Modeling Wildlife Roadkill Risk Using Citizen Science Data

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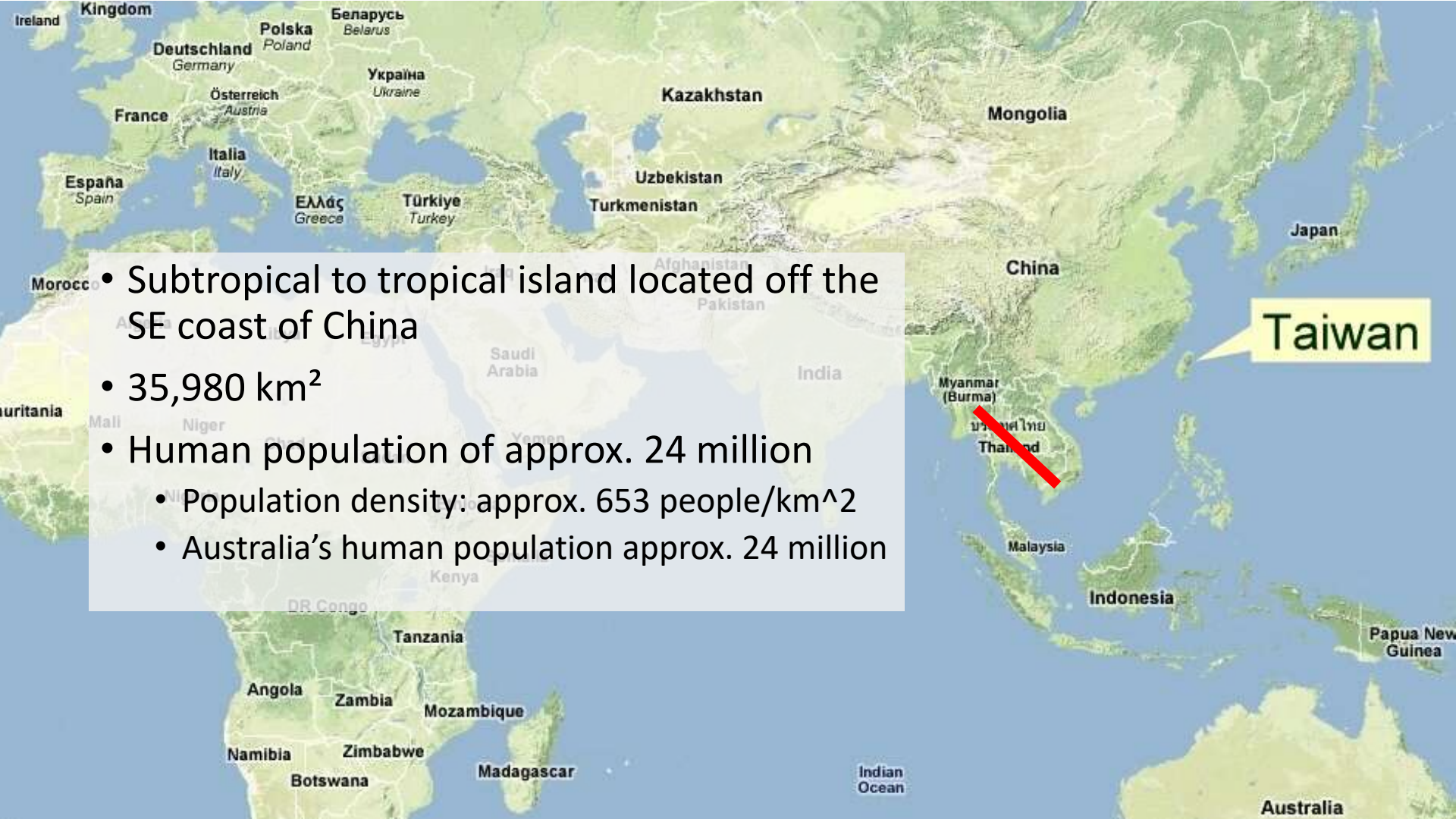
Outline

- Taiwan
  - Research Background
  - Objectives
  - Analysis
  - Results
- Australia
- Conservation Outcomes



- Subtropical to tropical island located off the SE coast of China
- 35,980 km²
- Human population of approx. 24 million
  - Population density: approx. 653 people/km^2
  - Australia's human population approx. 24 million

“For the past forty years, **economic development has been the primary goal** for Taiwan. As great as the economic success has been, it has not occurred without **compromising the environmental integrity of the landscape**. A small island to begin with, Taiwan's continued expansion of industry and agriculture has made **habitat destruction the primary threat to wildlife**.” - Taiwan Forestry Bureau

Nature **403**, 853-858 (24 February 2000) | doi:10.1038/35002501; Received 22 September 1999; Accepted 22 December 1999

Biodiversity hotspots for conservation priorities

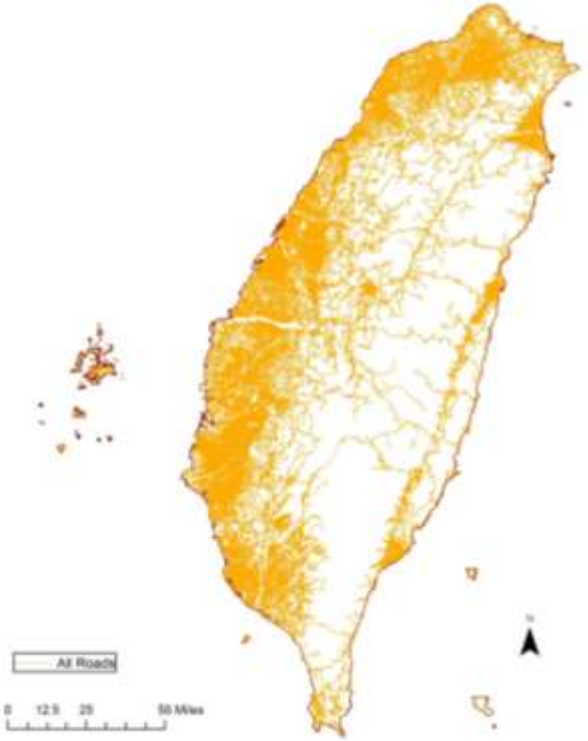
See associated Correspondence: Kumar, *Nature* **491**, 333 (November 2012)

Norman Myers[1], Russell A. Mittermeier[2], Cristina G. Mittermeier[2], Gustavo A. B. da Fonseca[3] & Jennifer Kent[4]

"Other areas **appear to feature exceptional** plant **endemism and exceptional threat**, but are **not sufficiently documented** to meet the hotspots criteria. They include the Ethiopian Highlands, the Angola Escarpment, southeastern China, **Taiwan**…"

Competing economic and environmental interests

- Intersection of high population and road density and high biodiversity
- Road density of 1.2 km/km^2
  - Approximately twice the road density of the USA (0.680 km/km^2)
  - Over 10 times the road density of Australia (0.106 km/km^2)
- Ecological impacts of roads are expected to be especially dramatic in island ecosystems



Prior Research in Taiwan:

US NSF-EAPSI Taiwan (summer 2015) &

Fulbright Research Fellowship Taiwan (Sept. 2016 – Aug. 2017)

- Established a collaboration with Te-En Lin, road ecologist at TESRI
- Continued collaboration on projects utilizing the Taiwan Road Observation Network (TaiRON).

Taiwan Roadkill Observation Network (TaiRON)

- Online citizen science roadkill observation database starting in 2011
  - Started as a Facebook group
  - Over 60,000 geospatially referenced data points of roadkill
  - Over 14,000 Facebook group members
  - Most citizen science data collected on a webapp

TaiRON Data Collected

- Photo with scale
- Date
- Time
- Location
- Species if known
- Uploaded to FB via web app (https://roadkill.tw/en/app?v=2.0)

Volunteers given observation kits with:

- Roadkill scale card
- Sample bags to send in roadkill samples
- Gloves for roadkill collection
- Other goodies

- Several project managers that quality check each observation and verify observation in the database

Objectives

- Quantify impacts of roads on native biodiversity across multiple spatial and ecological scales.
- Create a predictive roadkill maps to identify environmental features and areas of high roadkill risk for wildlife

Predictive roadkill mapping

- Using correlative species distribution models (SDMs) to create predictive roadkill maps
  - SDMs model the relationship between a species and its environment
  - Utilizing roadkill presence and environmental data

Species Distribution Models (SDMs) vs Hotspot Analysis

- SDM Predictive maps:
  - Detect **potential** roadkill risk
    - Able to predict risk in areas without data
  - **Identify the variables** that best explain the presence of the most roadkill data
- Hotspot Analysis
  - Only find spatially clustered data
  - **Does not incorporate environmental or landscape variables** in analysis
    - Not able to predict roadkill risk outside of roadkill occurrence data

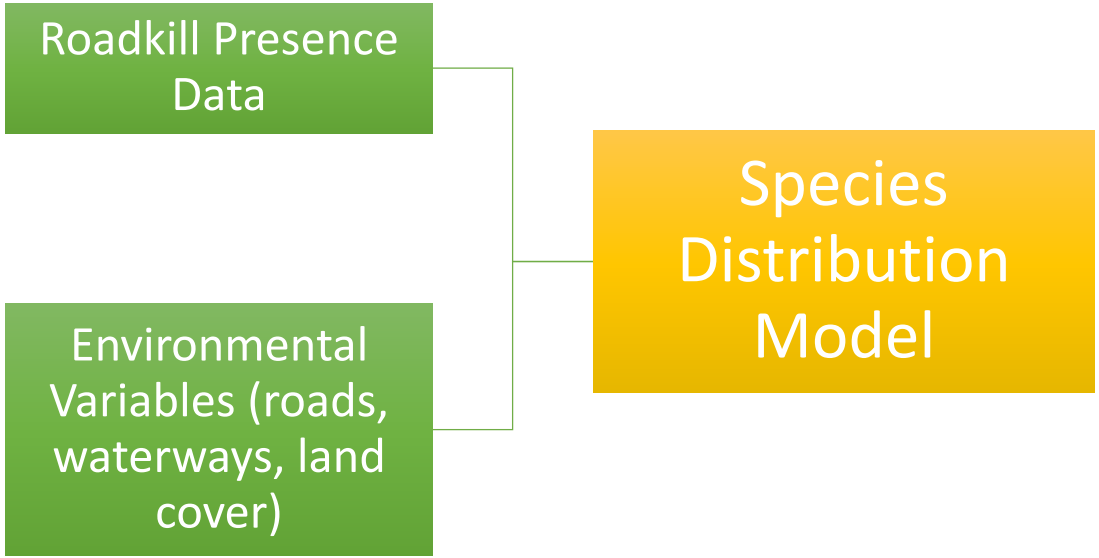
Taiwan

Using Correlative Species Distribution Models to Predict Roadkill Risk for Native Taiwan Herpetofauna

- Predict risk especially in areas without roadkill data
- Identify environmental variables that contribute to roadkill risk

Data	Data Source
Citizen Science Roadkill Observations	Taiwan Road Observation Network (TaiRON) (downloaded 11/22/2016)
Road Network	Ministry of Transportation and Communication (MOTC), Taiwan
Sub-meter Land Use Land Cover	Taiwan National Land Survey and Mapping Center (created May 2008)

Analysis


Roadkill Presence Data
Environmental Variables (roads, waterways, land cover)
Species Distribution Model

Arboreal frogs

Semi-arboreal snakes

Semi-arboreal lizards

Terrestrial frogs

Turtles

Arboreal lizards

Arboreal snakes

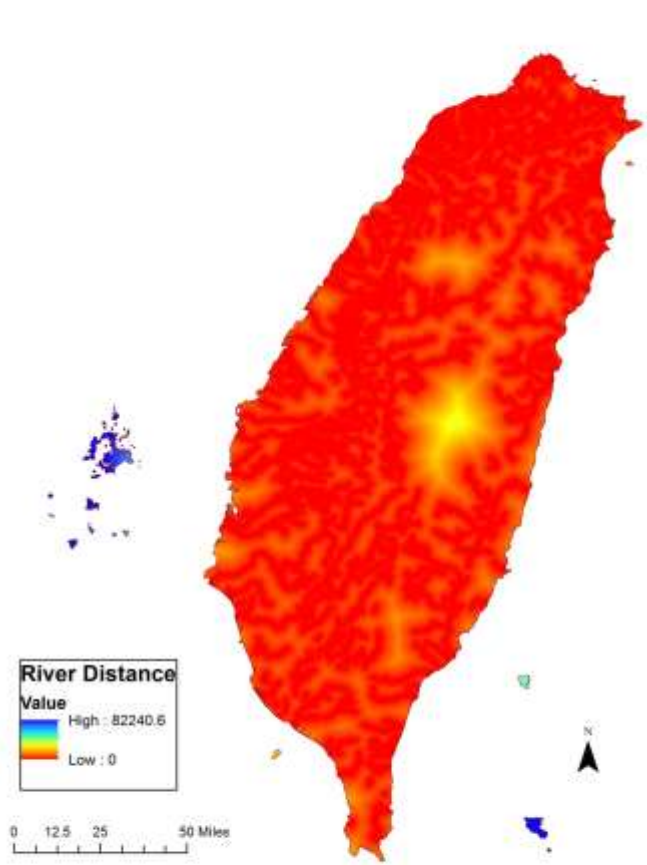
Terrestrial snakes

Terrestrial lizards

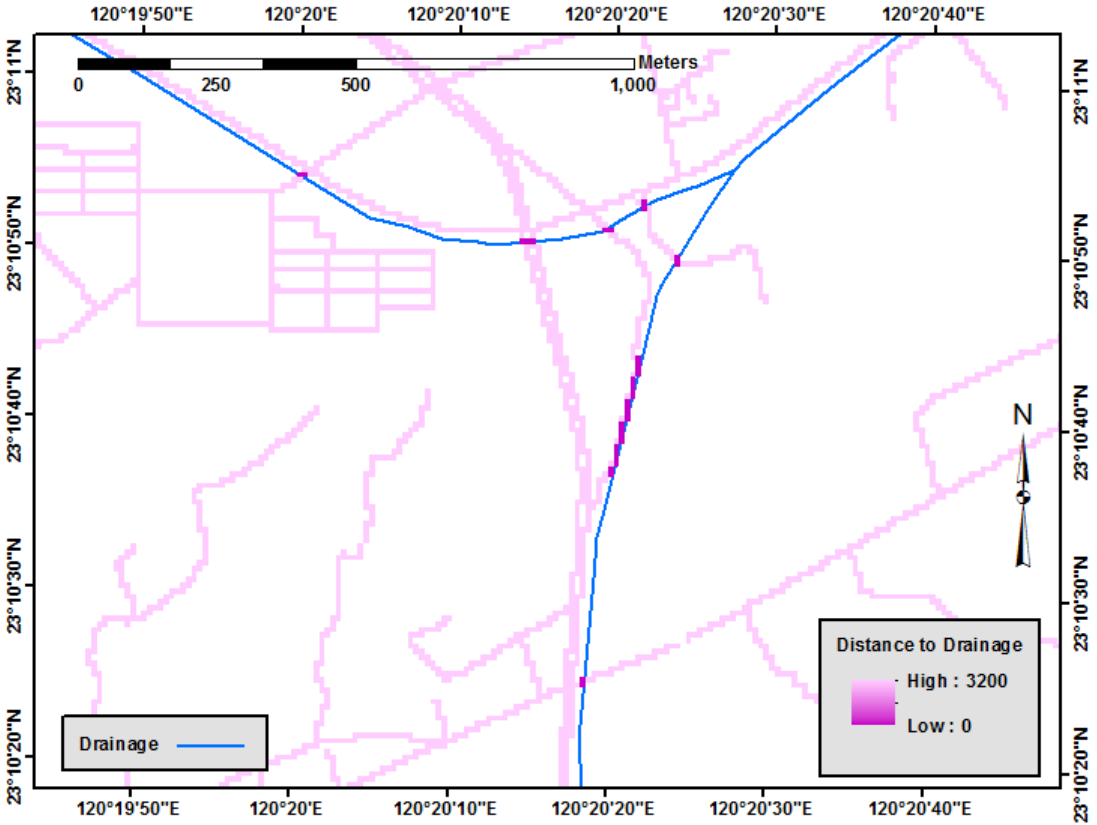
Semi-aquatic snakes

Distance Variables

- Created distance to variable gradient using a Euclidian distance method
- Masked gradient by road network

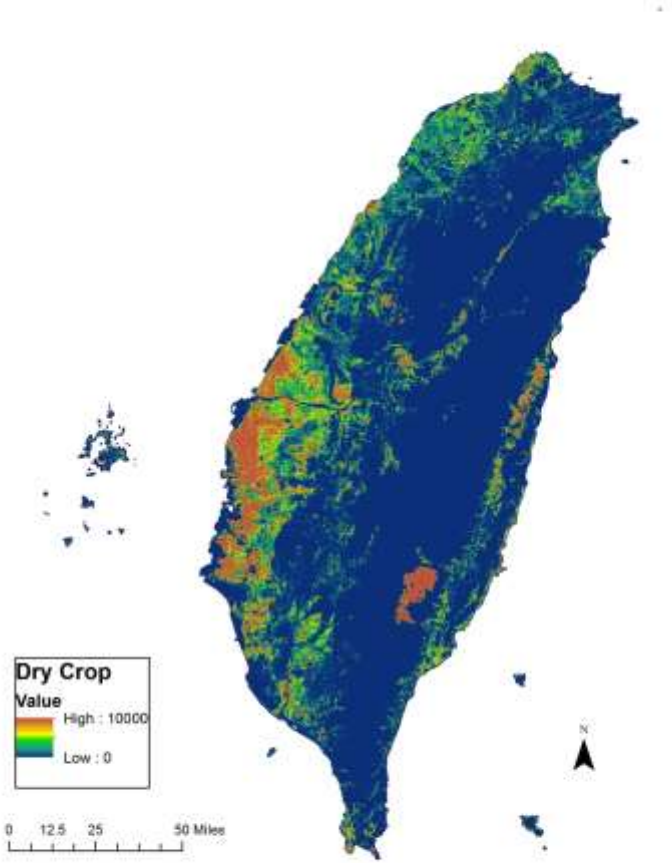


Distance to Drainages

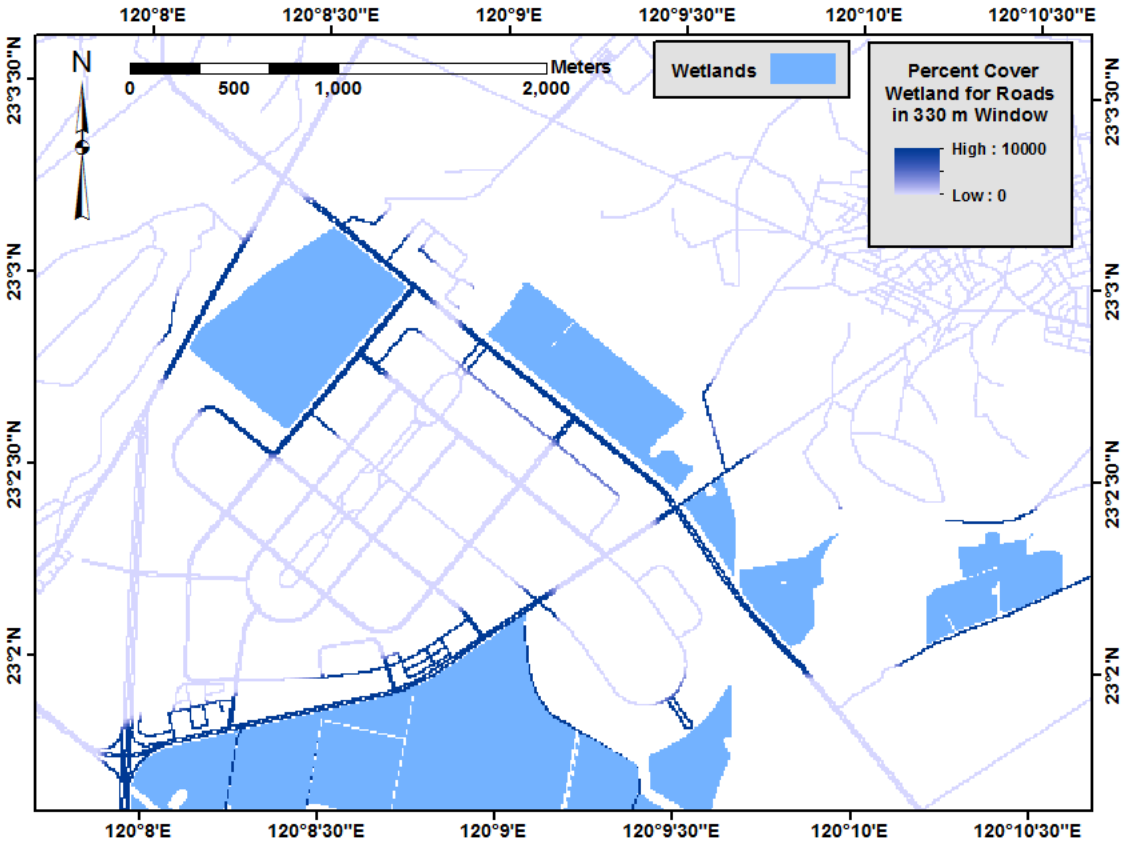


Land Cover Variables

- Created 250 m window percent cover layers
- Masked coverage layer by road network



Percent Cover of Wetland on Roads in 250 m Window

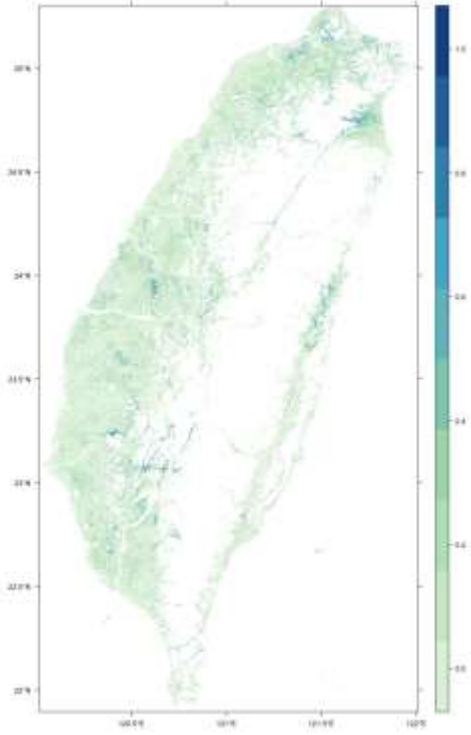


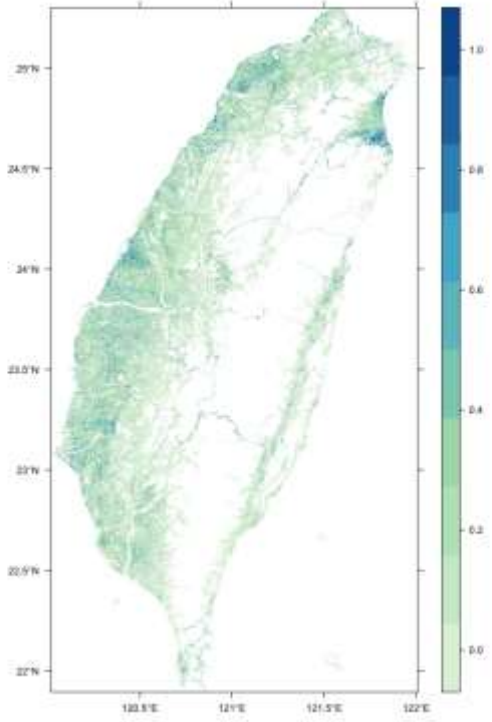
Arboreal frogs
AUC = 0.83

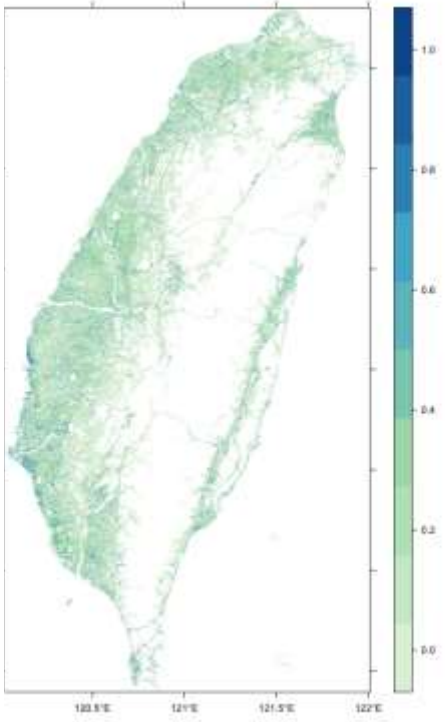
Semiaquatic snakes
AUC = 0.84

Turtles
AUC = 0.80

Higher AUC means more predictive power



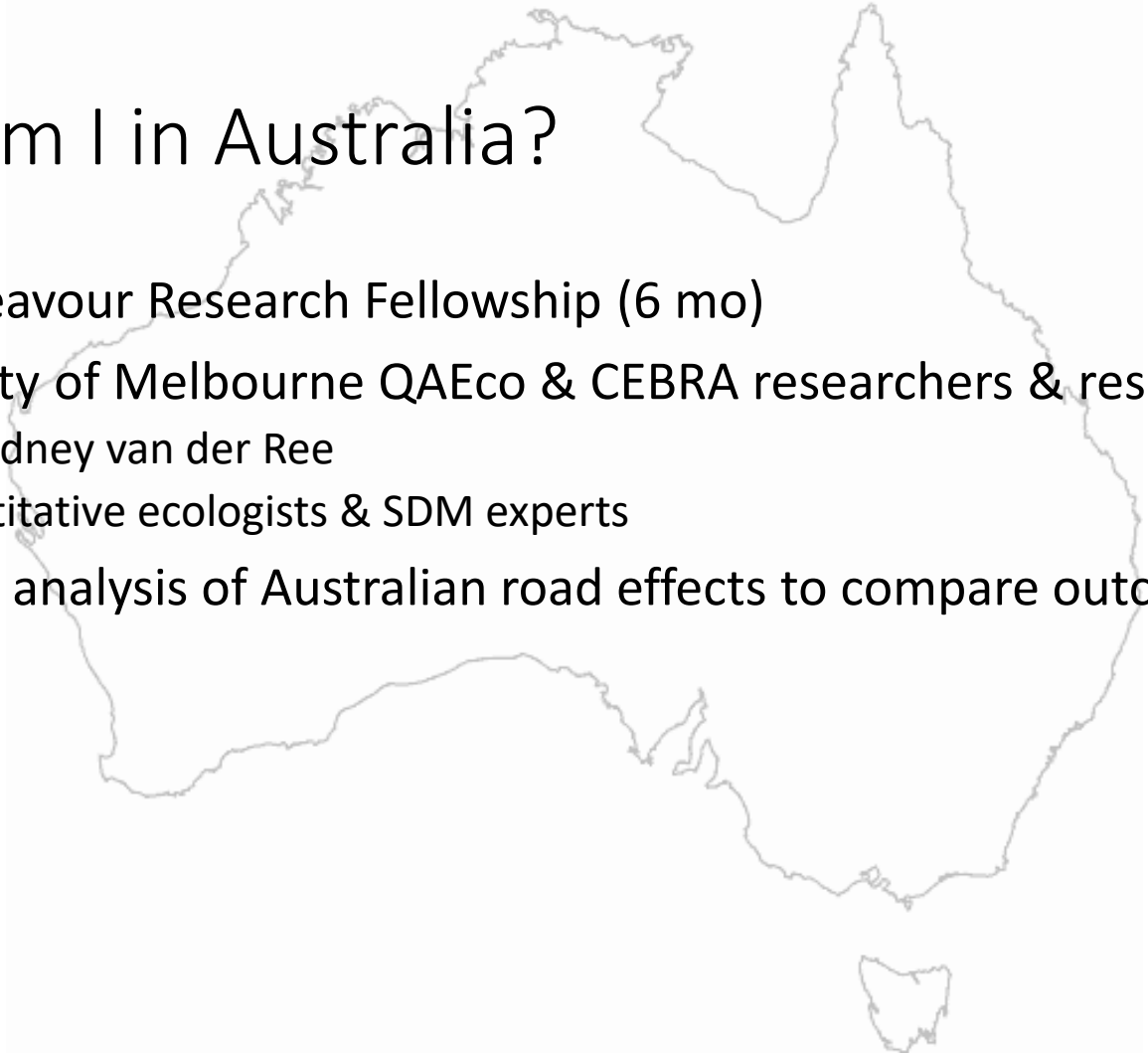




Interactive Maps

Why am I in Australia?

- On Endeavour Research Fellowship (6 mo)
- University of Melbourne QAEco & CEBRA researchers & resources
  - Dr. Rodney van der Ree
  - Quantitative ecologists & SDM experts
- Running analysis of Australian road effects to compare outcomes with Taiwan



Australia

*Predicting Roadkill Risk for Tasmanian Devils using citizen science observations**

- Exploring modeling roadkill risk across very different systems
- Compare modeling outcomes and challenges between Taiwan and Australia to make model more robust
  - TW: densely populated, developed dense road network
  - AU: sparsely populated outside of main cities, ongoing road development

* Data from Save the Tasmanian Devil Project (STDP) & Dr. Alistair Hobday

Conservation Outcomes

- Use predictive roadkill maps to ID critical areas for road mitigation
- Model threatened species roadkill to determine environmental variables related to road mortality
- Can use this method globally where there is roadkill data

Thank you!

- Te-En Lin & TaiRON
- Dr. Rodney van der Ree
- David Wilkinson
- Dr. Lee Fitzgerald & Lab
- QAEco & CEBRA

FULBRIGHT TAIWAN

NSF

ENDEAVOUR Scholarships and Fellowships

FRIENDS OF SUNSET ZOO

ETHS

INTERNATIONAL HERPETOLOGICAL SYMPOSIUM

TEXAS A&M UNIVERSITY

Other Current Research

- Data paper for the Taiwan Road Observation Network
  - Currently working with Te-En Lin to publish TaiRON data
- Citizen Science Data Validation: opportunistic vs systematic collection
  - Data collection underway

Future Research

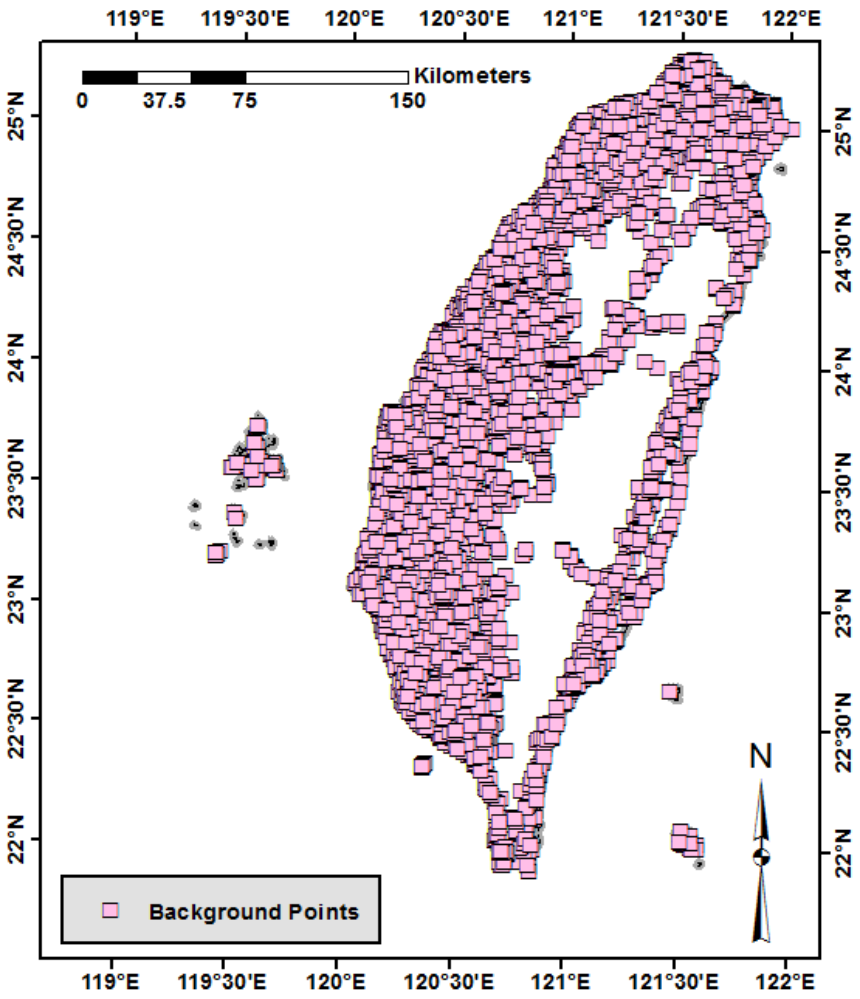
- Functional group models to find differences in important variables across groups
- Threatened species models
- Validate opportunistic citizen science data with scientifically rigorous observations in case there are biases in data
  - Survey areas of predicted high roadkill risk for which there is no current data

Analysis

Using R package “zoon”

```
workflow(occurrence = LocalOccurrenceDataFrame(terr_sna,
                                                columns=c(long = 'longitude',
                                                          lat = 'latitude',
                                                          value = 'value'),
                                                occurrenceType = "presence"),
         covariate = LocalRaster(rasstack),
         process   = Chain(Background(10000, bias = occur.bias),
                           Clean(),
                           StandardiseCov(exclude = "roadtype_ras_50_msk"),
                           Crossvalidate(k = 10)),
         model     = MaxEnt,
         output    = PrintMap )
```

10,000 Background Points Pseudo-Randomly Generated for Developing Maxent Niche Models (Using bias layer)

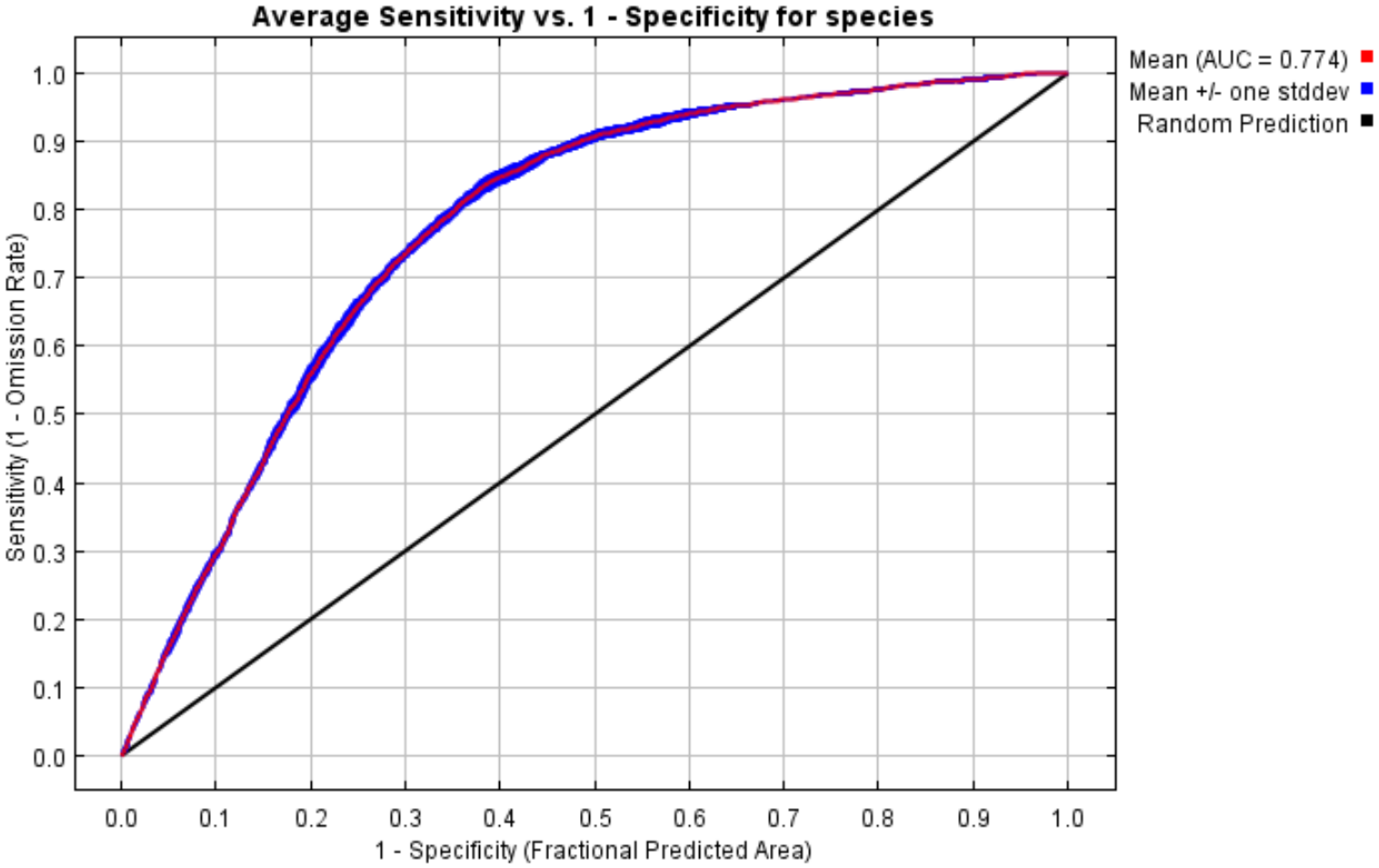


Crossvalidation Runs

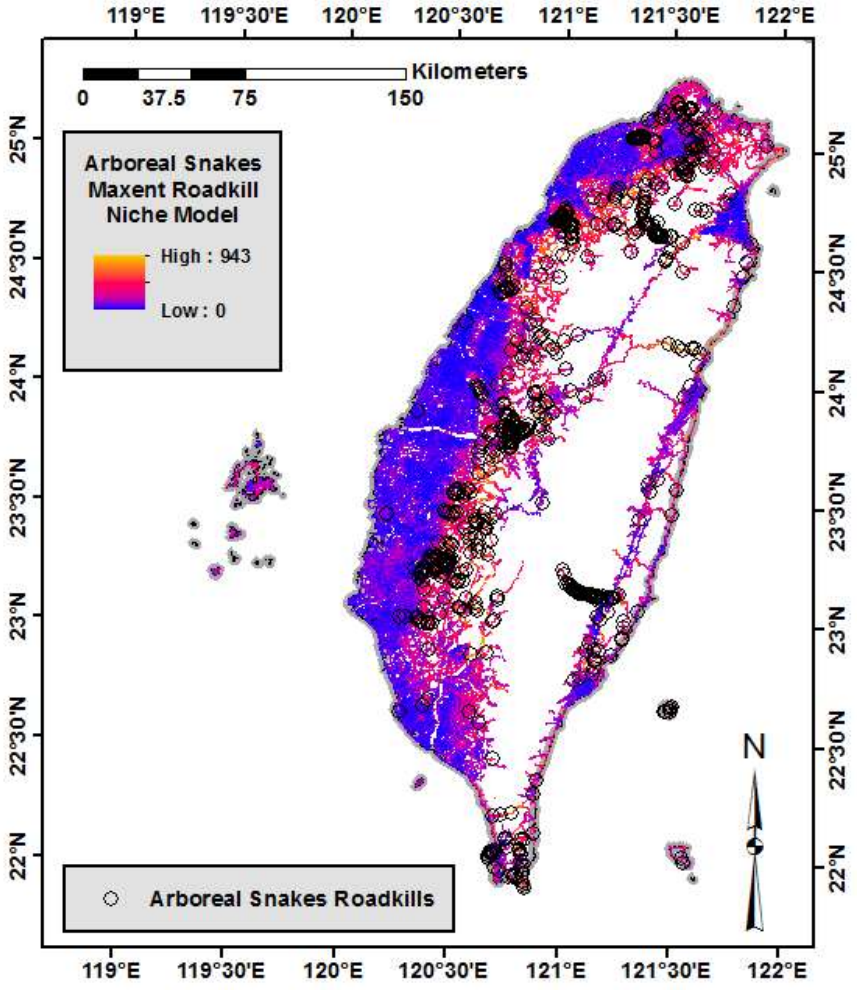
- Training vs Test
  - Data randomly partitioned into training data set and test data set
- 10-fold cross-validation runs

MaxEnt Ecological Niche Model

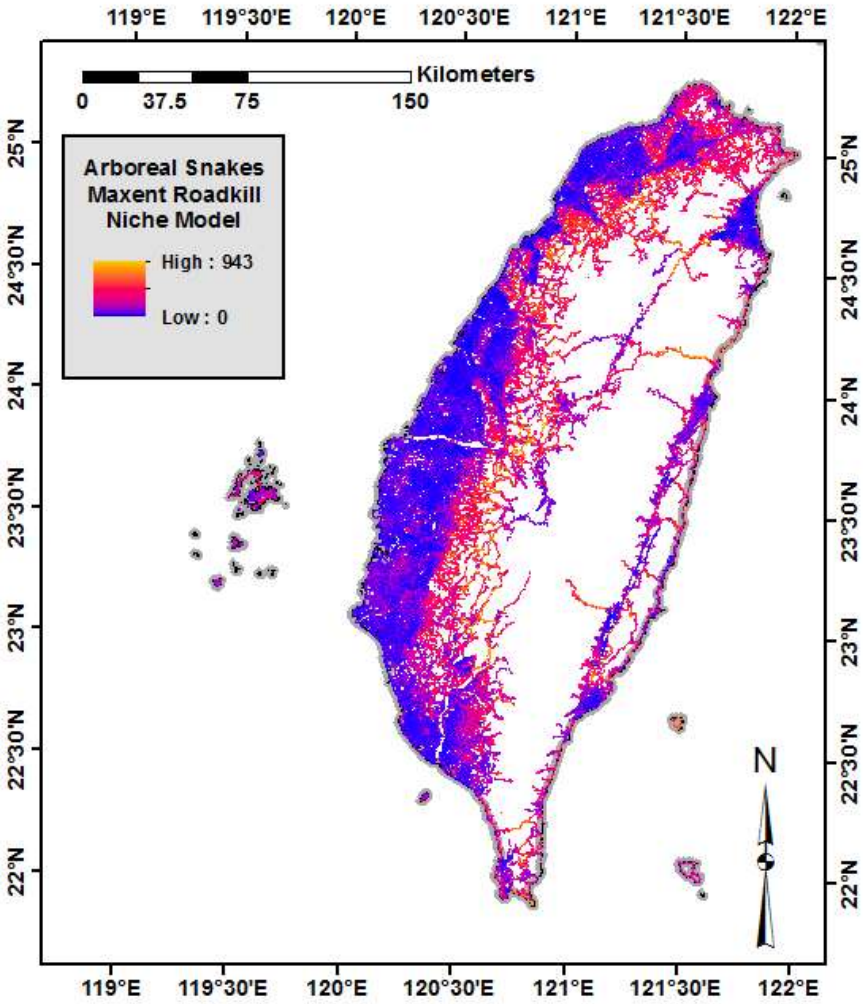
- Appropriate for presence only data, which is what TaiRON data is
- Model accuracy is evaluated using the Area Under the Curve (AUC) evaluation metric
- Widely used niche model because high accuracy and explanatory power
- *Regularization is good at parsing down variables (able to feed in many variables)*


Average Sensitivity vs. 1 - Specificity for species
Mean (AUC = 0.774)
Mean +/- one stddev
Random Prediction
Sensitivity (1 - Omission Rate)
1 - Specificity (Fractional Predicted Area)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

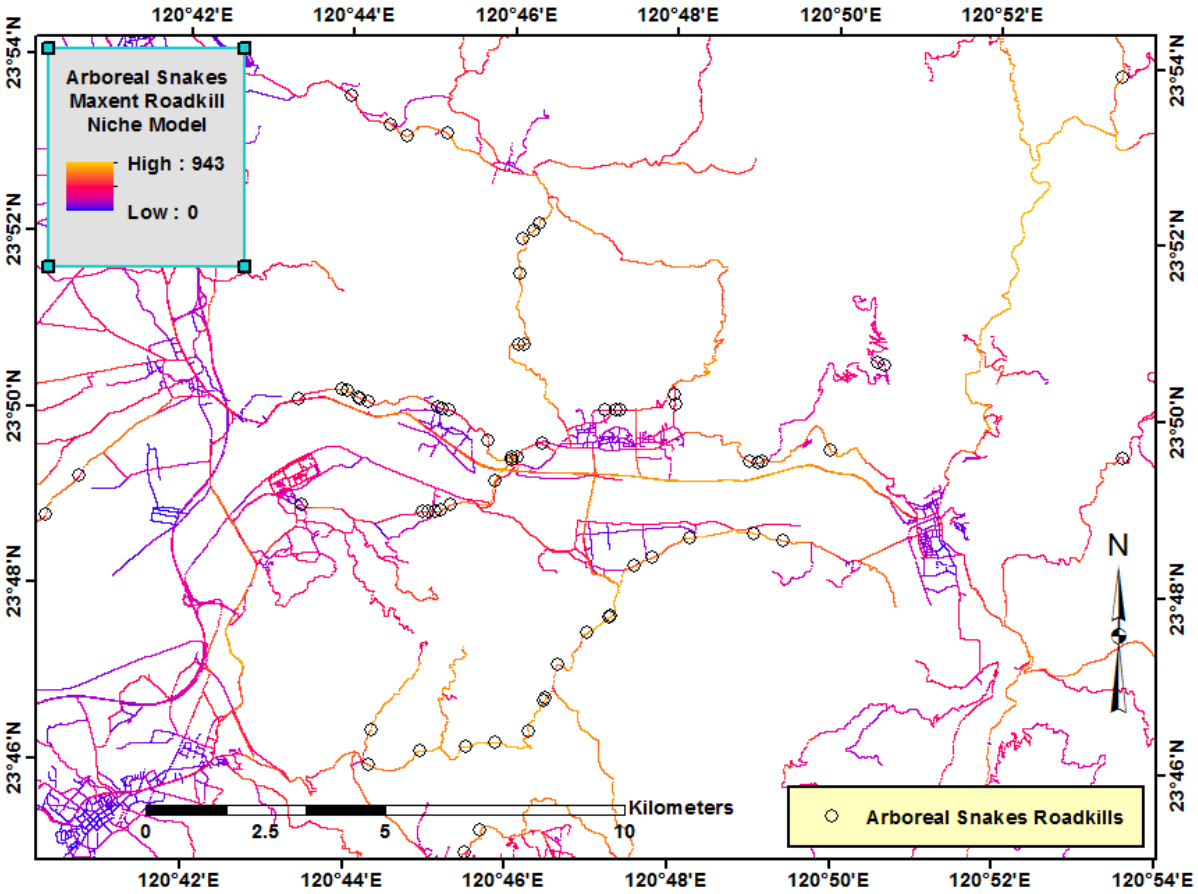
Arboreal Snakes Roadkill Maxent Model



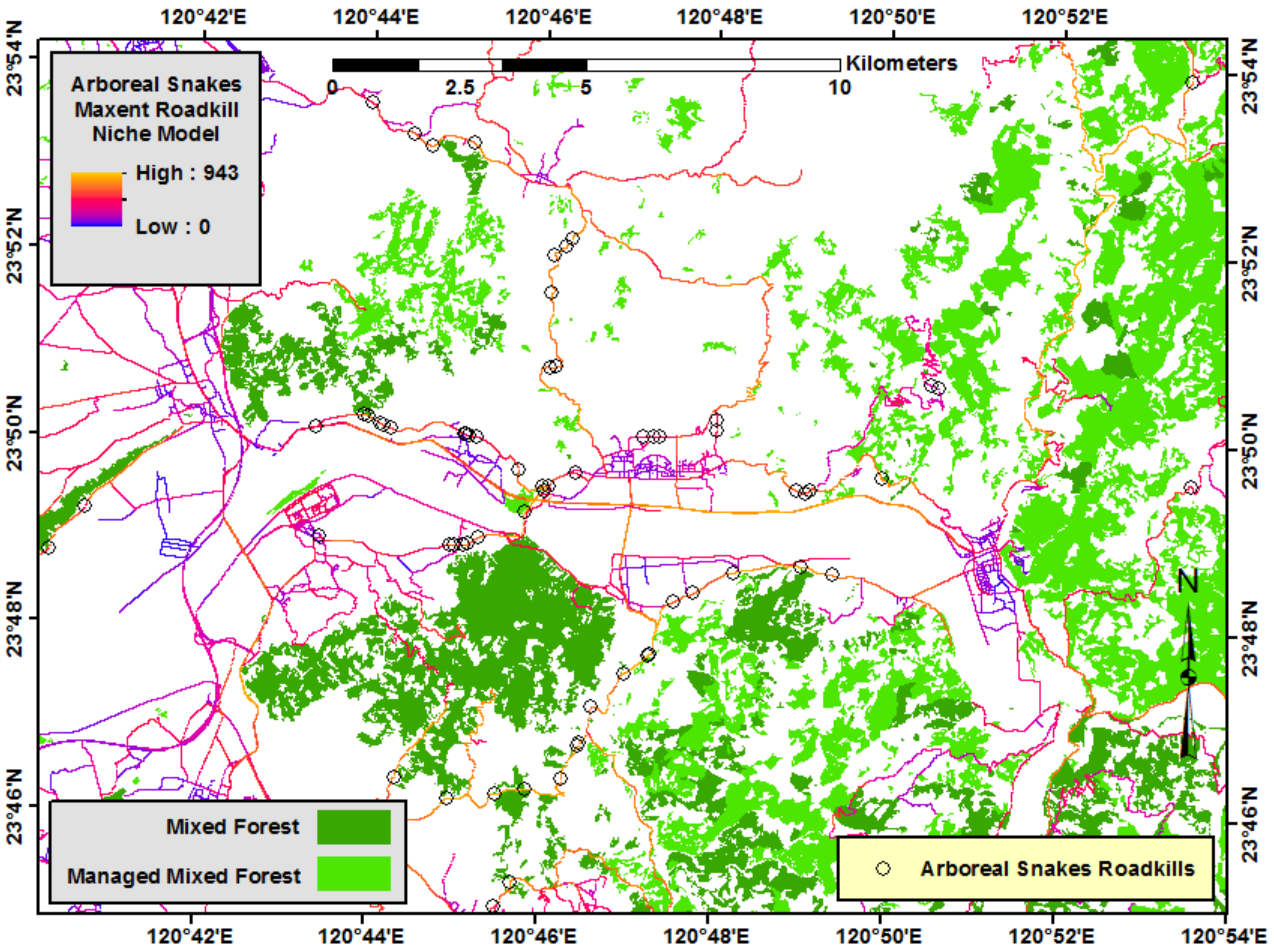
Arboreal Snakes Roadkill Maxent Model

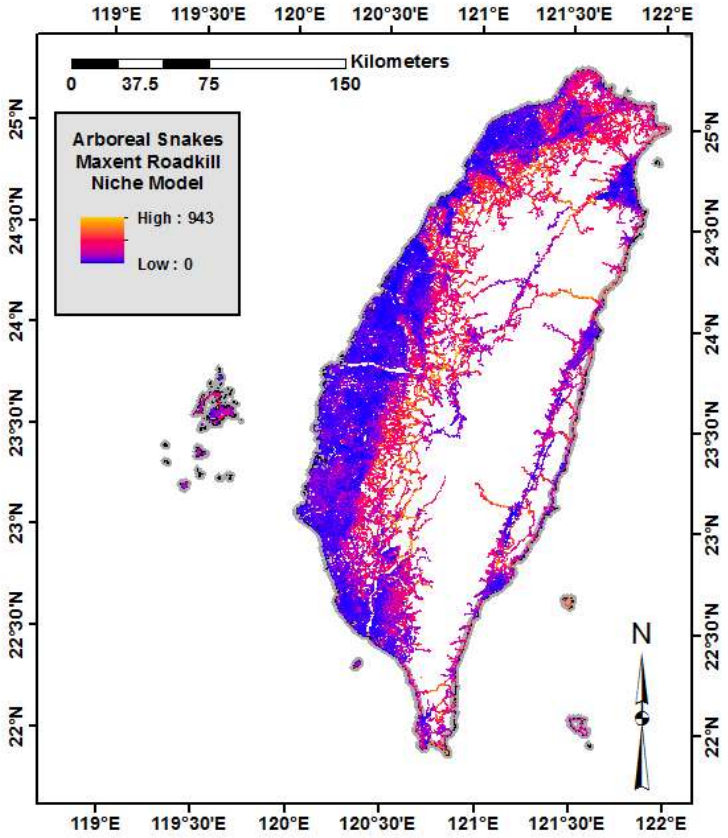


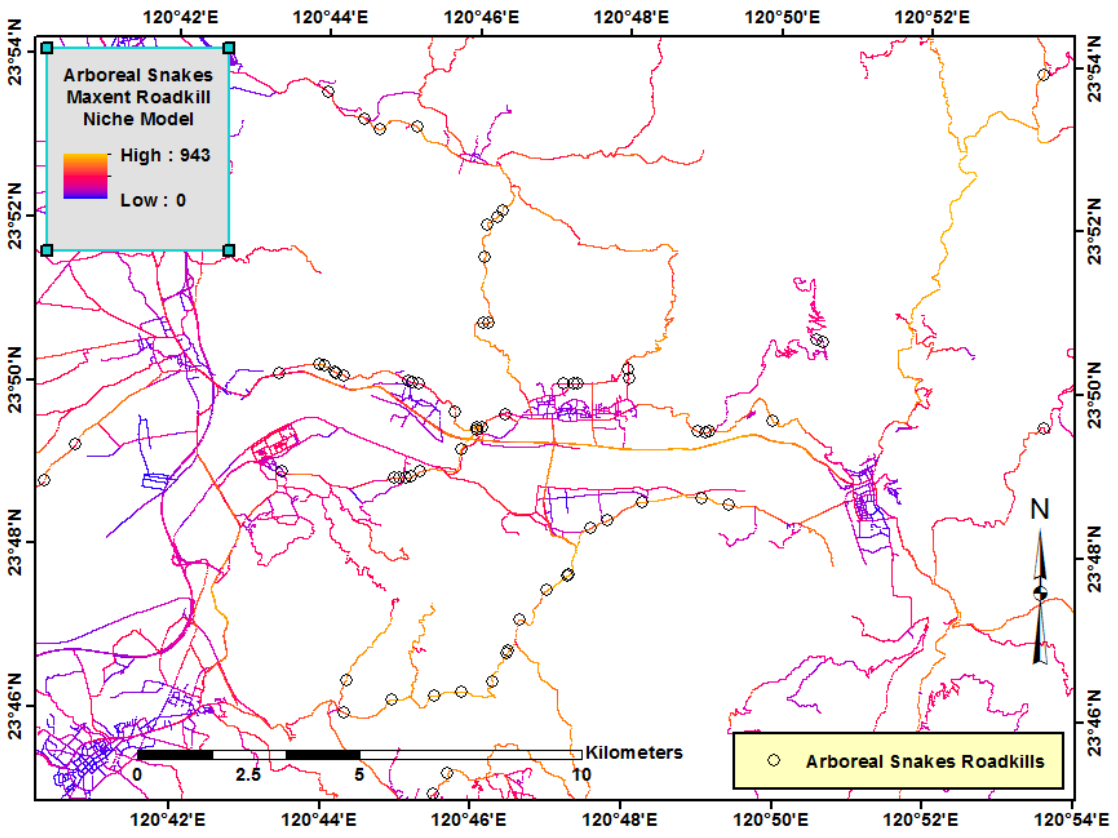
Arboreal Snakes Roadkill Maxent Model



Arboreal Snakes Roadkill Maxent Niche Model (8 Vars)




119°E
119°30'E
120°E
120°30'E
121°E
121°30'E
122°E
25°N
24°30'N
24°N
23°30'N
23°N
22°30'N
22°N
Kilometers
0
37.5
75
150
Arboreal Snakes
Maxent Roadkill
Niche Model
High : 943
Low : 0
N


120°42'E
120°44'E
120°46'E
120°48'E
120°50'E
120°52'E
23°54'N
23°52'N
23°50'N
23°48'N
23°46'N
Arboreal Snakes
Maxent Roadkill
Niche Model
High : 943
Low : 0
Kilometers
0
2.5
5
10
Arboreal Snakes Roadkills
N

Model Conclusions

- Determining optimal procedures for niche modelling and are now analyzing other functional groups
- Analyzing all herpetofauna provides lower accuracy models than evaluating separate functional groups
- 8 variables had less overfitting for AUC than 32 variables and only slightly less AUC value
- Pseudo-absence AUC is a better metric for measuring model performance and overfitting than background AUC
  - Able to detect differences in overfitting that background was not

Why Herpetofauna?

- Amphibians and reptiles (herpetofauna) have the highest levels of road mortality and are the most threatened terrestrial vertebrates
- Due to their terrestrial lifestyles, diverse life histories, and urgent need for conservation, herpetofauna are ideal for studying road-effect zones across multiple landscape and ecological scales