

# A pilot model combining GPS and Environmental data to examine dog-tick interactions in Ramah Navajo Nation

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## Background

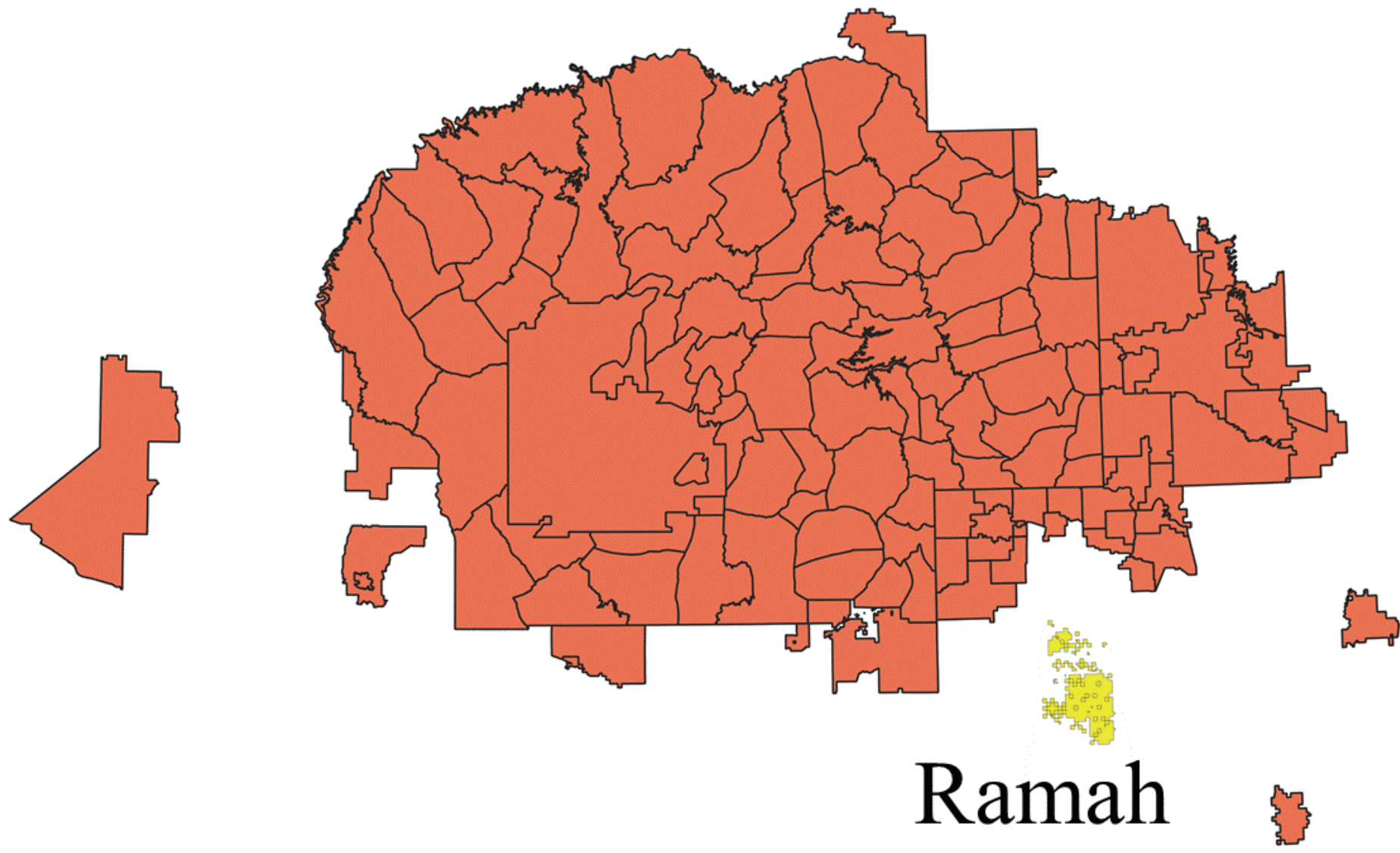


Fig 1. Ramah, Navajo Nation

- Ramah is located in the south east of Navajo Nation (Fig 1).
- 0.3% of people from Navajo Nation lived in Ramah.
- Out of 337 tested dogs, 54 were positive to Rocky Mountain Spotted Fever (Fig 2).
- Brown dog ticks are the biggest concern for the health of dogs and human.

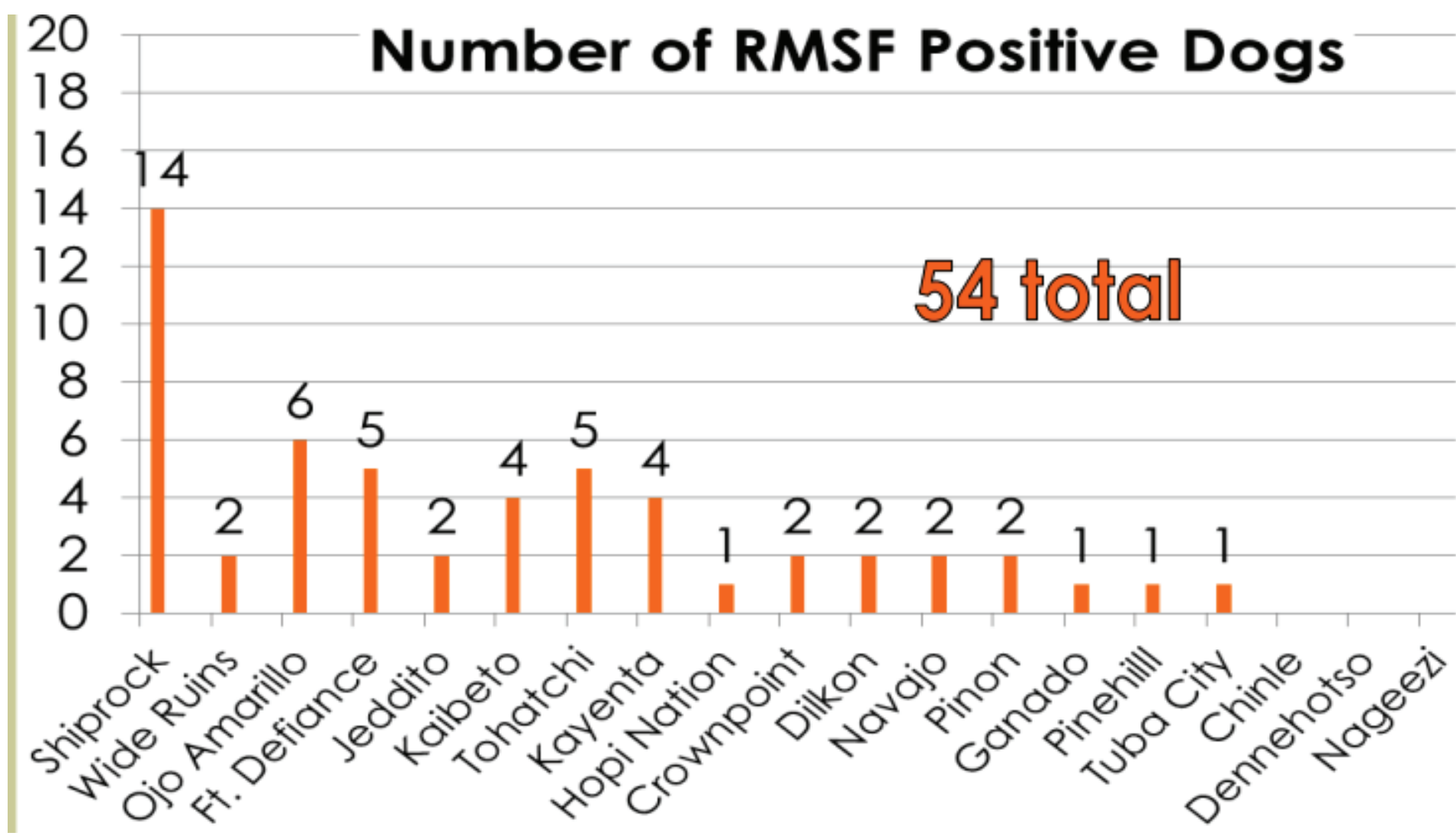


Fig 2. Affected dogs in Navajo Nation

## Workflow

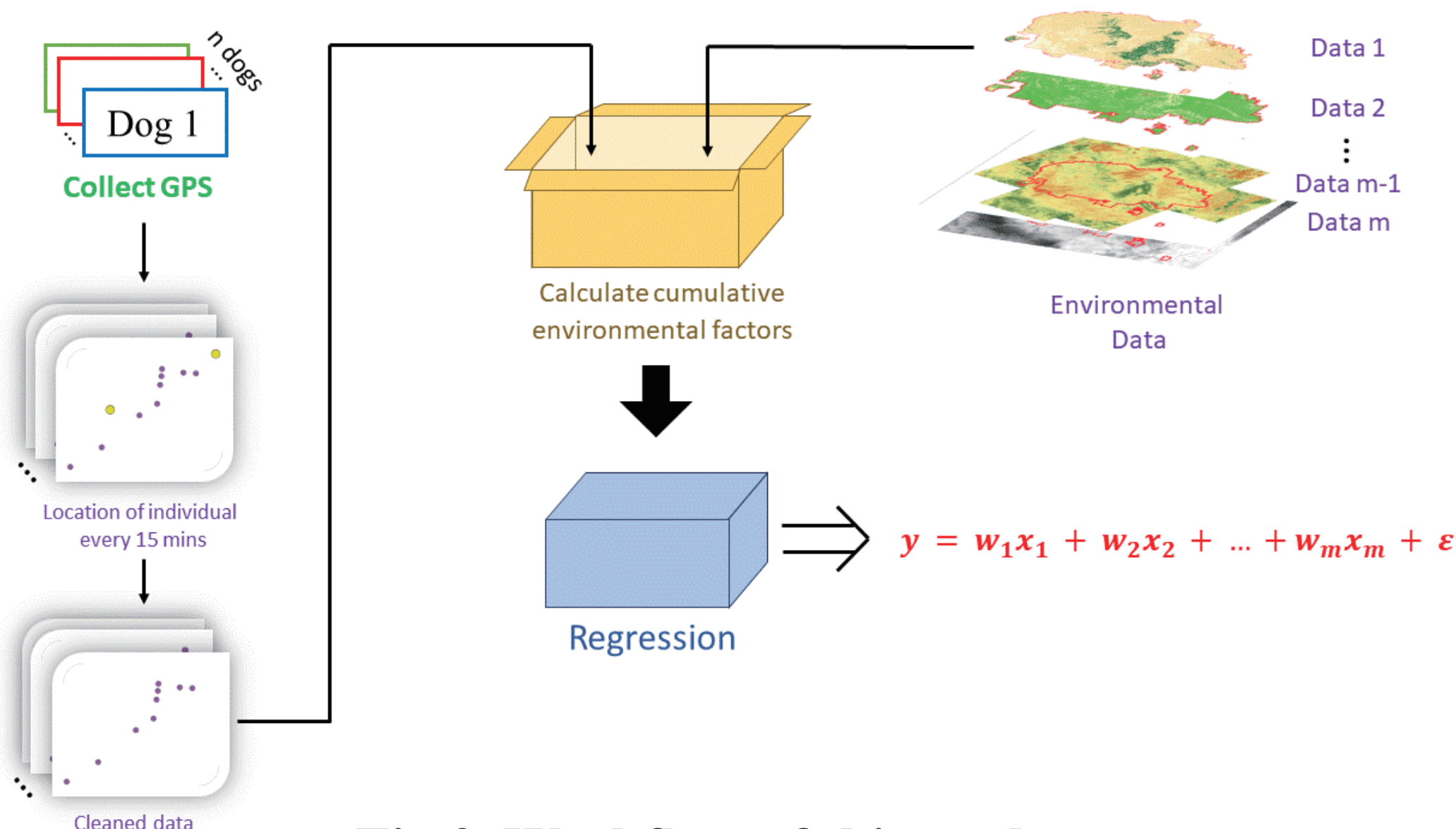


Fig 3. Workflow of this study

1. Collect GPS data for each individual at 15 mins interval (Fig 4).

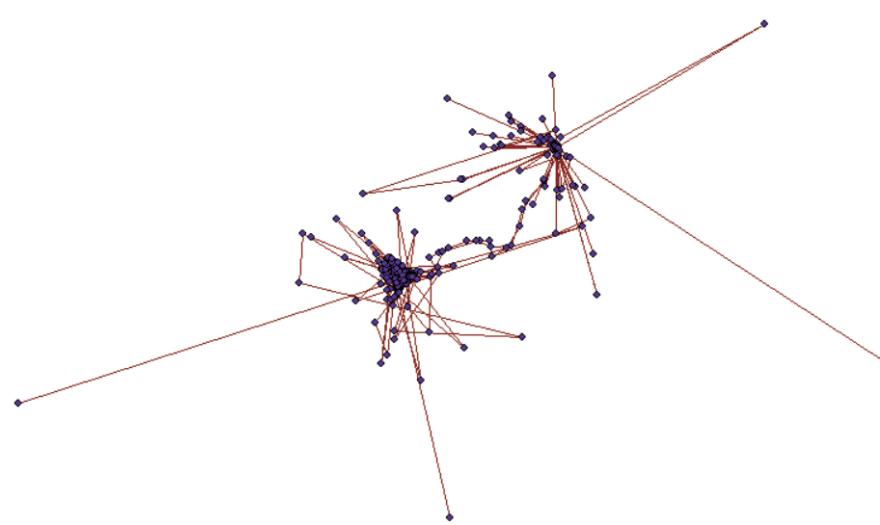


Fig 4. Origin GPS data

Tab 1. Sample of GPS

GMT Time	Lat	Lon	Alt (meter)	Duration (second)	Temp (°C)	Satellites
6/24/2021 4:42:12 PM	0	0	0	2	24.5	0
6/24/2021 5:01:10 PM	0	0	0	70	29.5	0
6/24/2021 5:20:27 PM	35.09	-106.61	1556.9	41	27	5
6/24/2021 5:40:28 PM	35.09	-106.61	1542.0	27	25.5	5

Invalid GPS: Alt (Altitude) < 800 or Duration > 70 or Satellites (satellite number) < 4



Fig 5. Cleaned GPS data

3. Collect Environmental data covering our study period.

Raster Time Series

2. Clean the GPS data (Tab 1, Fig 5).

4. Make a regression model.

y: 32 (8 weeks x 4 dogs) tick counts observations.  
x1: Normalized Difference Vegetation Index, NDVI (raster, numeric).  
[x2, x3, x4]: [temperature, precipitation, travel distance] (time series, numeric)  
x5: landscape (raster, categorical)

## Methodology

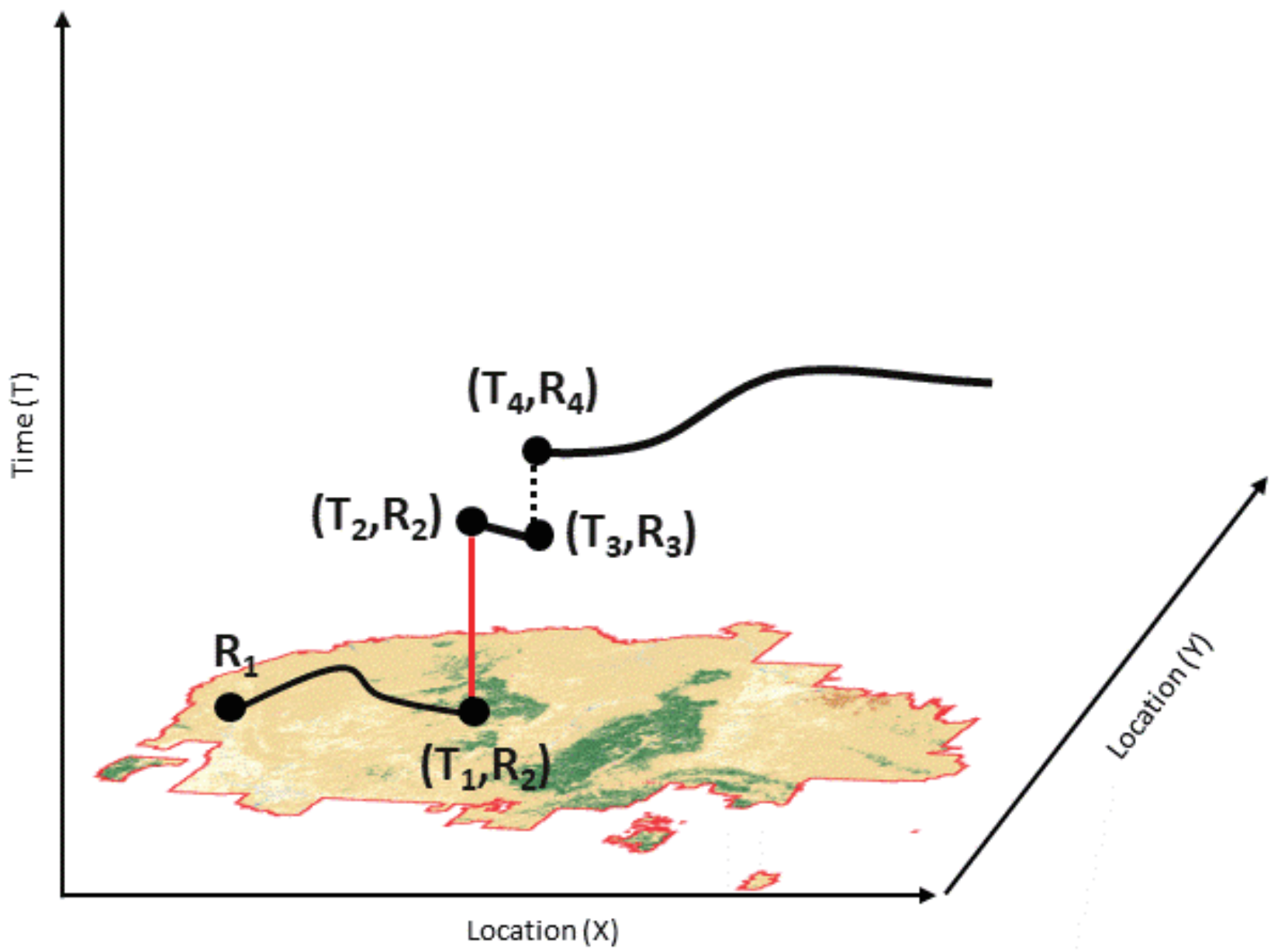


Fig 6. Raster-Numerical factor

- For the raster-numerical factor, we can calculate the cumulative environmental factor as:  
 $E_{ij} = R_1 + (T_2 - T_1)R_2 + (T_4 - T_3)R_3$ 
  - $E_{ij}$ : cumulative environmental factor for Dog i, Week j.
  - $T_1/T_3$ : time 1/3 when entering the place.
  - $T_2/T_4$ : time 2/4 when leaving the place.
  - $R_1 \dots R_4$ : environmental raster values.
- For the time series-numeric factor, we can sum the number at each week.
  - e.g. Week 1 Temp = Day 1 Temp + ... Day 7 Temp

Tab 2. Time Series data

Time	Temperature (°F)	Precipitation
Day 1	77	3.759
Day 2	78	1.329
.....		
Day n	72	1.352

## Demo Results using Simulated Data

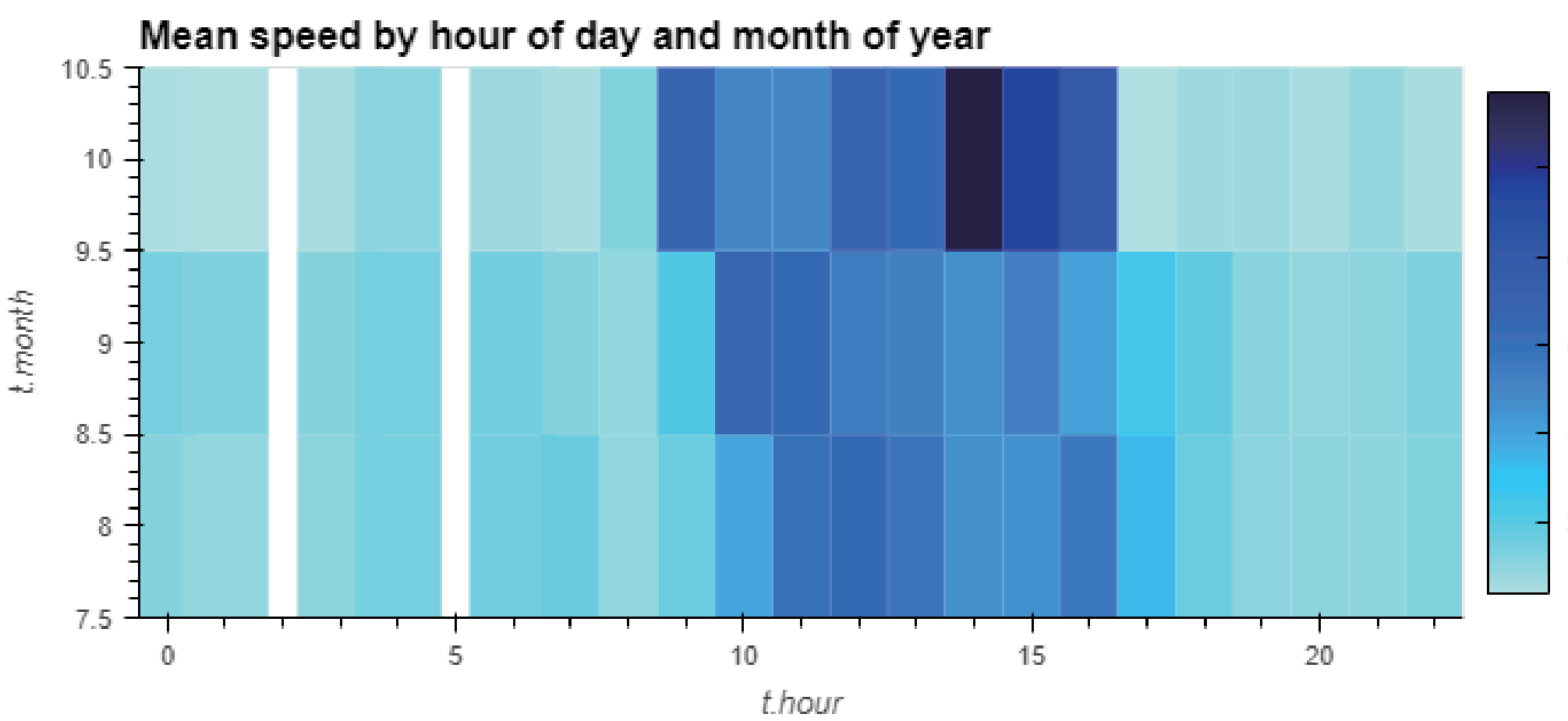


Fig 7. Speed -- time

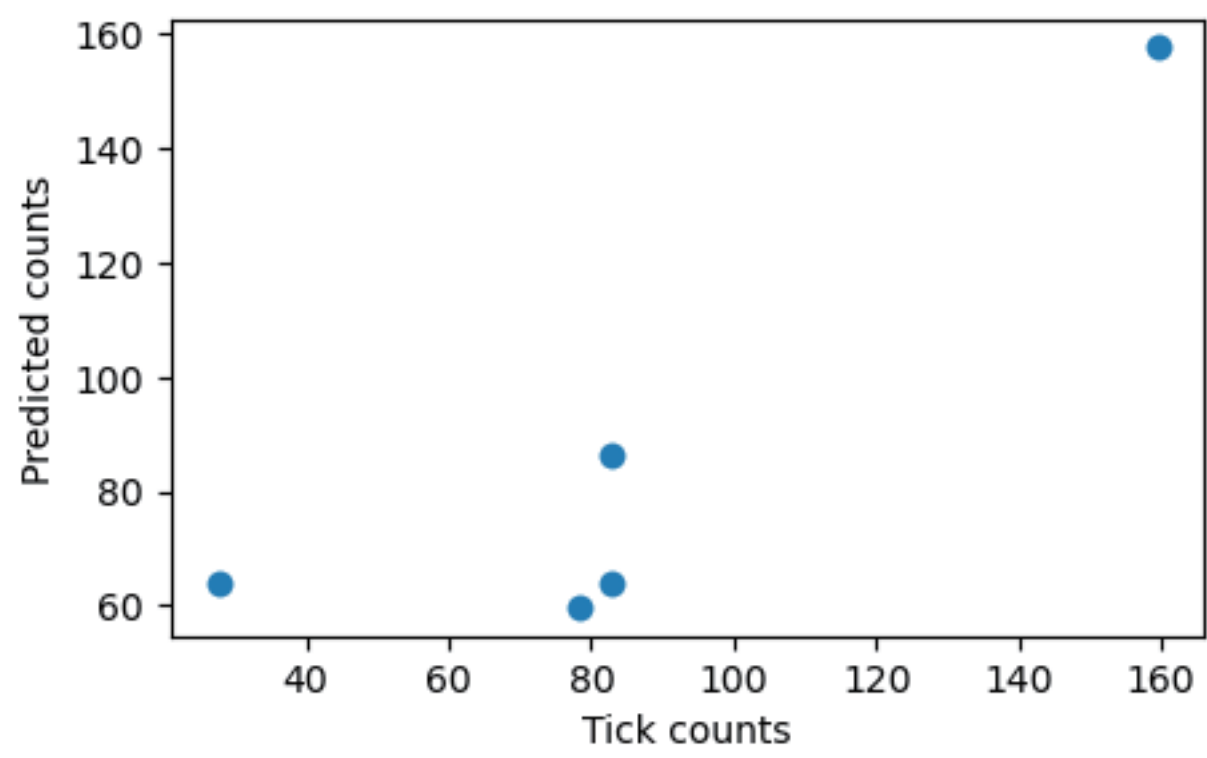


Fig 8. Observation -- Prediction

OLS Regression Results						
Dep. Variable:	y	R-squared (uncentered):	0.972			
Model:	OLS	Adj. R-squared (uncentered):	0.862			
Method:	Least Squares	F-statistic:	8.820			
Date:	Mon, 04 Mar 2024	Prob (F-statistic):	0.247			
Time:	09:58:26	Log-Likelihood:	-20.706			
No. Observations:	5	AIC:	49.41			
Df Residuals:	1	BIC:	47.85			
Df Model:	4					
Covariance Type:	nonrobust					
	coef	std err	t	P> t	[0.025	0.975]
Precipit	0.2430	0.385	0.632	0.641	-4.645	5.131
Temperatur	0.0443	0.038	1.174	0.449	-0.435	0.524
LULC_1	-0.0908	0.048	-1.904	0.308	-0.696	0.515
LULC_2	-0.0319	0.061	-0.527	0.691	-0.801	0.738
Omnibus:	nan	Durbin-Watson:	2.888			
Prob(Omnibus):	nan	Jarque-Bera (JB):	0.544			
Skew:	-0.776	Prob(JB):	0.762			
Kurtosis:	2.547	Cond. No.	467.			

Fig 9. Model performance statistical measure

- For these 2 monthes, animals' speeds are generally high from 10 am to 17 pm.
- This gives information about how the dogs behave daily, and can link to the map for further interpretation

- Simulated data with 1 month, 1 animal (Fig 8).
- Fig 9 reveals the model's performance