

2023 Mojave Desert Tortoise Drone Surveys in Zones 2-5 of the Red Cliffs Desert Reserve

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¹Resi Solutions

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1 Introduction

- Background
- Drone Surveys
- Computer Vision

2 Red Cliffs Desert Reserve Surveys

- Red Cliffs Desert Reserve
- g_0 surveys
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- Results

3 Conclusions

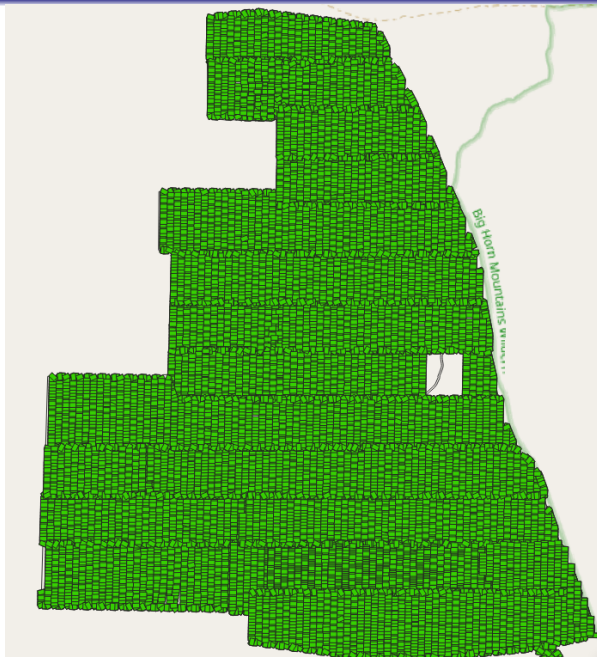


History:

- 2021
 - Experiments with surrogates
- 2022
 - USFWS Arena test
 - Red Cliffs Desert Reserve survey, 1st season (Zone 6)
- 2023
 - Red Cliffs Desert Reserve survey 2nd season (Zones 2-5)







Object Detection

- Manually tag images to assemble training data
- Train a neural network to detect tortoises and burrows

 PyTorch





Tortoise Model:

- $n = 562$
- Trained on both Mojave desert ($n=265$) and Bolsón (237) tortoises, as well as some styrotorts ($n=30$)
- Segregate training (75%) and validation (25%) sets
- Recall $\sim 84\%$

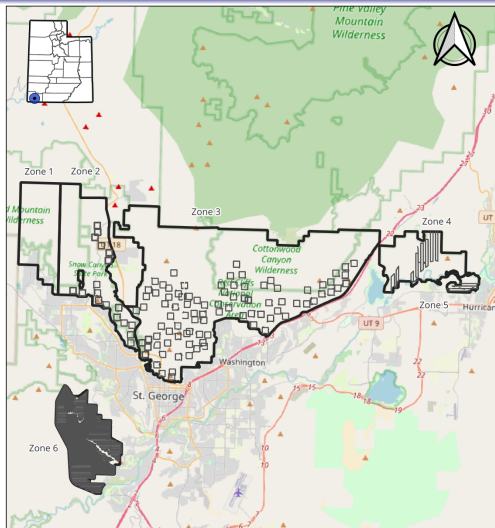




- 2022 and 2023
- Red Cliffs Desert Reserve
- Washington County, Utah
- 60 surveys performed by Utah DNR
- Drone/AI surveys performed in conjunction with pedestrian surveys



Red Cliffs Desert Reserve



RCDR Tortoise Surveys
Drone Transects
Resi-2023-014

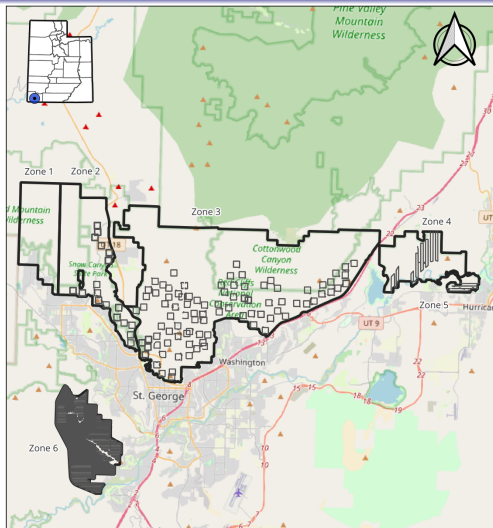
■ Photos (2022/2023)
□ RCDR Zones



0 2.5 5 7.5 km

- 88,000 photographs
- 1.75 million image tiles
- Block surveys, rectangular and linear transects
- > 7,100 acres (11 square miles)
- ~28 pilot-days

Red Cliffs Desert Reserve



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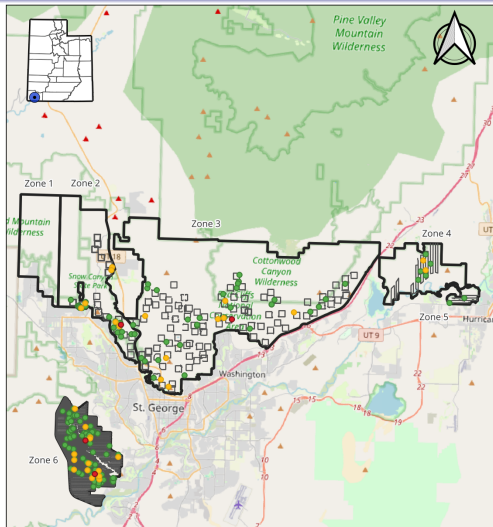
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Red Cliffs Desert Reserve



Red Cliffs Desert Reserve



RCDR Tortoise Surveys
Drone Detections
Resi-2023-014

Drone detections

- Adult
- Juvenile
- Carcass

□ RCDR Zones



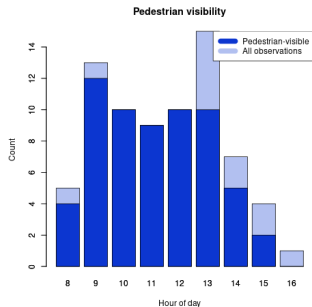
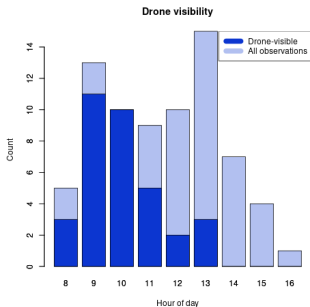
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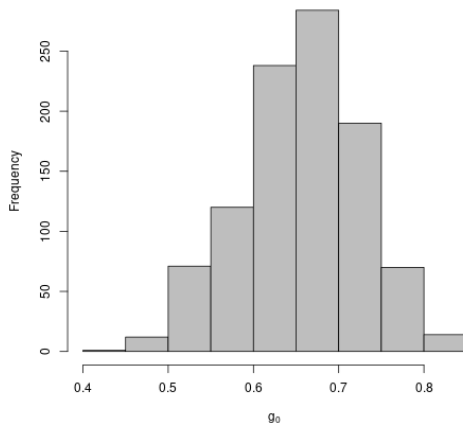
- 190 unique tortoise detections
 - 155 adults
 - 31 juvenile
 - 4 carcasses
- 6.7 detections / pilot-day



Surface Activity - 2024



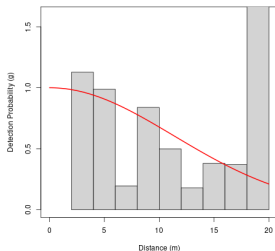
| Date | Drone Surface Activity (g_0) | | Pedestrian Surface Activity (g_0) | |
|---------|----------------------------------|---------------|---------------------------------------|---------------|
| | Morning Obs | Afternoon Obs | Morning Obs | Afternoon Obs |
| May 8 | 0.77 | 0.25 | 1.00 | 1.00 |
| May 9 | 0.85 | 0.15 | 0.85 | 0.77 |
| May 11 | 0.58 | 0.09 | 0.83 | 0.55 |
| Average | 0.73 | 0.16 | 0.89 | 0.77 |

g_0 surveys g_0 estimate

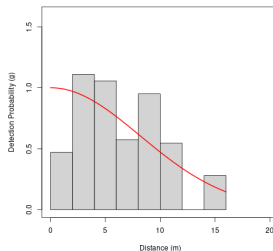
- Mean: 0.67
- 2022 mean: 0.38

Detection curves

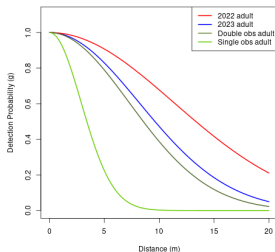
Adult detection function (2022)



Adult detection function (2023)

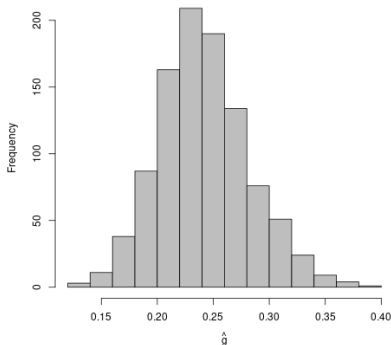


Fitted detection curves

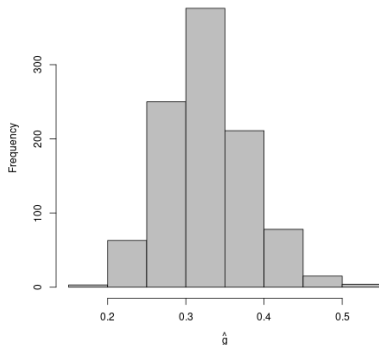


Distance analysis - DRONEDISTANCE

Overall detection rate (\hat{g})



Mean ~ 0.25
2022



Mean ~ 0.3
2023

Density and abundance

| Zone | Density (N/km^2) | km^2 Total | Abundance |
|-------|----------------------|--------------|-------------------|
| 2-5 | 20.1 [13.8, 28.9] | 138.14 | 2779 [1908, 3995] |
| 6 | 28.0 [18.9, 41.7] | 27.56 | 772 [521, 1149] |
| Total | 21.4 [14.7, 31.1] | 165.70 | 3550 [2429, 5144] |

Comparison with 2024 pedestrian survey results

| | Density | (N / km^2) | km^2 | Abundance | |
|-------------------------|---------|----------------|--------|-----------|-------------|
| Drone, Zones 2,3,5 | 19.0 | [12.7-28.4] | 116.94 | 2221 | [1480-3316] |
| Pedestrian, Zones 2,3,5 | 20.7 | [16.3-26.3] | 116.94 | 2425 | [1908-3081] |
| Drone, Zone 3 | 12.8 | [8.2-19.8] | 95.86 | 1223 | [790-1898] |
| Pedestrian, Zone 3 | 17.5 | [13.3-23.1] | 95.86 | 1681 | [1274-2218] |

- The drone/AI method is very successful at locating tortoises when they are available for detection
- Surveys must be performed when animals are available for detection: 9 AM - 1 PM
- Pedestrian interactions can affect visibility to drones
- Drone/AI surveys must not be performed at the same time as pedestrian surveys.

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- Advantages of drone/AI surveys:
 - No surface disturbance
 - Approximately 10 times more efficient (80 ac/hr)
 - With better cameras this could 25x or greater (200 ac/hr)
 - Quantitative density and abundance estimates with confidence intervals
 - Within 8% of pedestrian estimates
 - Can be used for more than one resource, further increasing cost effectiveness
 - Permanent record, can be reanalyzed with improved models
- Disadvantages of the drone method
 - No detailed observation or measurements



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