Calibration of a novel Bluetooth Low Energy (BLE) monitoring device in a sheep grazing environment

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TECH CARE

Background & Aims:

Tools for monitoring animal location and proximity are expensive and difficult to implement in extensive sheep systems.

Can Bluetooth Low Energy (BLE) be utilized as a means of sheep localisation within a field environment?

Background & Aims:

1. Calibration of BLE devices
   - Relationship between RSSI (Received Signal Strength Indictor) & distance
   - Development of distance prediction equation
2. Localisation of BLE Beacons
   - Off-sheep static test
   - On-sheep localisation

Device Design:

WISP (Wearable Integrated Sensor Platform)

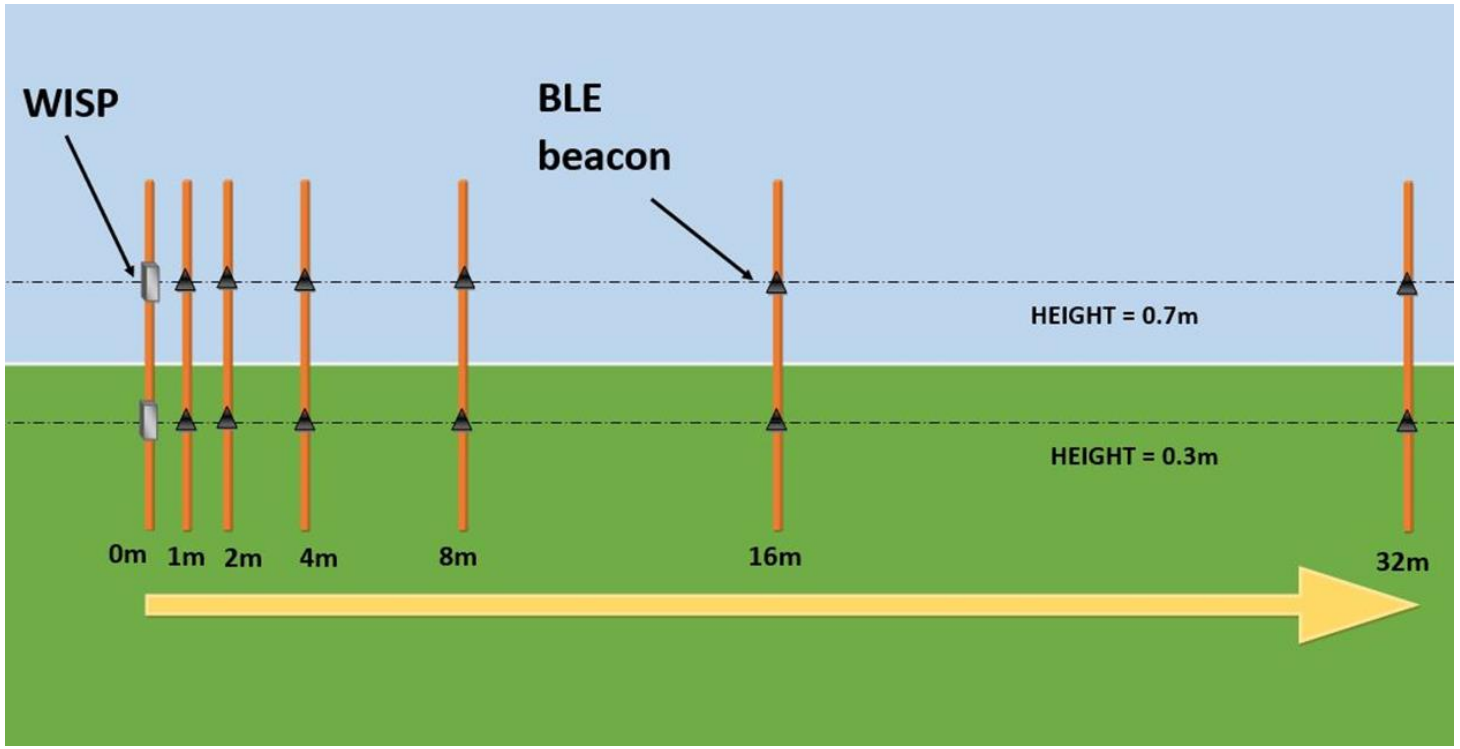
What's in the box?

- Sensors: **BLE reader**
  + GNSS / Accelerometer
- 5-minute duty cycle
- LoRa & Flash Drive
- 16 beacons
  (identity + average RSSI)

Device Calibration

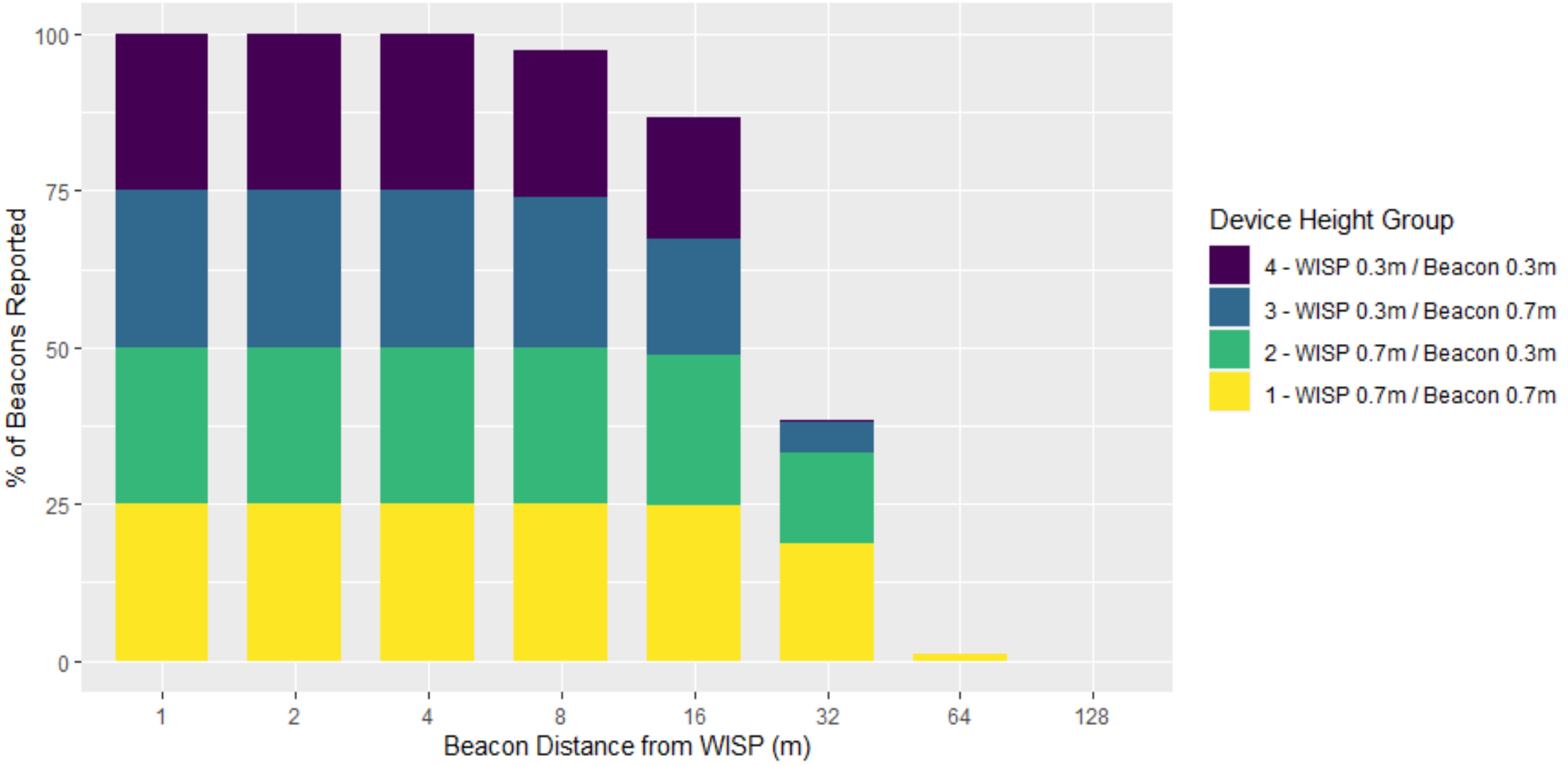
1. What is the device range?
2. What is the relationship between RSSI and beacon distance?
3. Does device height influence the range or reported RSSI?

Device Calibration

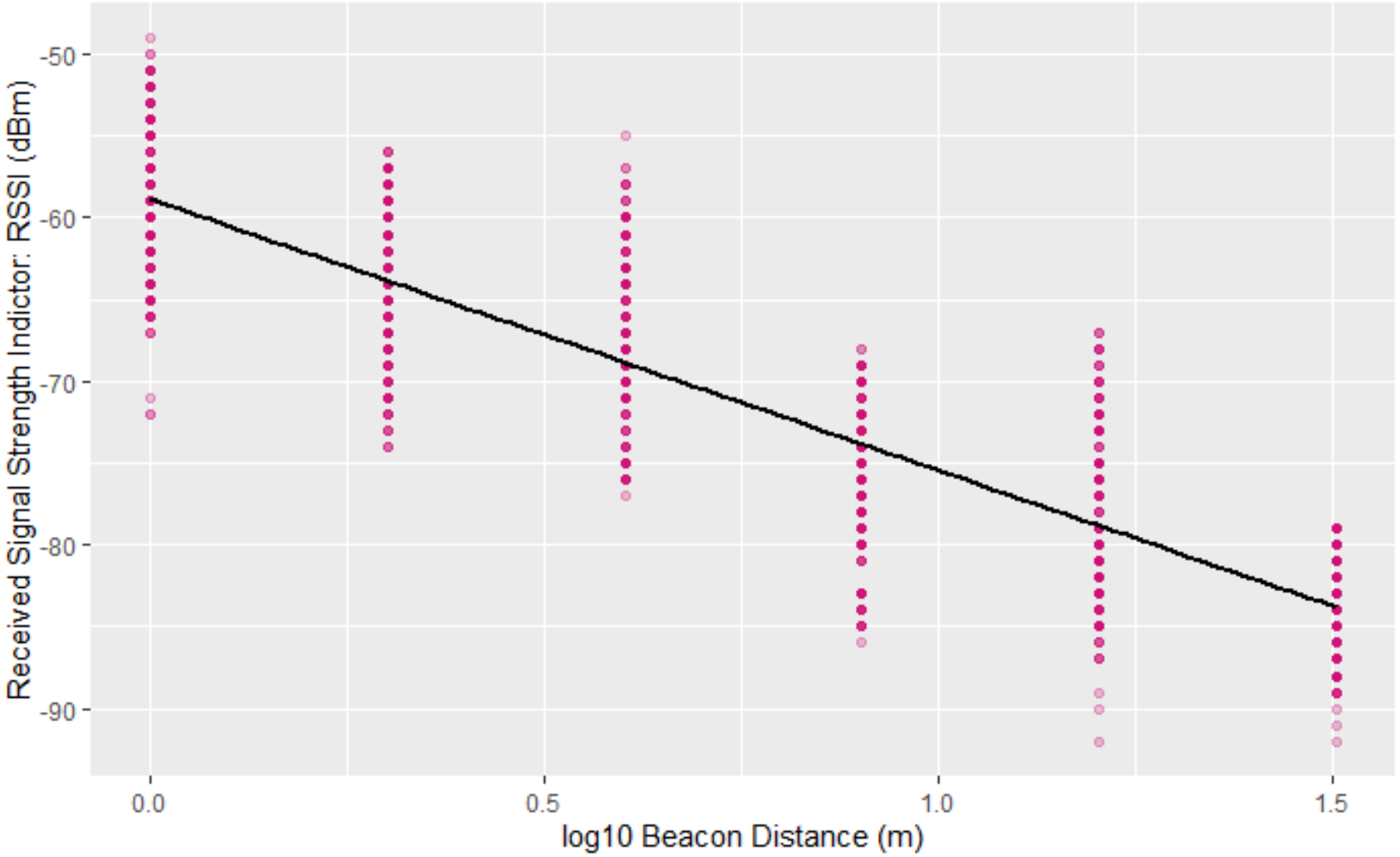


- **6** WISPs
- 8 BLE beacons
- Tested at $\log_2$ intervals (**1-128m**)
- **240** RSSI readings per distance
- WISPs & beacons tested at heights of **0.7m** & **0.3m**

Percentage of Total Beacons Reported per Distance



Change in RSSI over Log Distance



*Where both devices located at a height of 0.7m

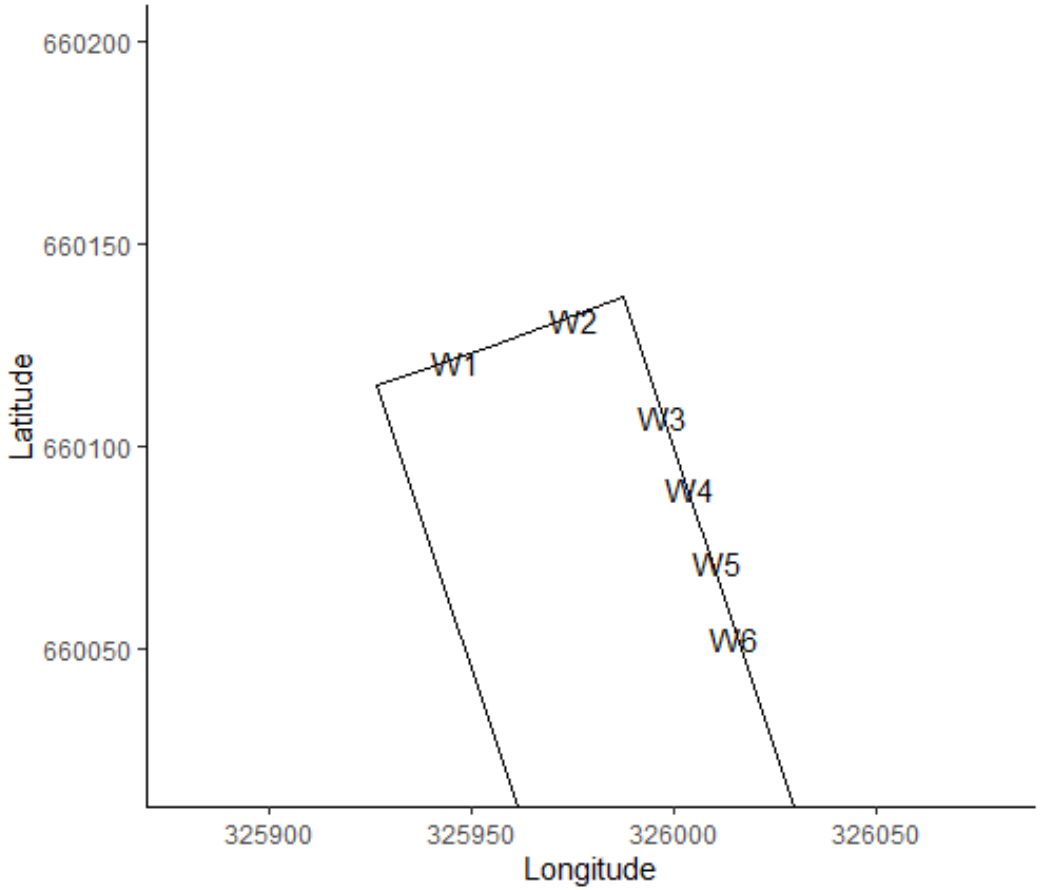
Distance Prediction Equation

2) Adjusted Predicted Distance =

$$\frac{Predicted\ Distance - (1.05 \times RSSI) - 2.19}{0.64}$$

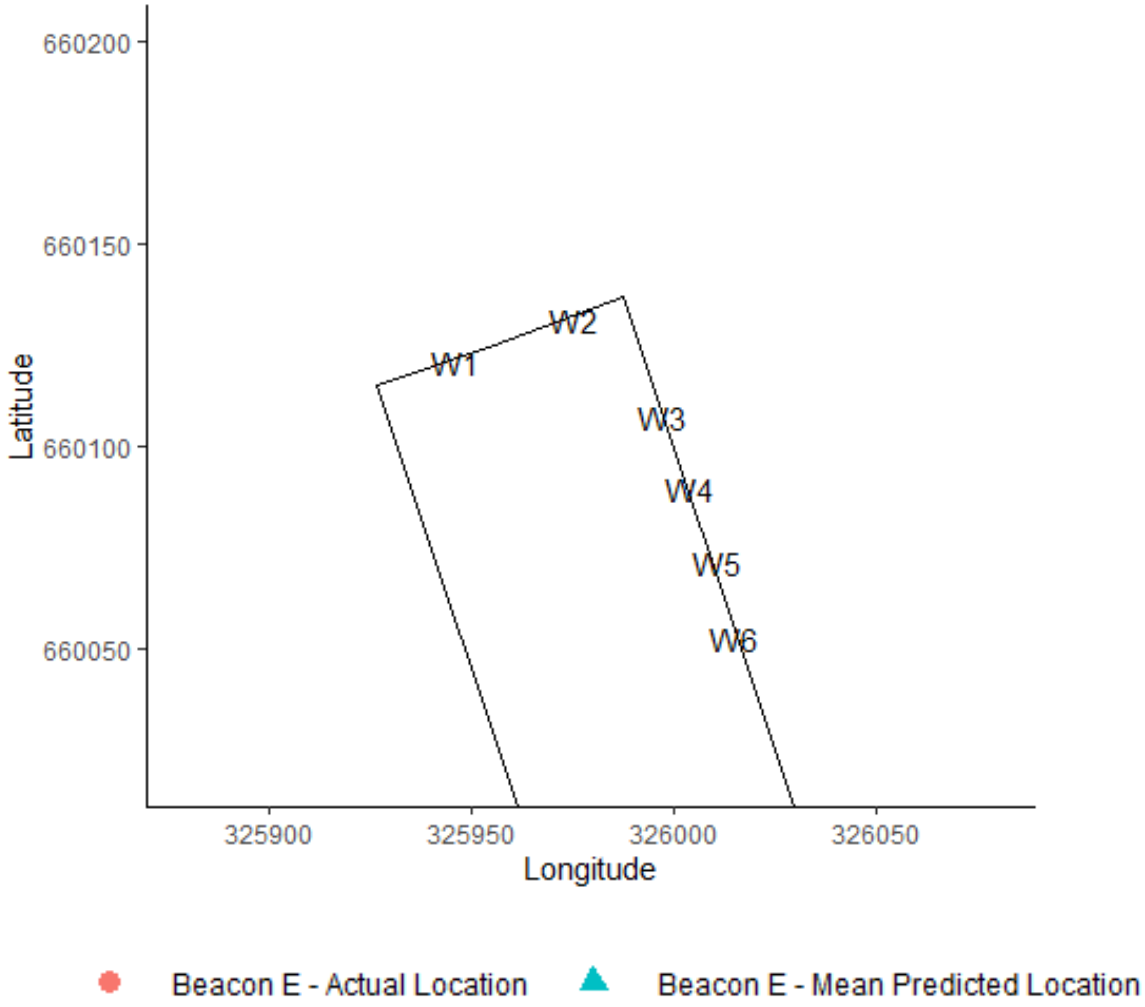
$$10^{\frac{Adjusted\ Predicted\ Distance}{10}}$$

Localisation of Static BLE Beacons



1. Calculate predicted distance from RSSI
2. Plot predicted distance as radius
3. Find intersecting points
4. Remove points out with boundary
5. Find mean of locations within boundary

Localisation of Static BLE Beacons



1. Calculate predicted distance from RSSI
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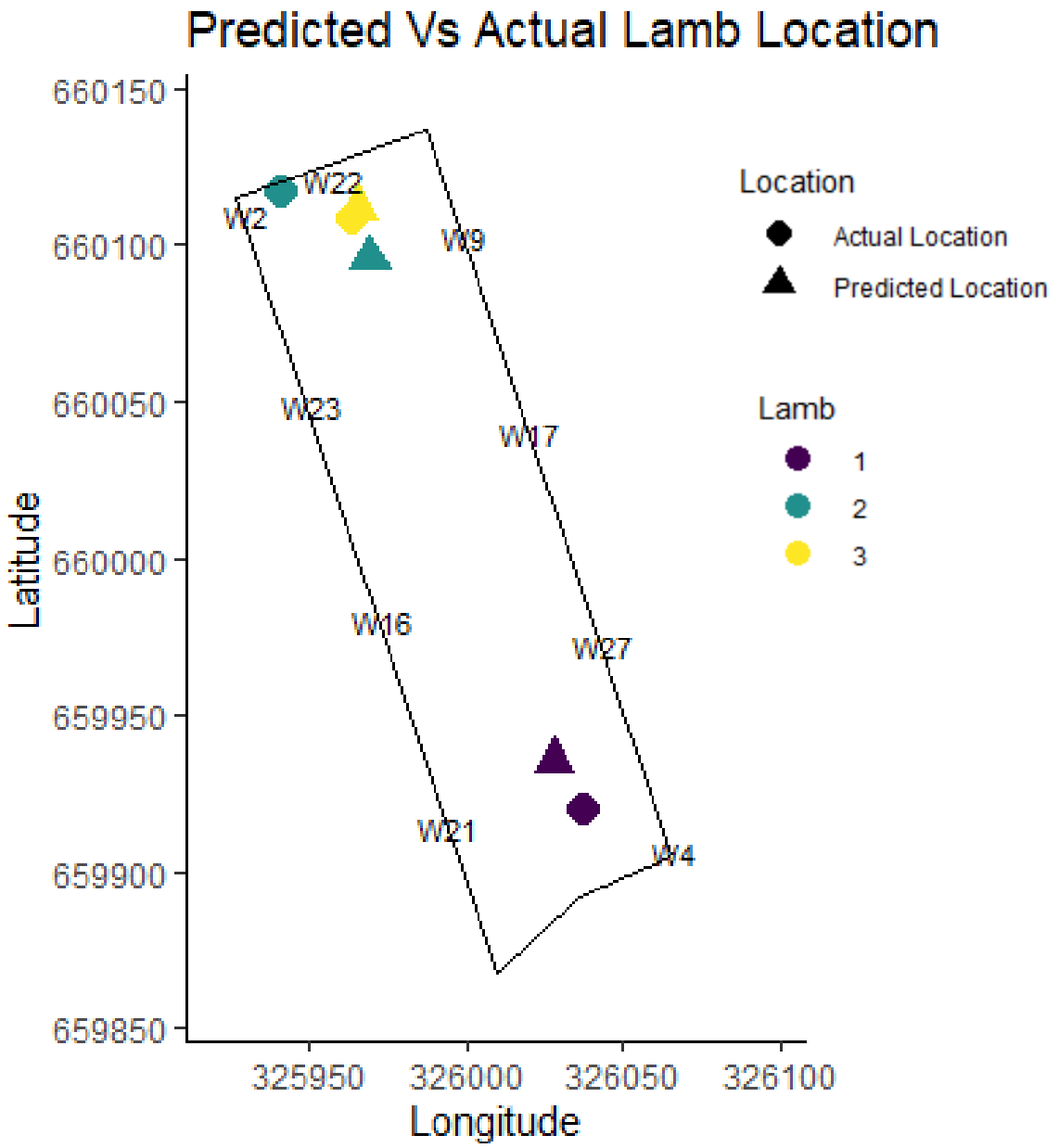
4. Remove points outside boundary
5. Find mean of locations within boundary

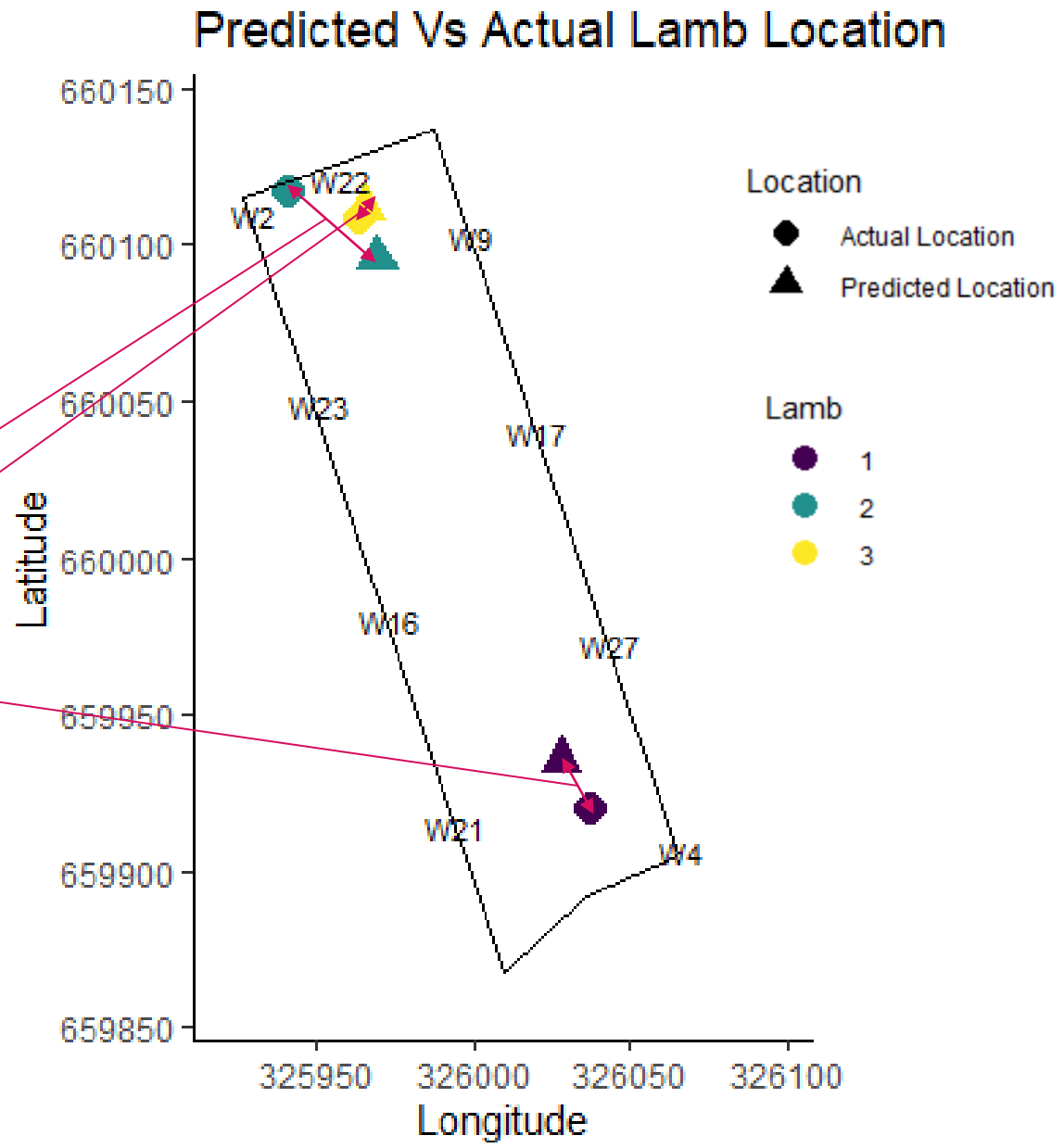
On-Sheep Localisation

- Weaned lambs with BLE beacon + GPS
- 9 WISPs (1.4 Ha)
- Data selected:
  - 3 stationary lambs
  - Minimum of 3 WISPs (within 5-minute period)



On-Sheep Localisation

- Difference between BLE (Predicted) & GPS (Actual) Location:
  - Lamb 1 = 18.38m
  - Lamb 2 = 35.12m
  - Lamb 3 = 3.91m
- Mean difference = 19.14m



On-Sheep Localisation

Lamb	WISP ID	Distance (m) based on BLE	Distance (m) based on GPS	Difference (m)
1	4	36.73	31.57	+5.16
1	21	51.52	43.22	+8.3
1	27	51.52	52.91	-1.39
2	2	13.98	13.27	+0.71
2	22	51.52	16.71	+34.81
2	23	57.57	68.58	-11.01
3	2	25.92	33.80	-7.88
3	9	32.74	35.92	-3.18
3	22	15.90	14.32	+1.58

Conclusions

- **BLE could be utilised as a means of sheep localisation in outdoor environments where there are a high density of BLE readers.**

- Further optimisation to improve accuracy (depending on system and intended use)
- Limits to approach but could provide more information regarding location and movement than proximity ranges or presence / absence.

Thank You for listening!

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