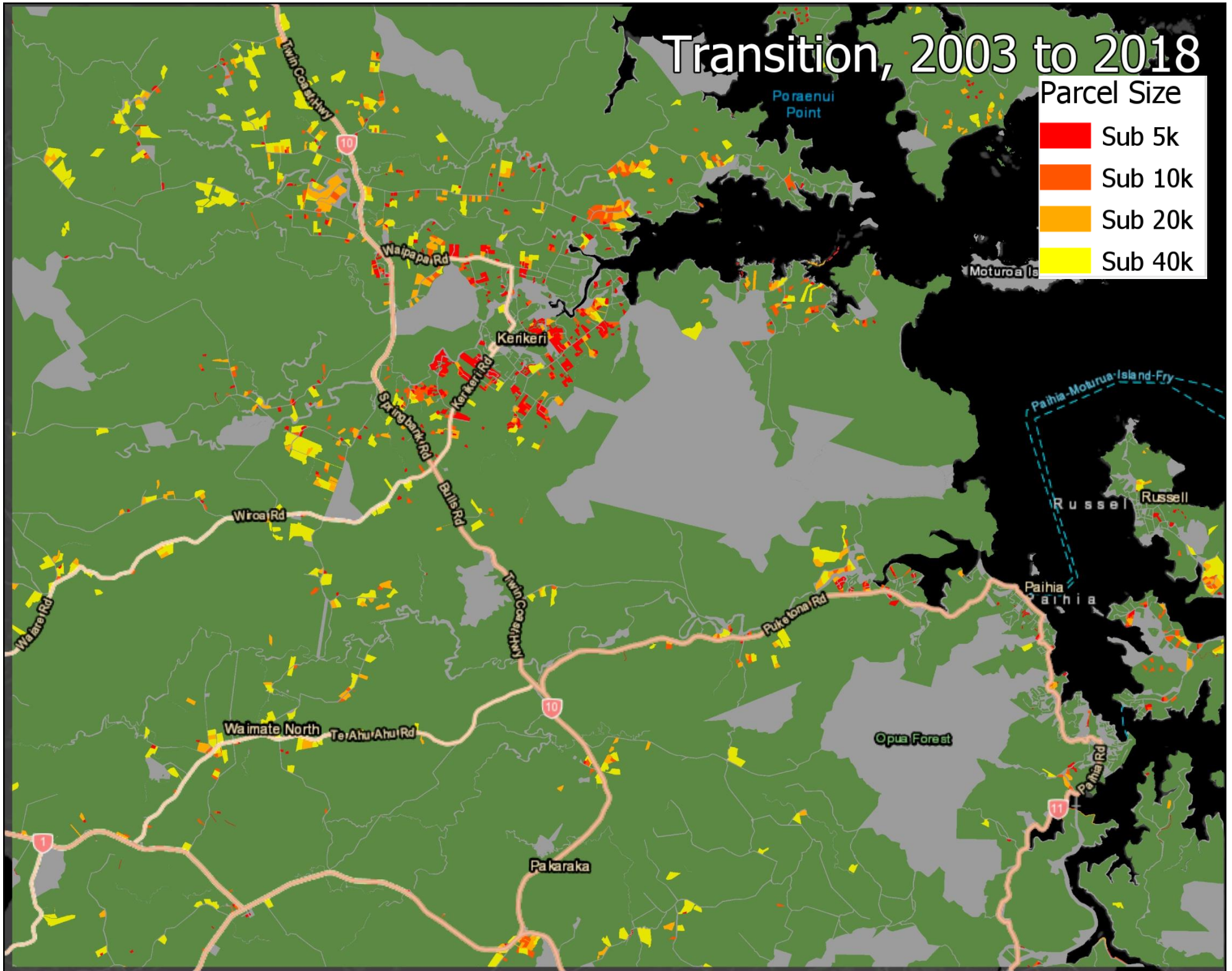




# Transition, 2003 to 2018

## Parcel Size

- Sub 5k
- Sub 10k
- Sub 20k
- Sub 40k



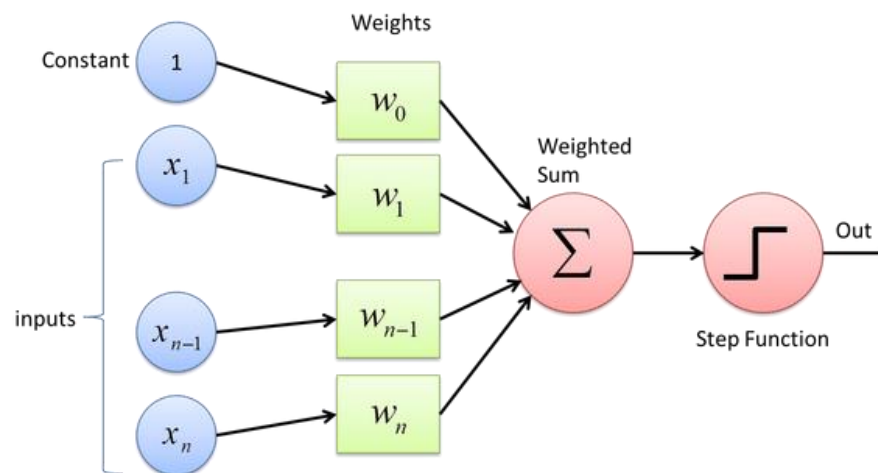


## Net Transition by Parcel Threshold, 2003 to 2018

Threshold	Cells	Hectares
Over 40,000m <sup>2</sup>	-227,583	-1,456
Sub 40,000m <sup>2</sup>	104,714	671
Sub 20,000m <sup>2</sup>	46,783	299
Sub 10,000m <sup>2</sup>	29,393	188
Sub 5,000m <sup>2</sup>	44,665	285

## 3. Modelling Drivers and Susceptibility

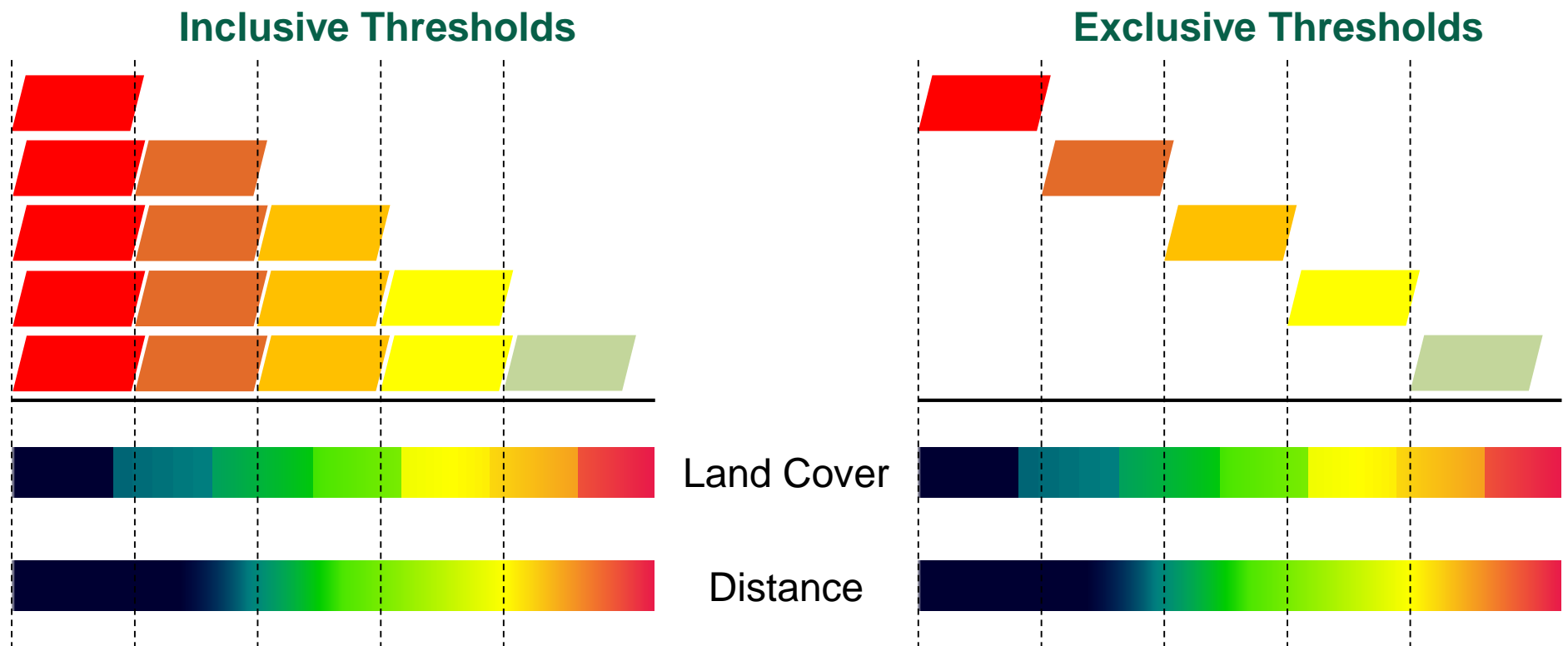
- Machine Learning Algorithm:
  - Multi-layer perceptron (MLP) neural network



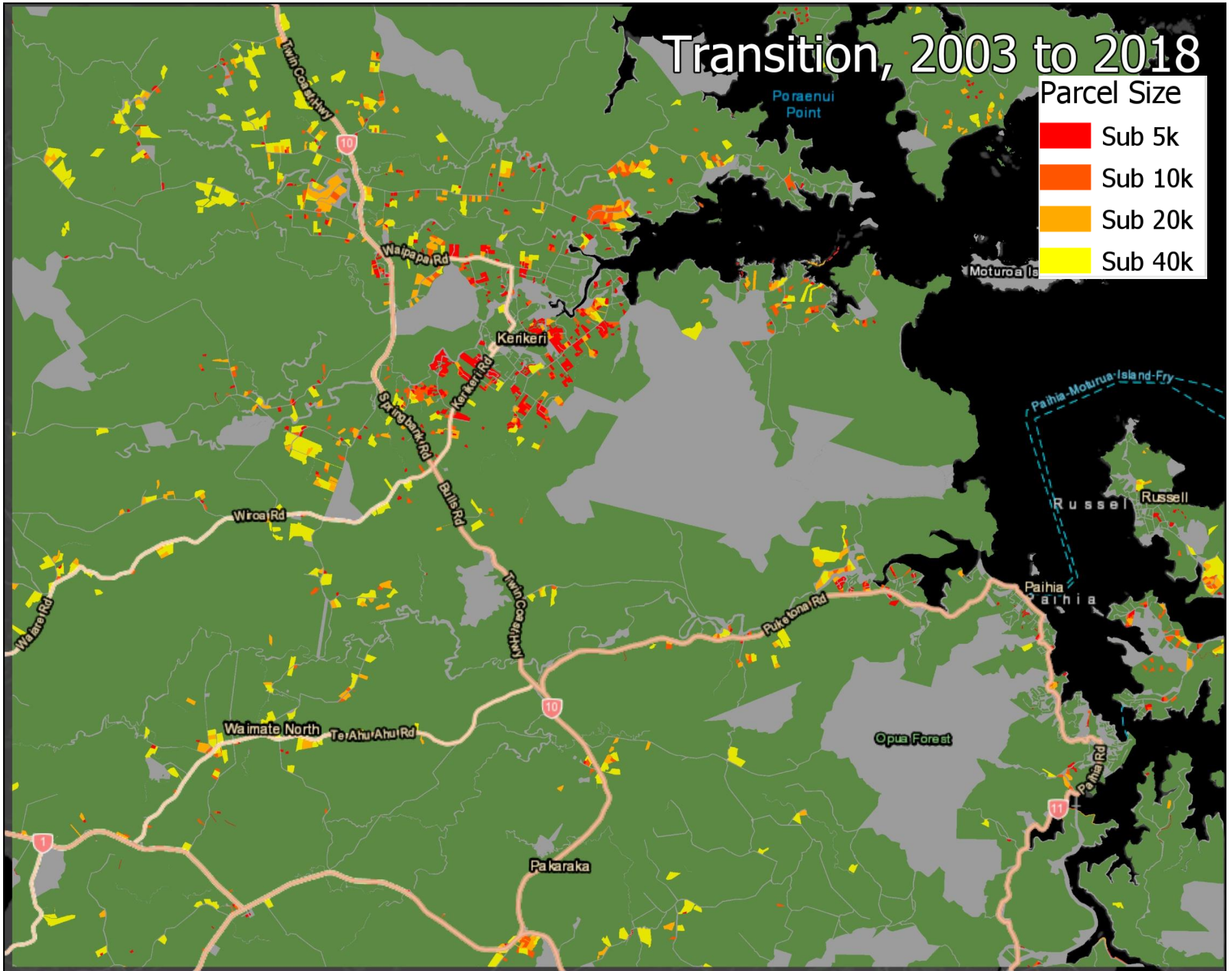
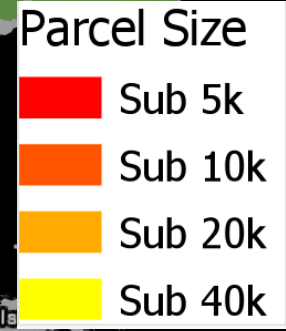
- Combines **transition** and **driver** layers to **evaluate** and **weight** susceptibility criteria
  - **5,000** iteration
  - **Sample of 20,000** cells (50/50)

# 3. Modelling Drivers and Susceptibility

- Two variations performed:
  1. **Inclusive** – all areas below thresholds
  2. **Exclusive** – all area between thresholds

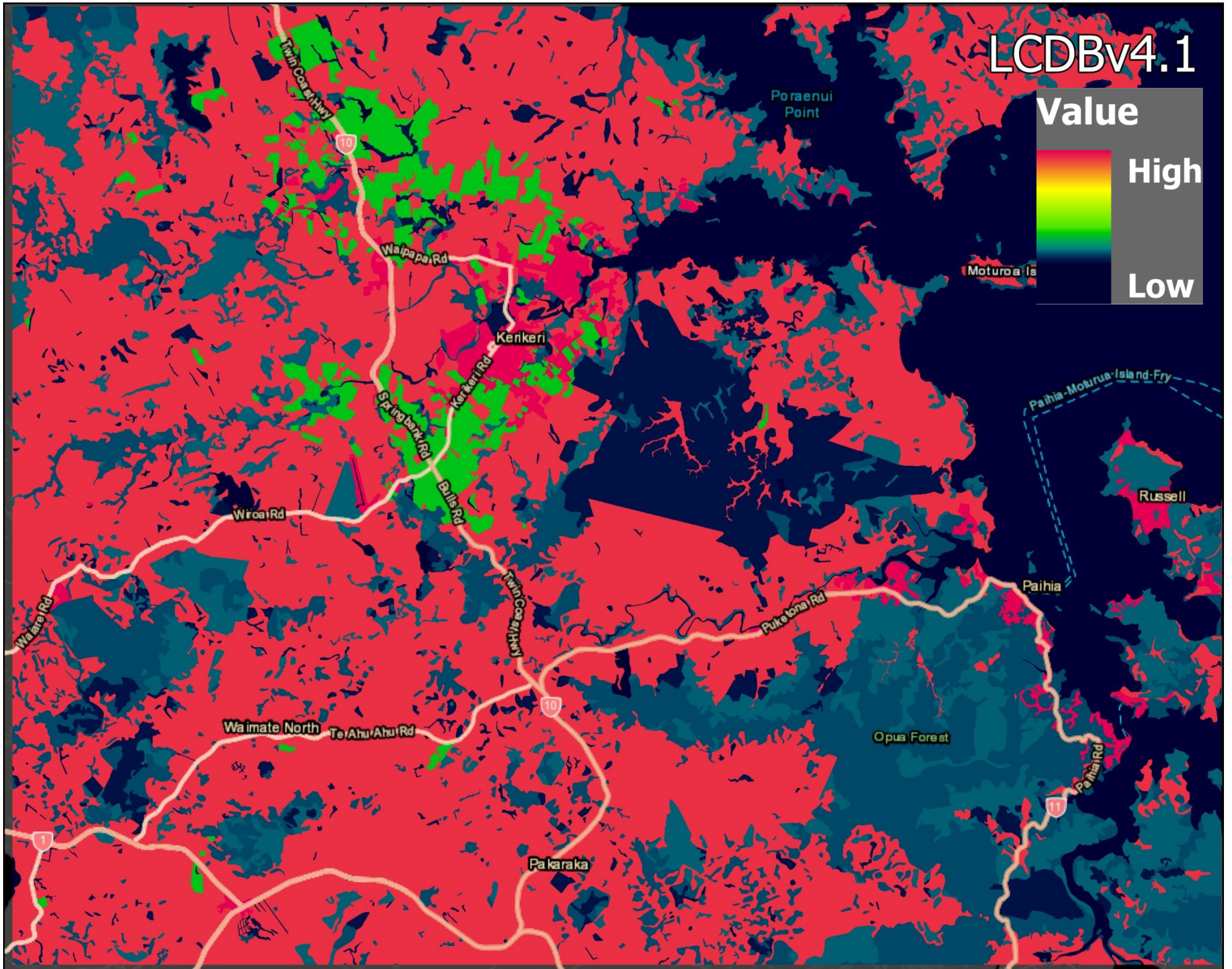
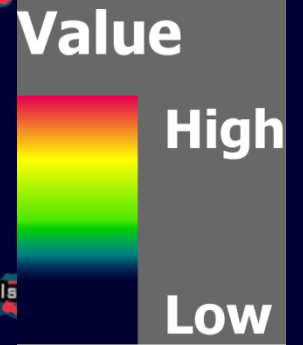


# Transition, 2003 to 2018



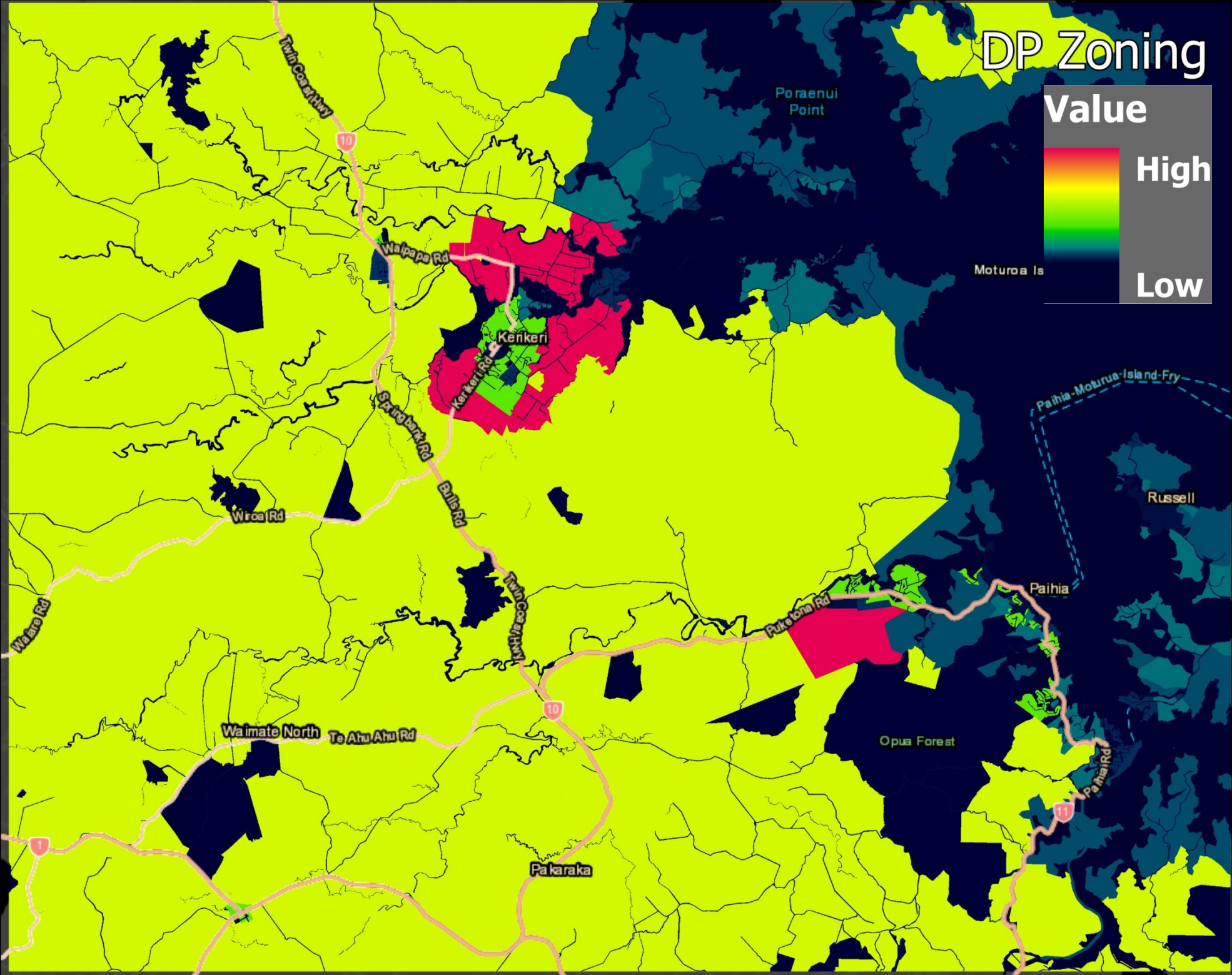
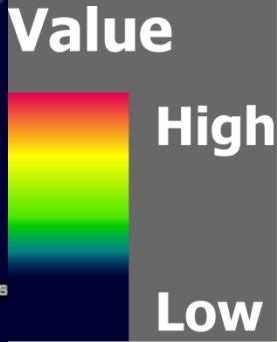


# LCDBv4.1

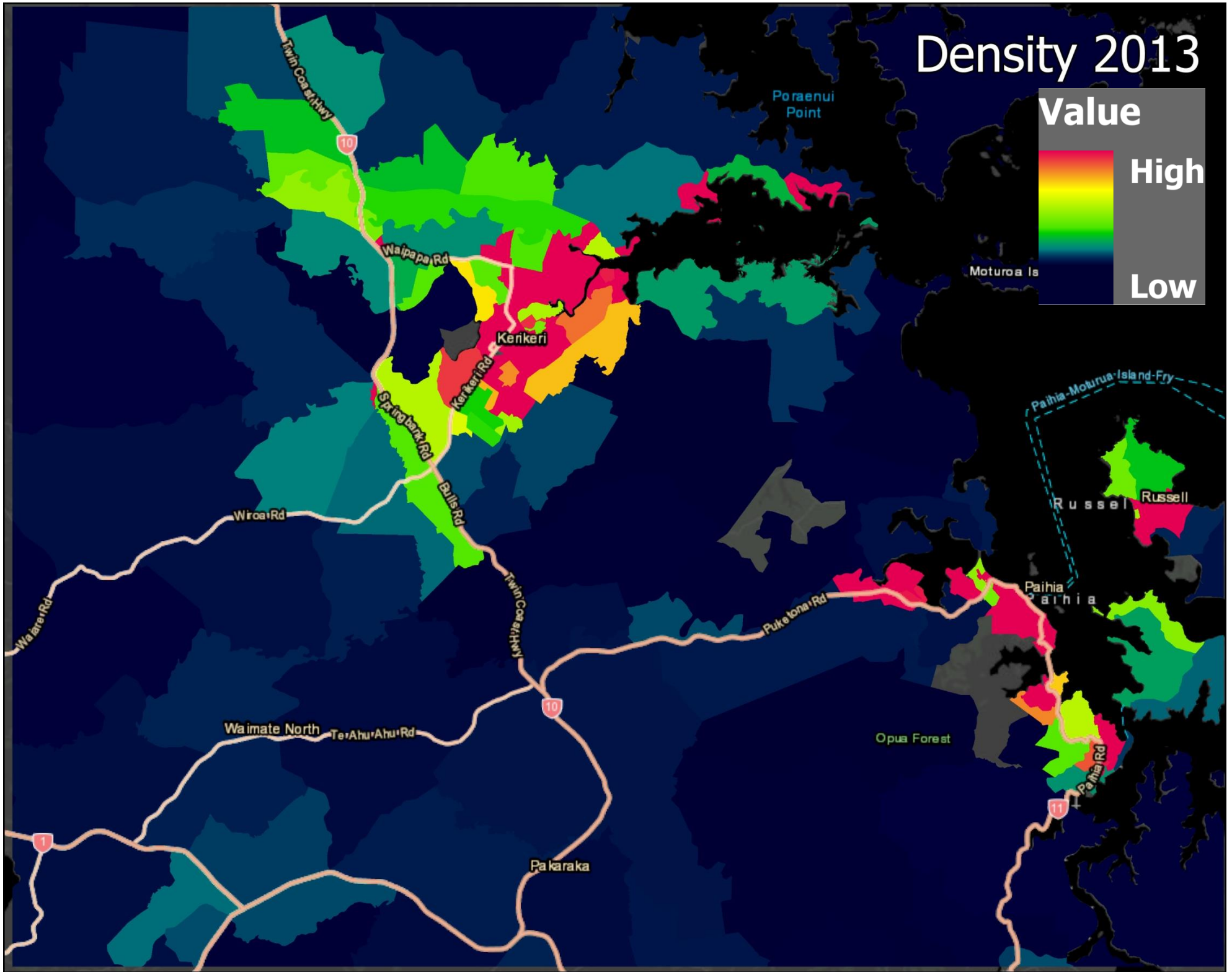
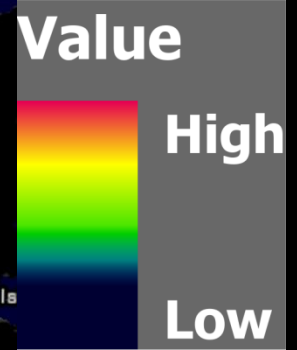




# DP Zoning



# Density 2013



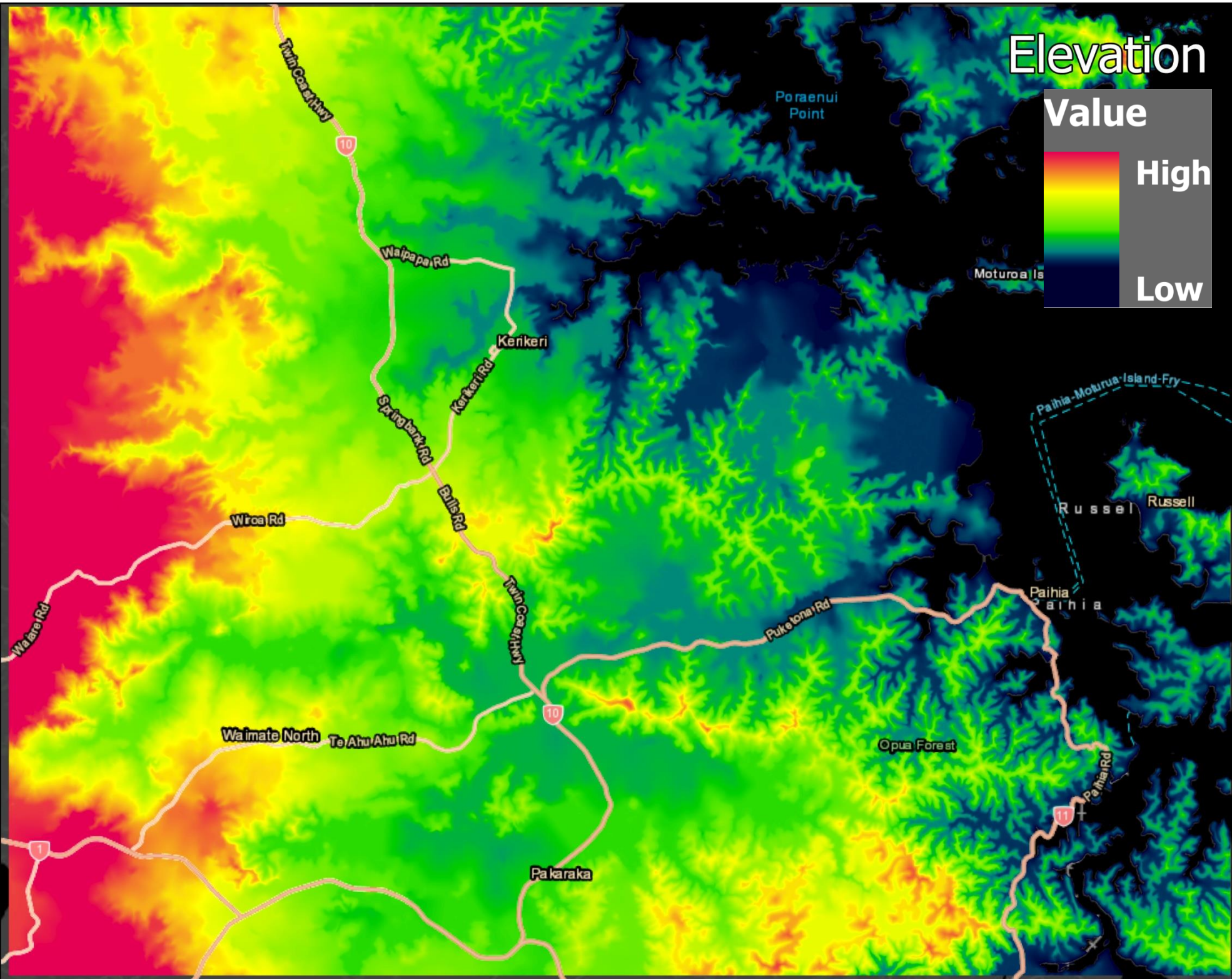


# Elevation

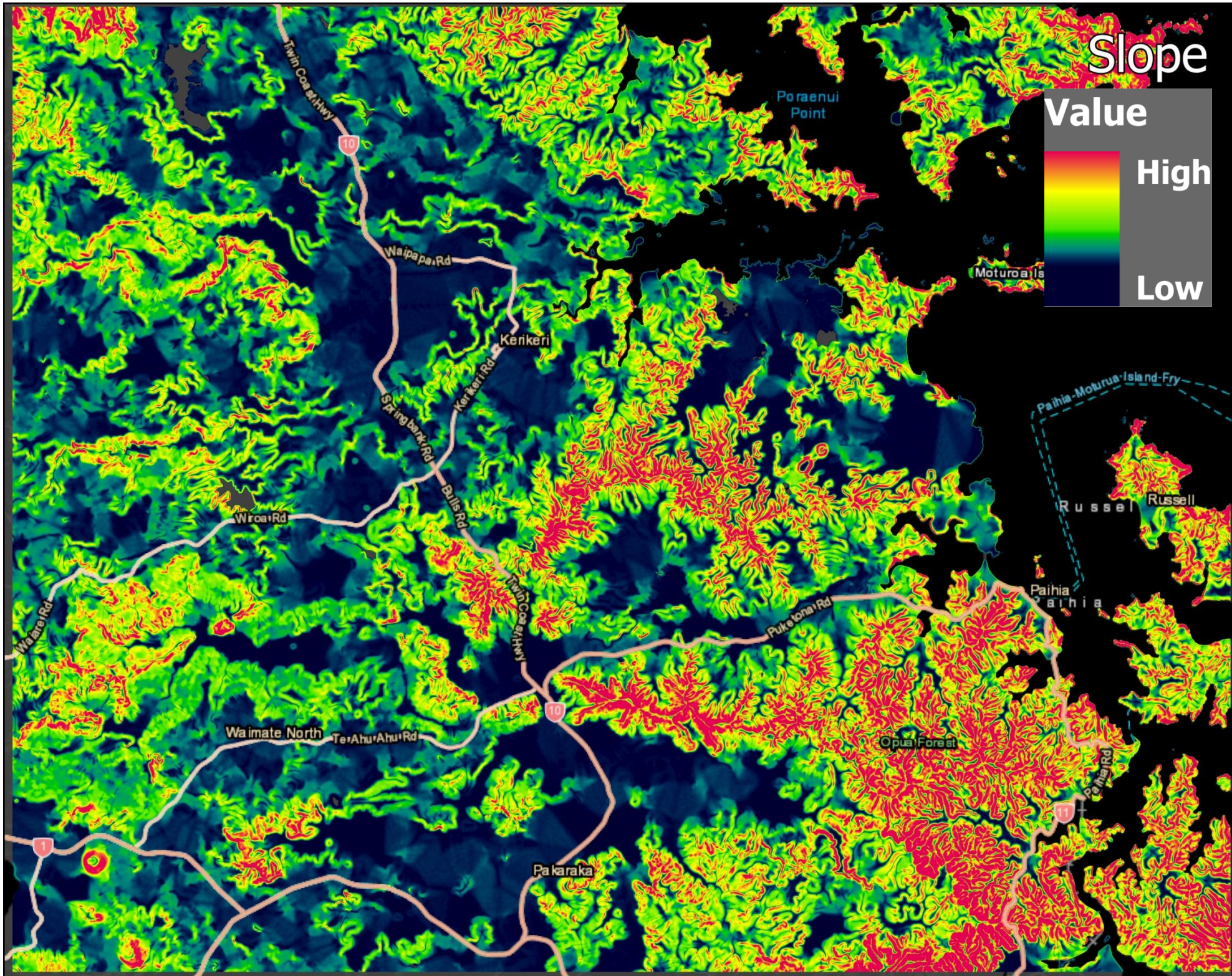
Value

High

Low

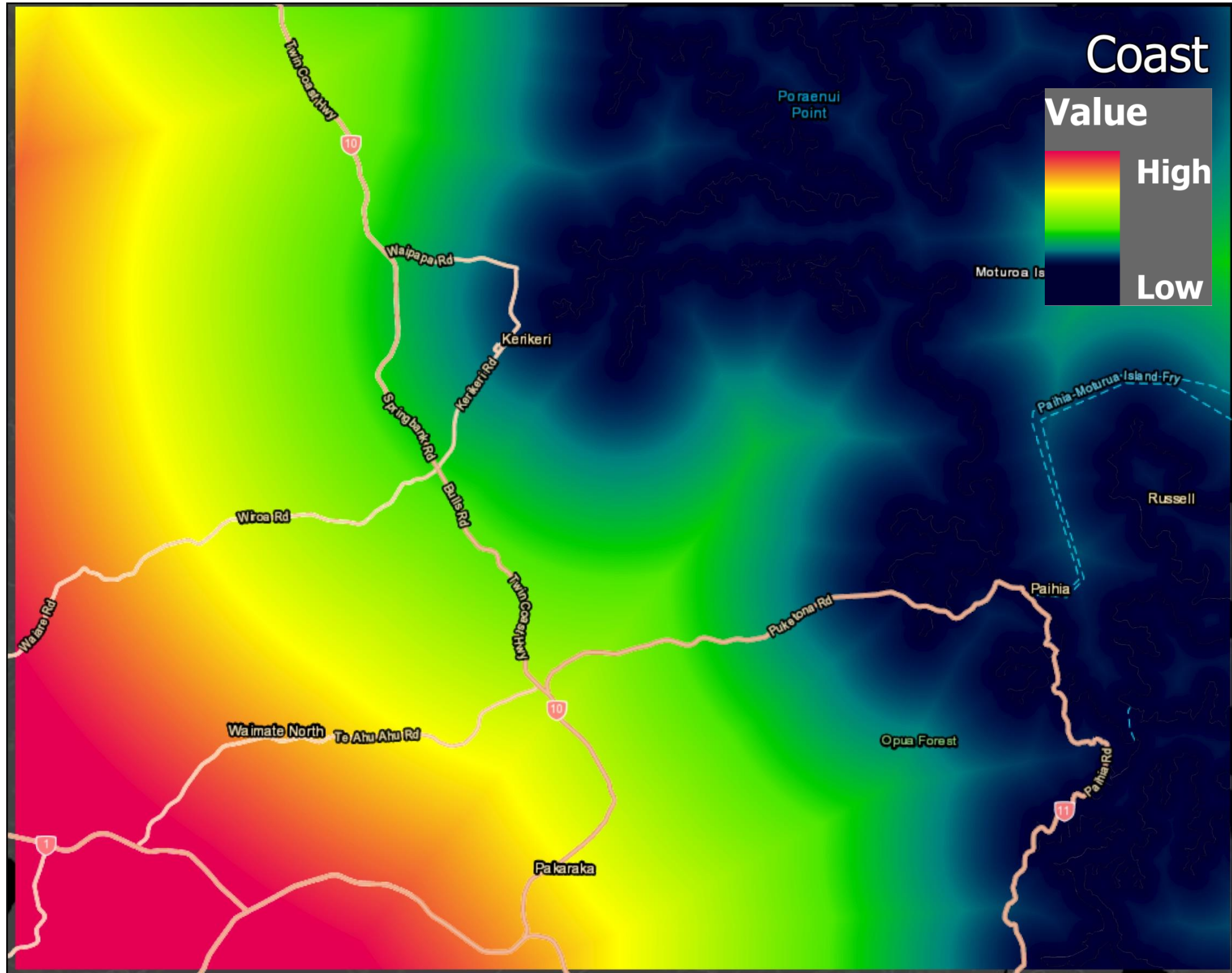
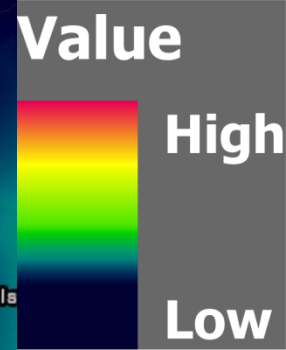








# Coast

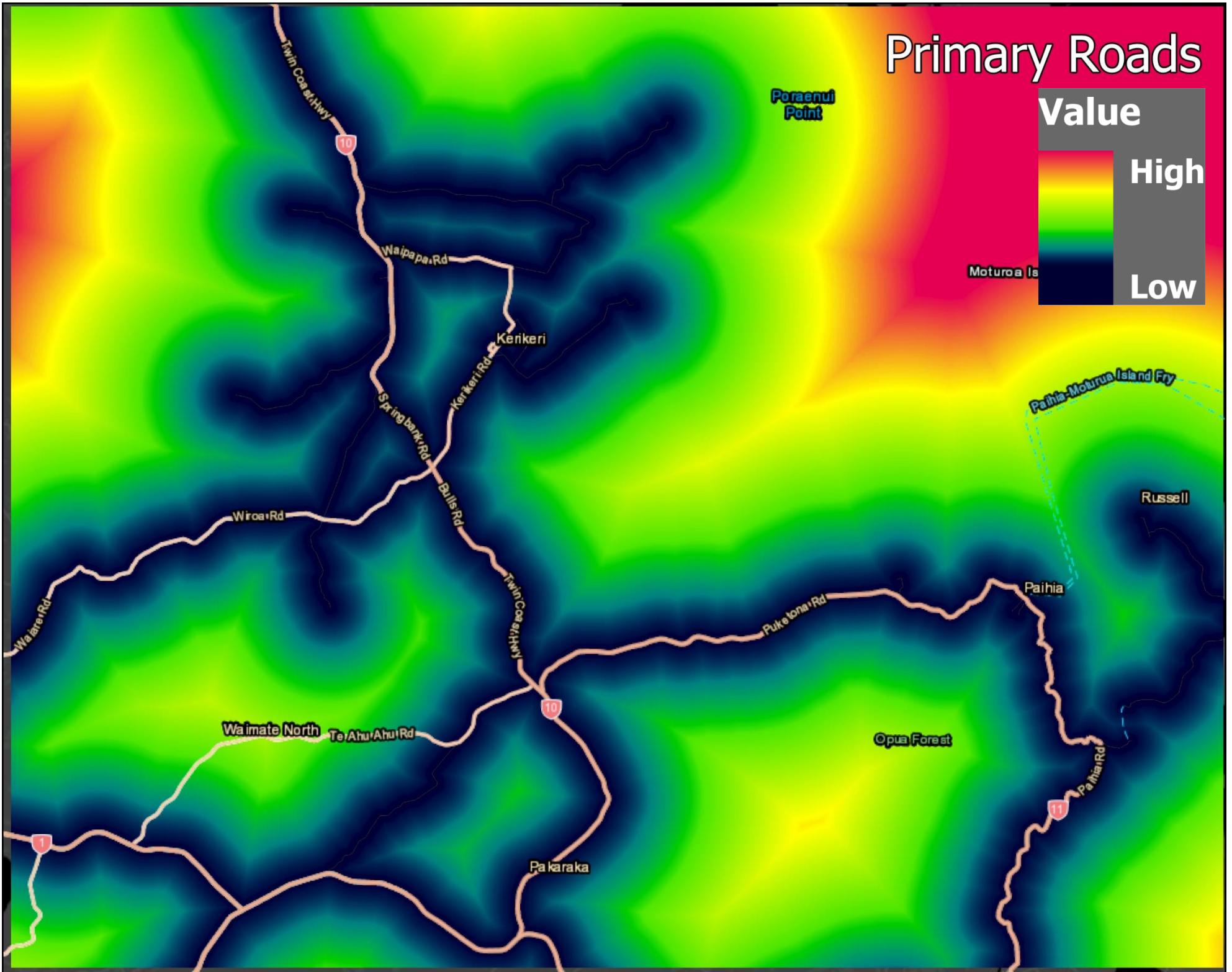


# Primary Roads

Value

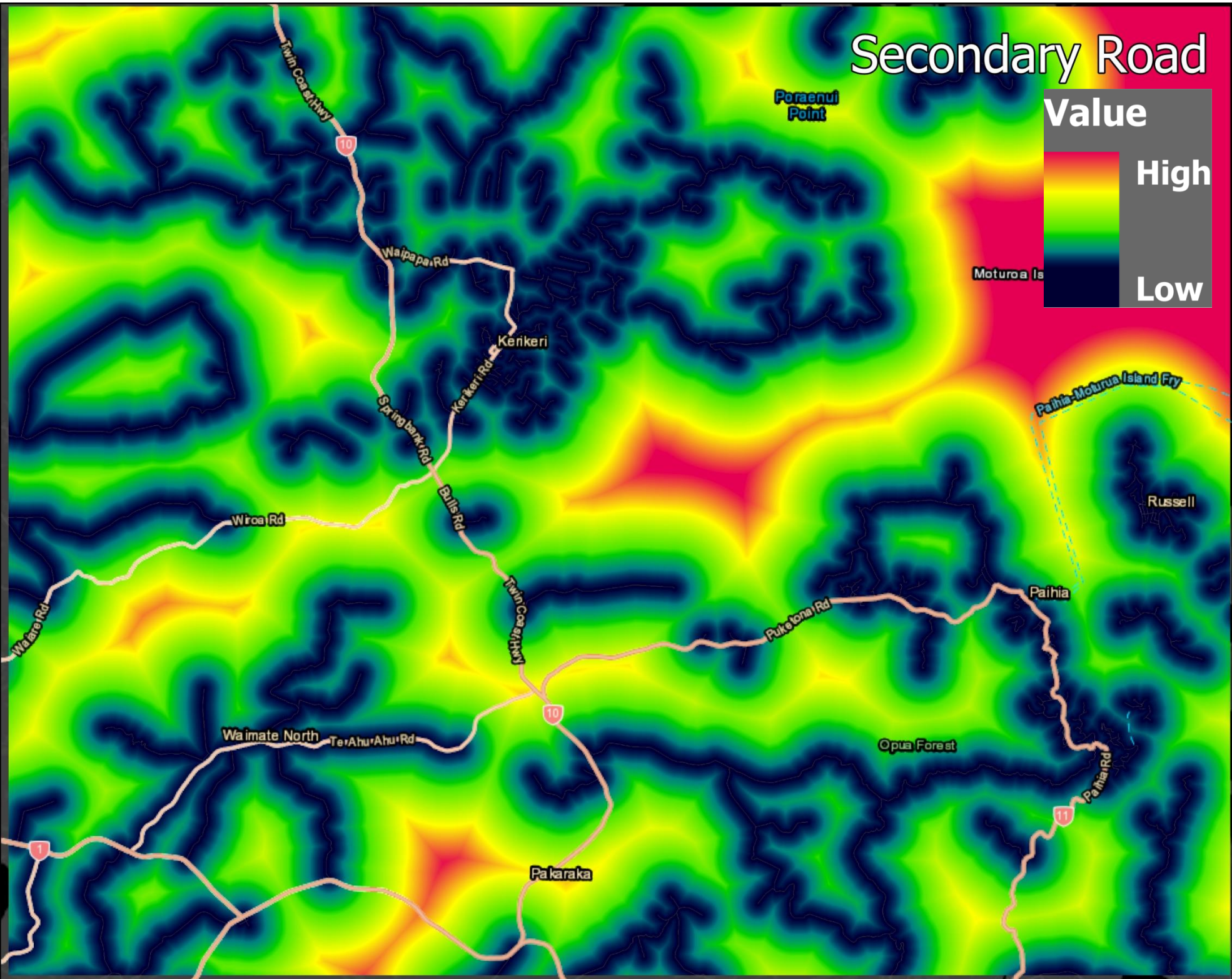
High

Low





# Secondary Road







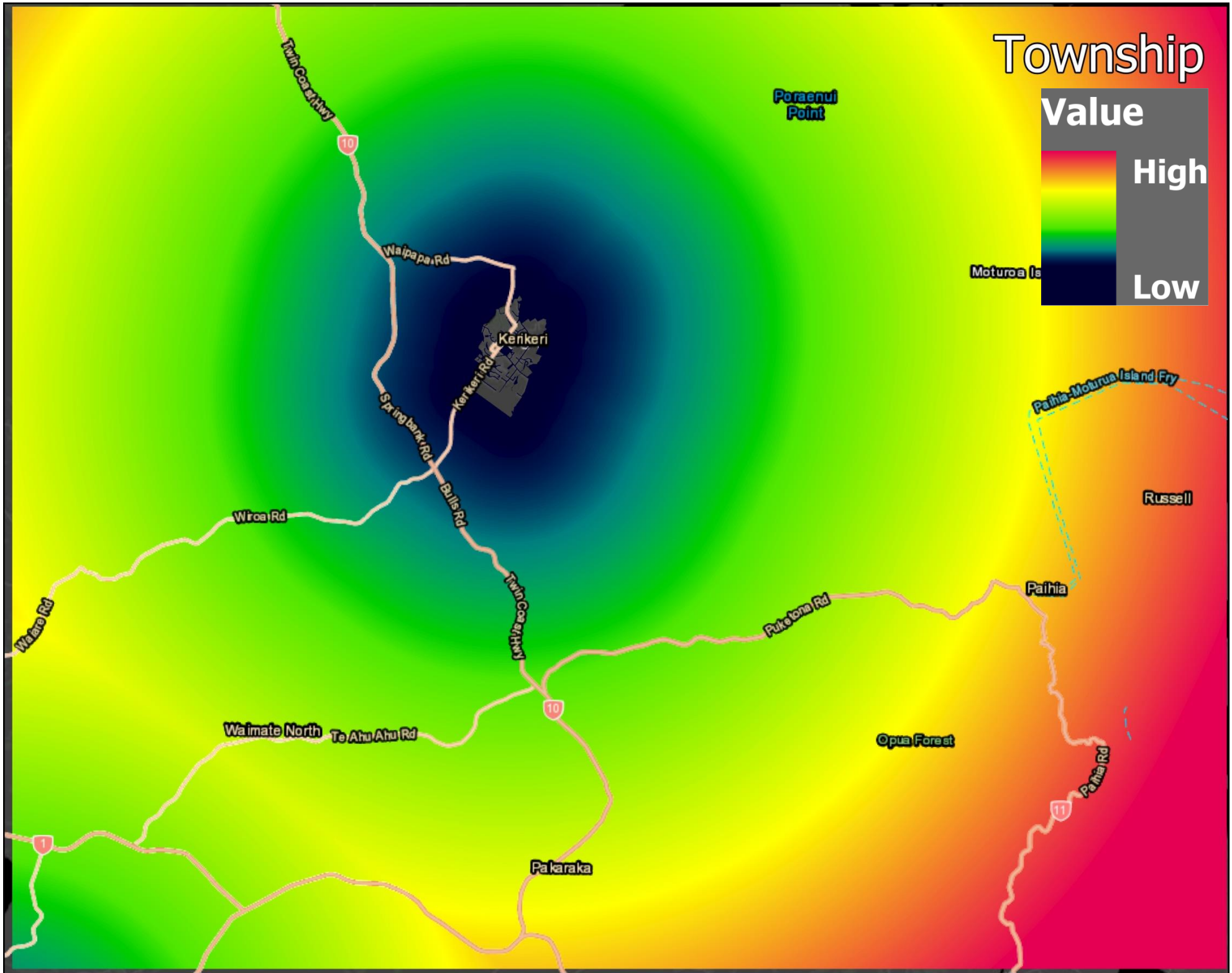


# Township

Value

High

Low

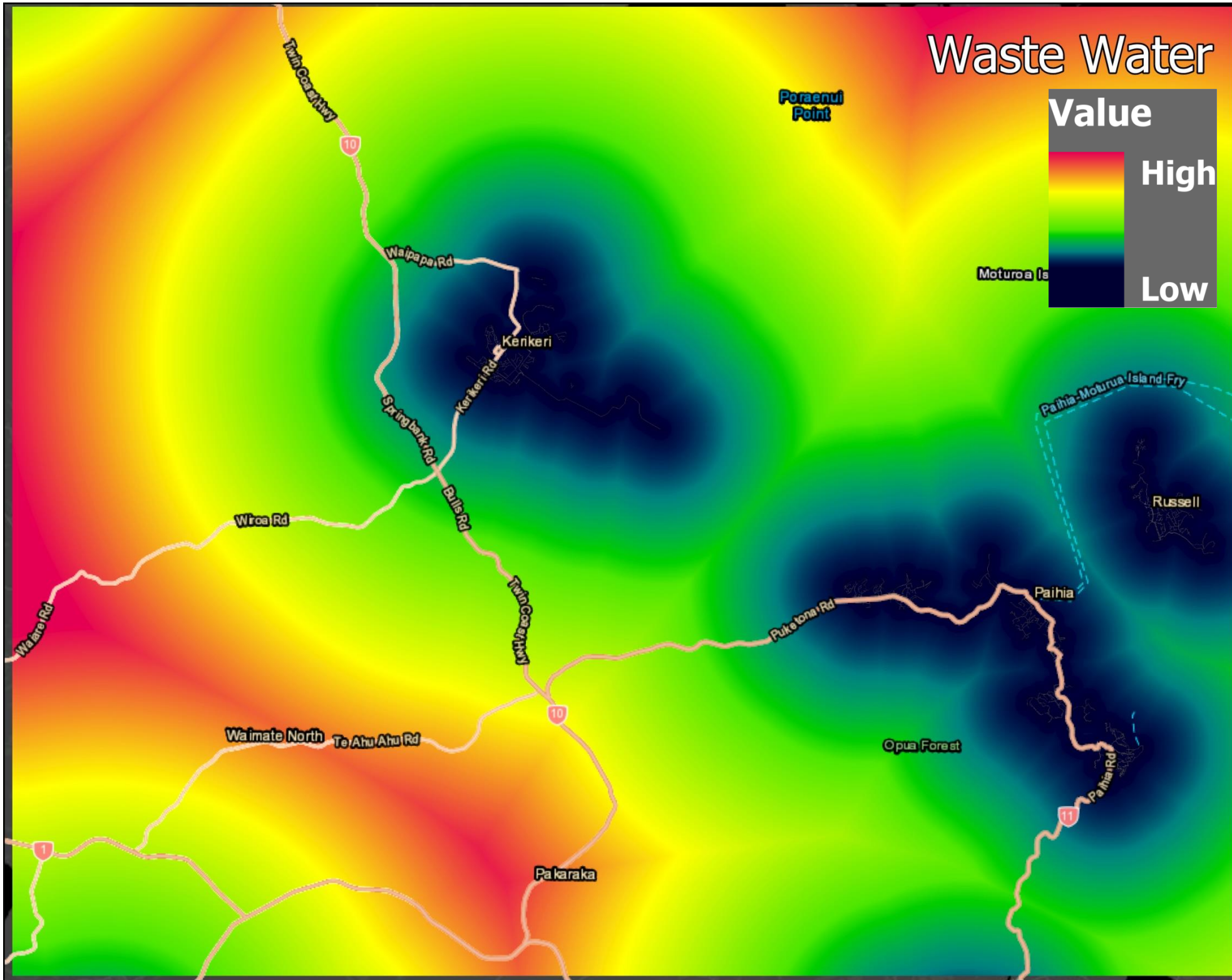


# Waste Water

Value

High

Low











## Inclusive Model Results

Parameters		Sub 5K	Sub 10K	Sub 20K	Sub 40K
Model Accuracy		89.15%	84.38%	83.93%	81.66%
Transition Skill		0.7487	0.6850	0.7432	0.7272
Persistence Skill		0.8172	0.6900	0.6138	0.5394
Distance From	Town	5	11 *	8	5
	Anthropogenic	2	9	1 *	1 *
	Coast	9	5	5	4
	Waste Water	6	10	6	7
	Roads Primary	4	2	3	3
	Roads Secondary	1 *	1 *	2	2
Cover By	Slope	10	7	11 *	9
	Zoning	8	8	6	7
	Elevation	7	4	7	8
	LCDB	11 *	6	10	11 *
	Pop Density	3	3	9	10

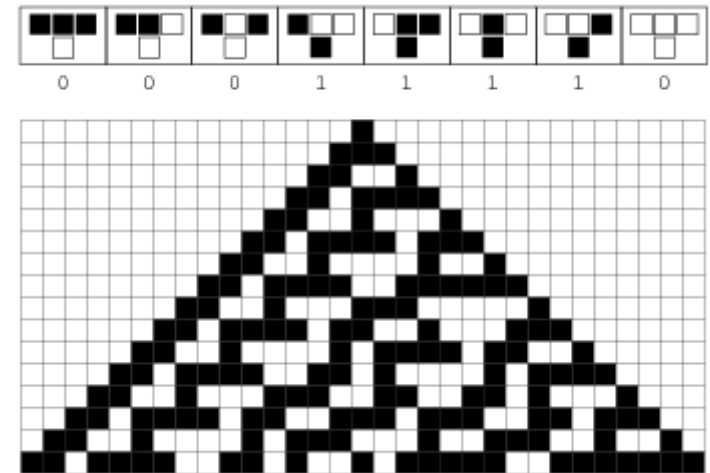


## Exclusive Model Results

Parameters		Sub 5K	Sub 10K	Sub 20K	Sub 40K
Model Accuracy		89.12%	84.14%	84.29%	81.00%
Transition Skill		0.7631	0.7303	0.8142	0.7079
Persistence Skill		0.8019	0.6353	0.5566	0.5321
Distance From	Town	5	3	8	8
	Anthropogenic	1 *	1 *	1 *	1 *
	Coast	9	6	5	4
	Waste Water	6	4	3	7
	Roads Primary	2	2	2	2
	Roads Secondary	4	8	4	3
Cover By	Slope	11 *	11 *	10	9
	Zoning	8	7	7	6
	Elevation	7	10	6	5
	LCDB	10	5	9	10
	Pop Density	3	9	11 *	11 *

## 4. Predicting Future Change

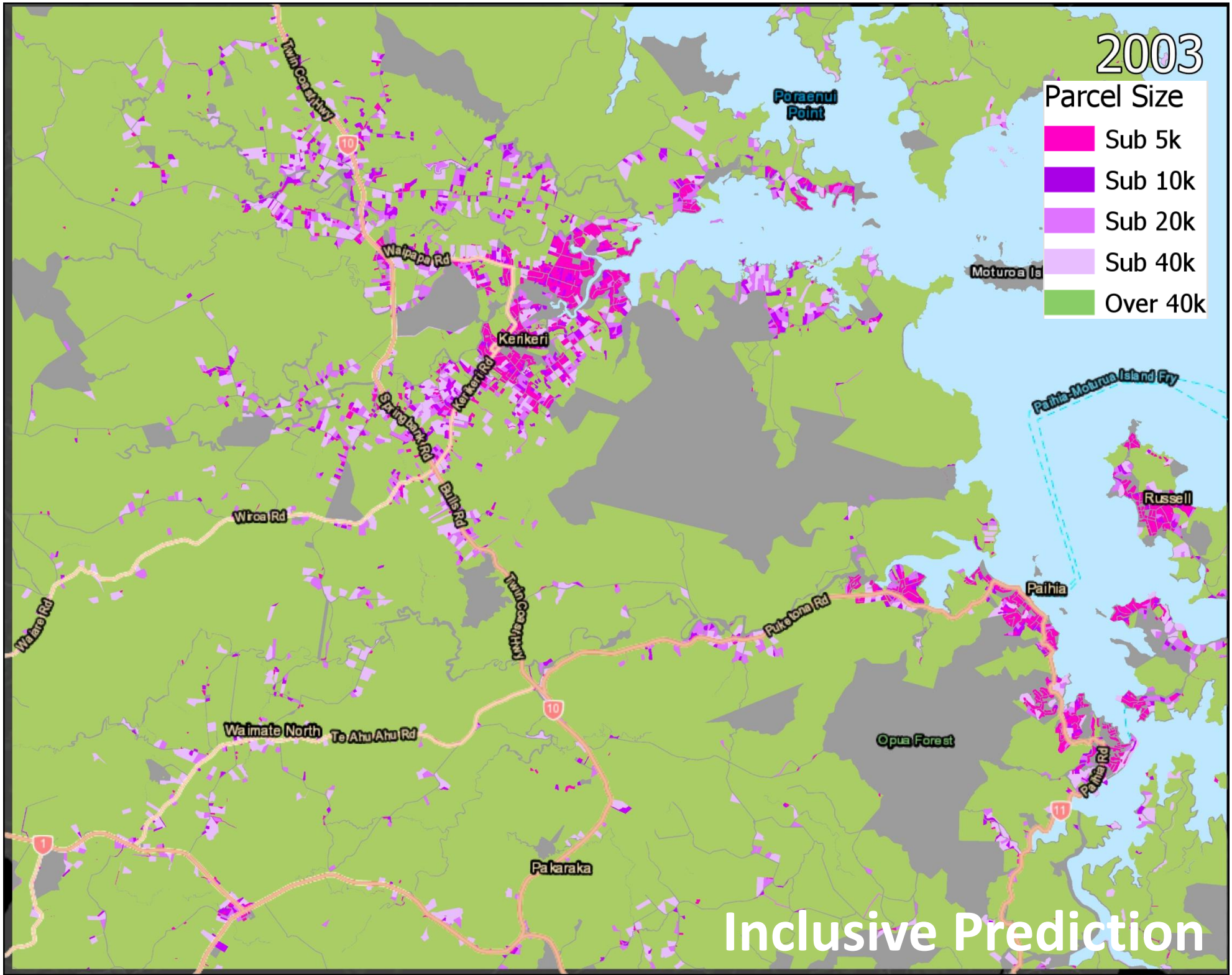
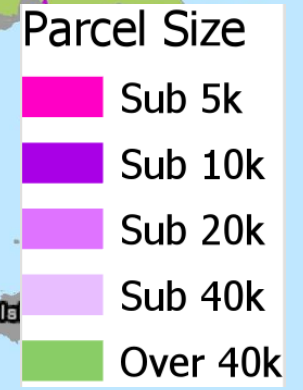
- Form of Cellular Automata
- Rate of base period transition projected into the future
- Prioritizes cells:
  - using Markov Chain (change table),
  - with highest susceptible scores, and
  - adjacent to or between growth areas
- 5 year intervals



## 4. Predicting Future Change

- Inclusive Model Results, 2033

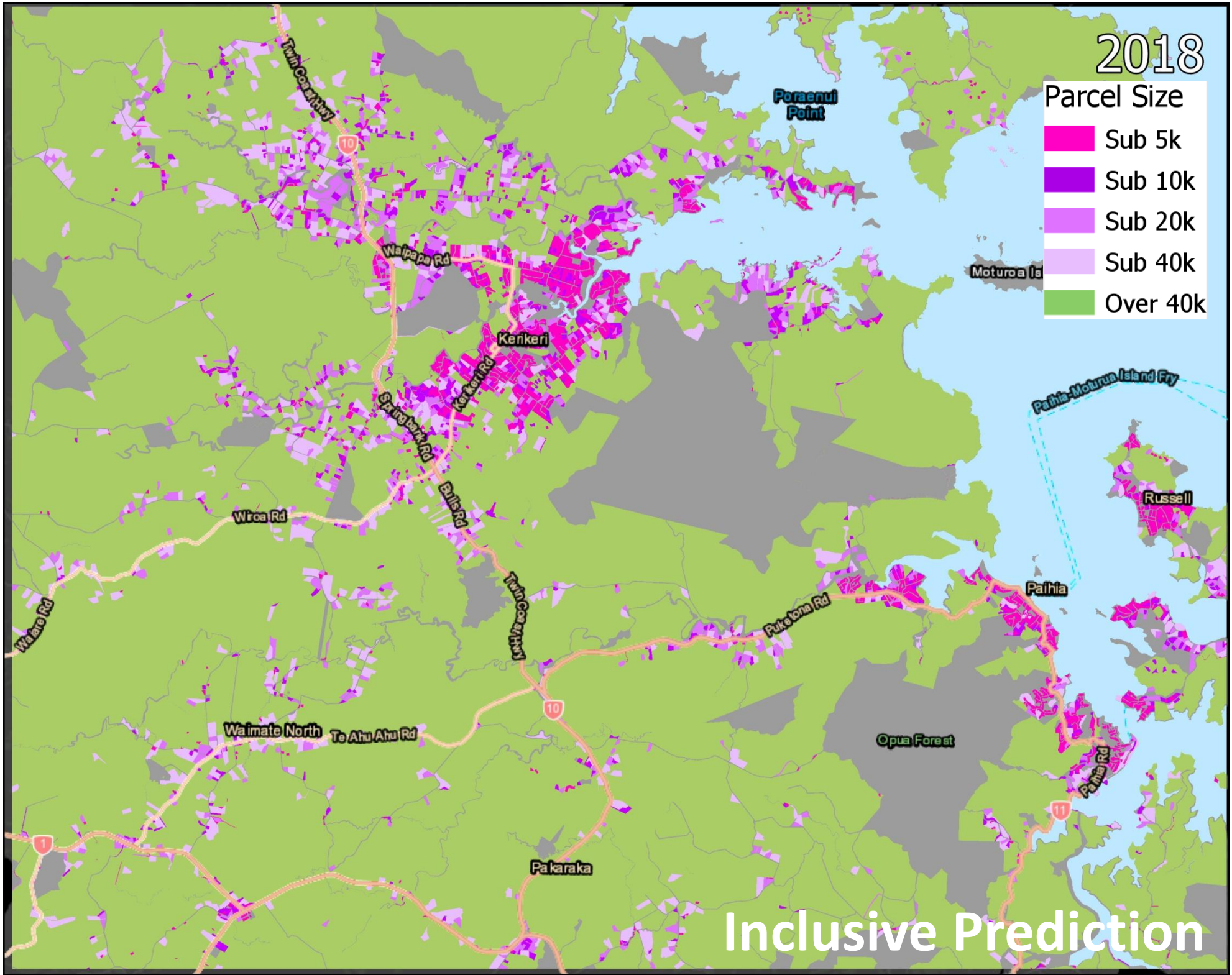
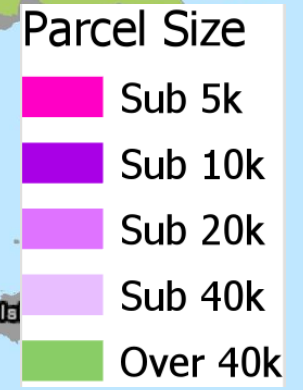
2003



Inclusive Prediction



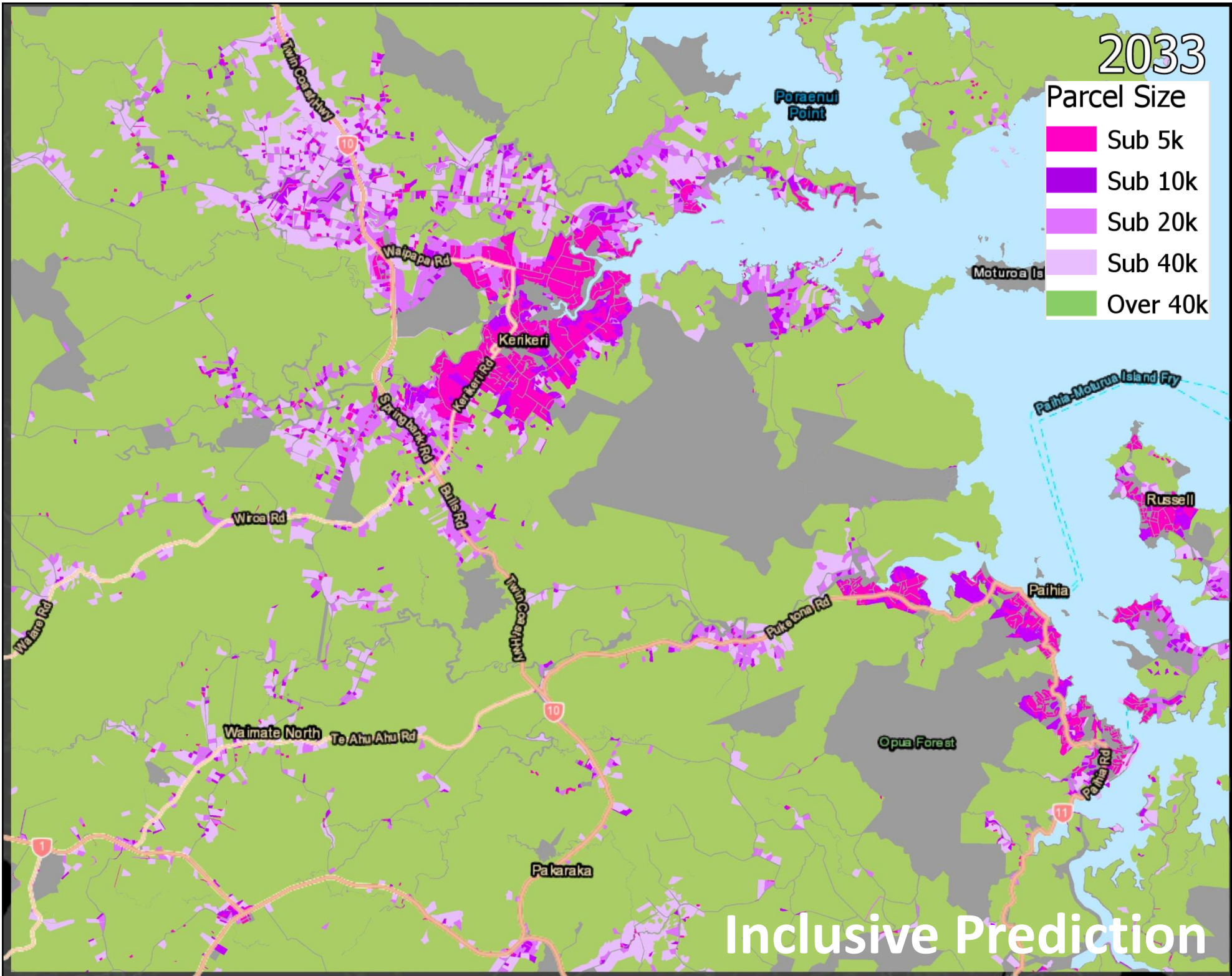
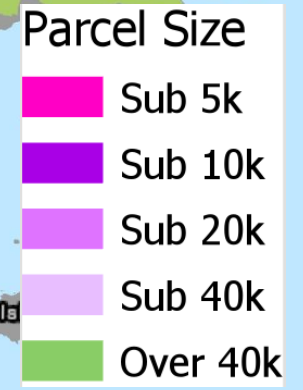
2018



Inclusive Prediction



2033



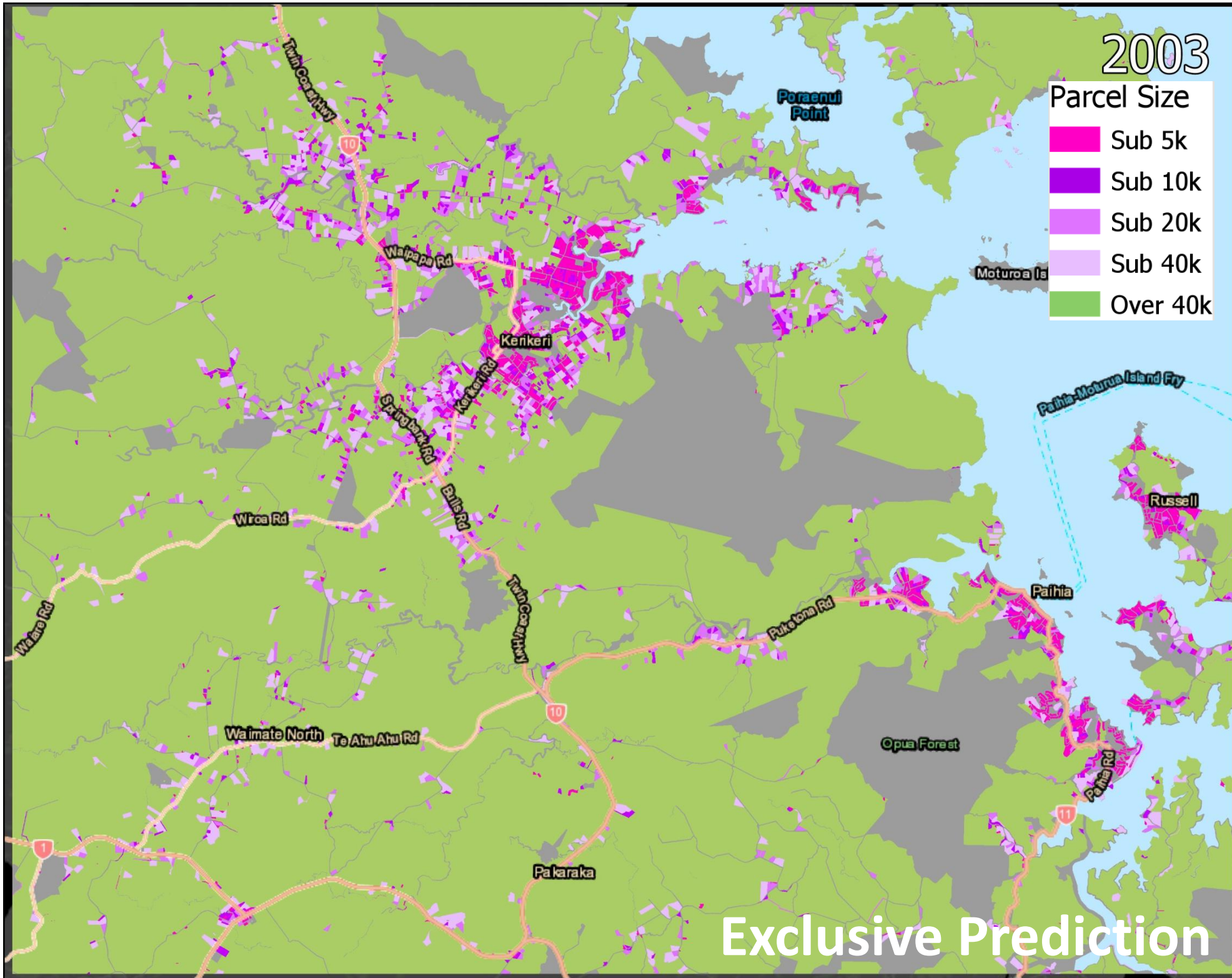
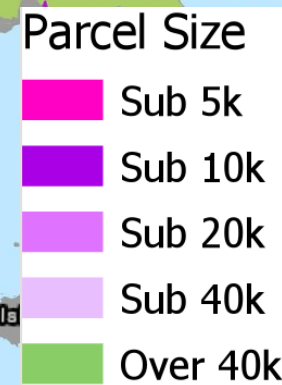
Inclusive Prediction

## 4. Predicting Future Change

- Exclusive Model Results, 2033



2003

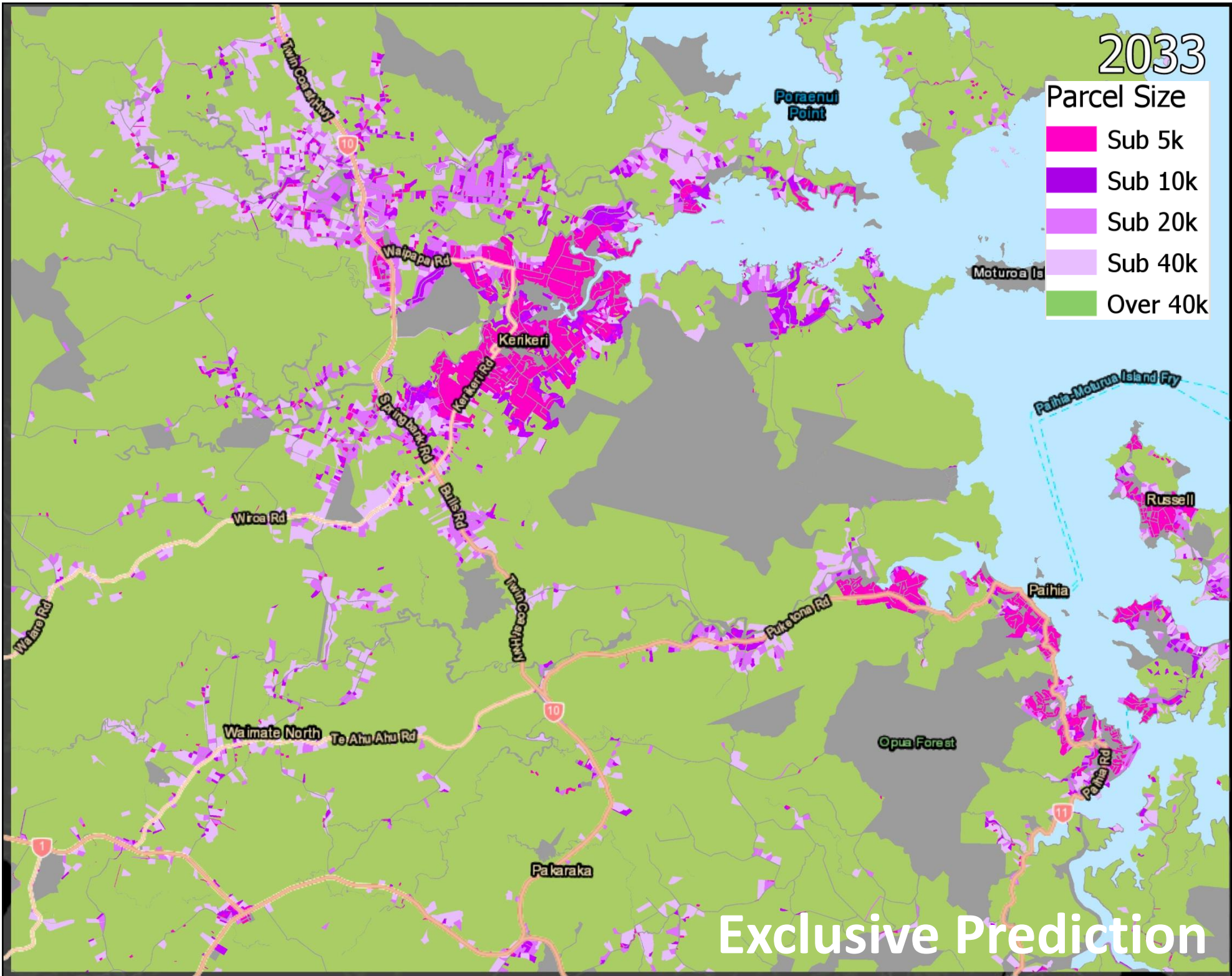
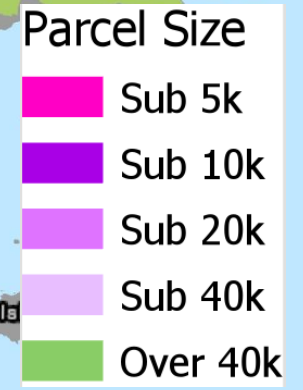








2033



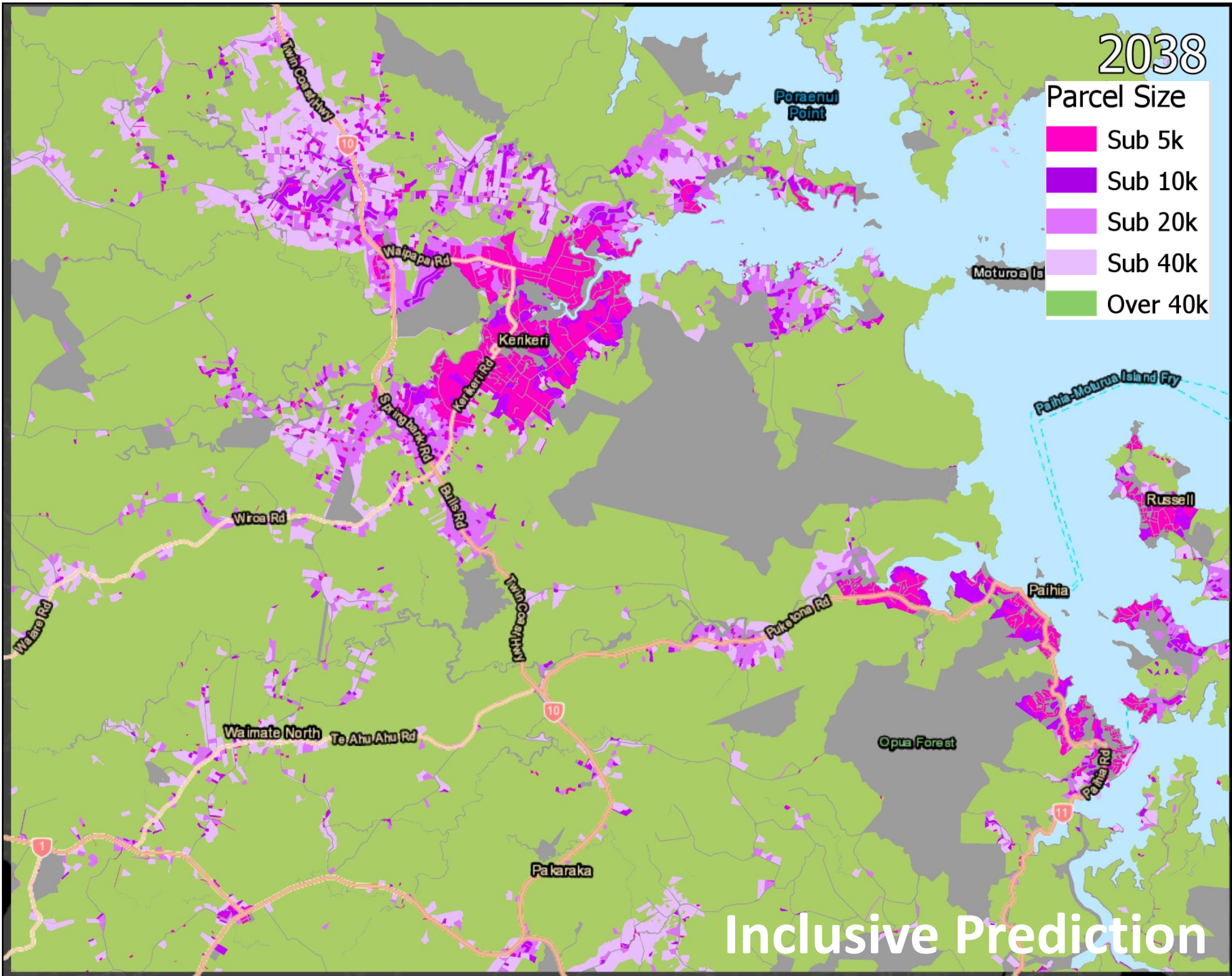
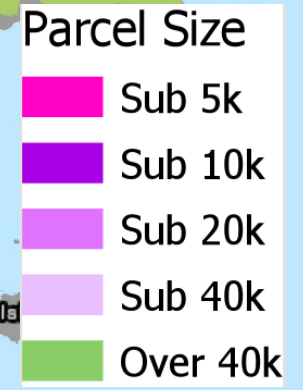
Exclusive Prediction

## 4. Predicting Future Change

- Comparison of 2038 predictions



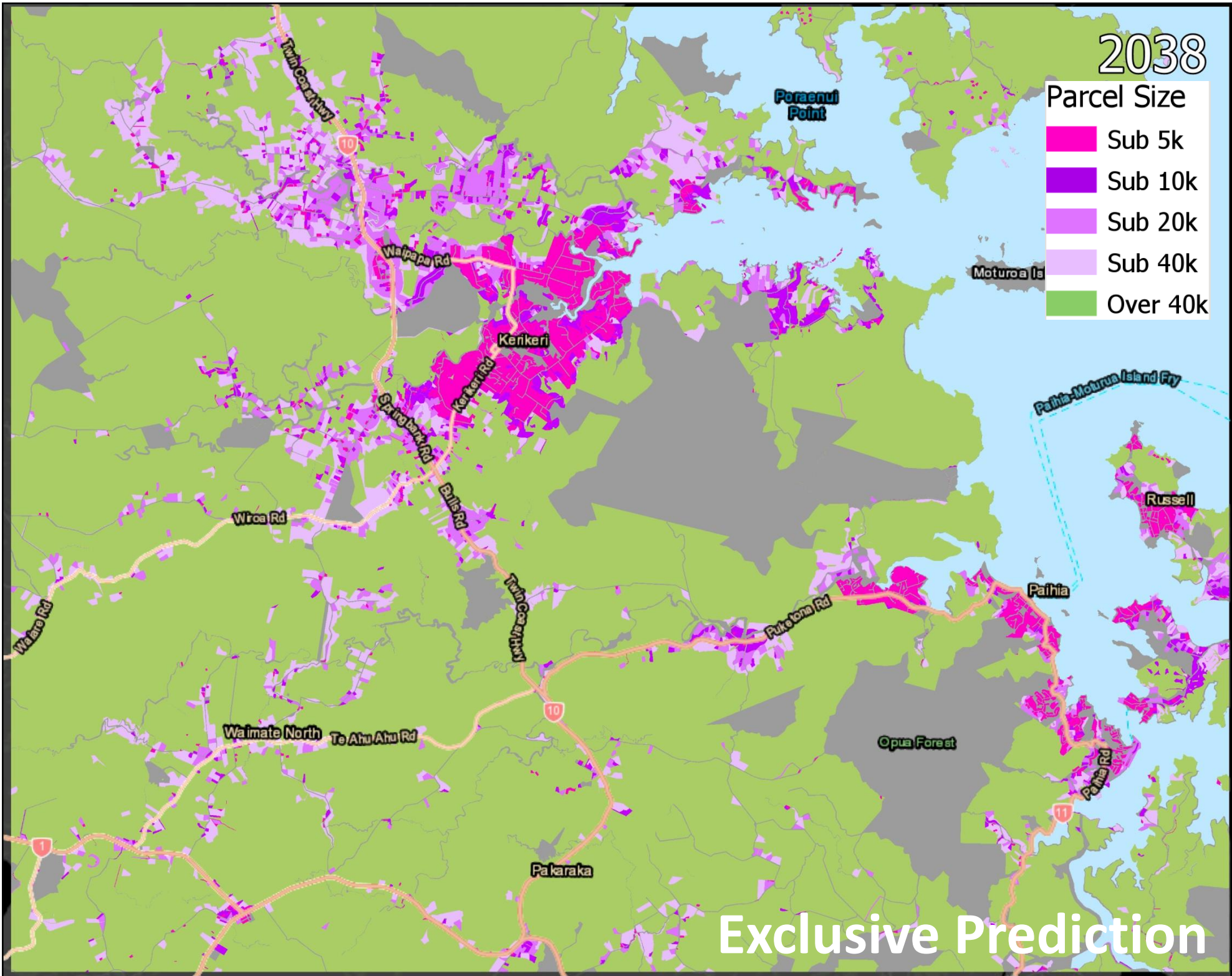
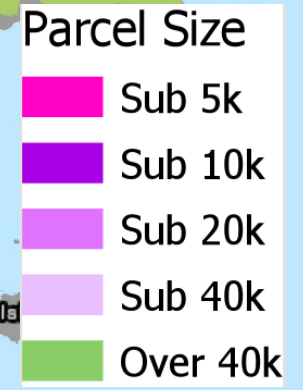
2038



Inclusive Prediction



2038



Exclusive Prediction



## Comparison of Results

1. Highest accuracy results for Sub 5,000
2. Persistence harder to measure with larger thresholds, and accuracy drops
3. Inclusive model, stronger for more generalized results
4. Exclusive model, more accuracy/stability in models, however, prediction prioritizes transition of smaller parcels
5. Both models yield similar predictions
  - Sub 5,000 & 10,000 = Kerikeri Township Infill
  - Sub 20,000 & 40,000 = Kerikeri Irrigation Scheme “V”
  - Subdivision of Versatile Soils

## Limitation

- **Precision**

- Only a measure of susceptibility, does not conform to or redraw parcel boundaries

- **Persistence vs. Transition accuracy**

- **The other 20%**

- **Intervention:**

- conscious- eg. zoning/plan changes

- unconscious- eg. private developments



## Continued Development

- **Additional Variables**
- **Validation**
- **Larger area with larger cells (generalises coverage)**
- **External analysis to augment change rate**
- **Assessing Impacts (eg. agriculture, soils, habitats etc.)**

## Implementing Scenarios

- **Roading Development**
  - Dynamic
  - Scheduled
  
- **Incentive and Constraints**
  - New Zoning
  - UGBs
  - Conservation



# Questions?



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