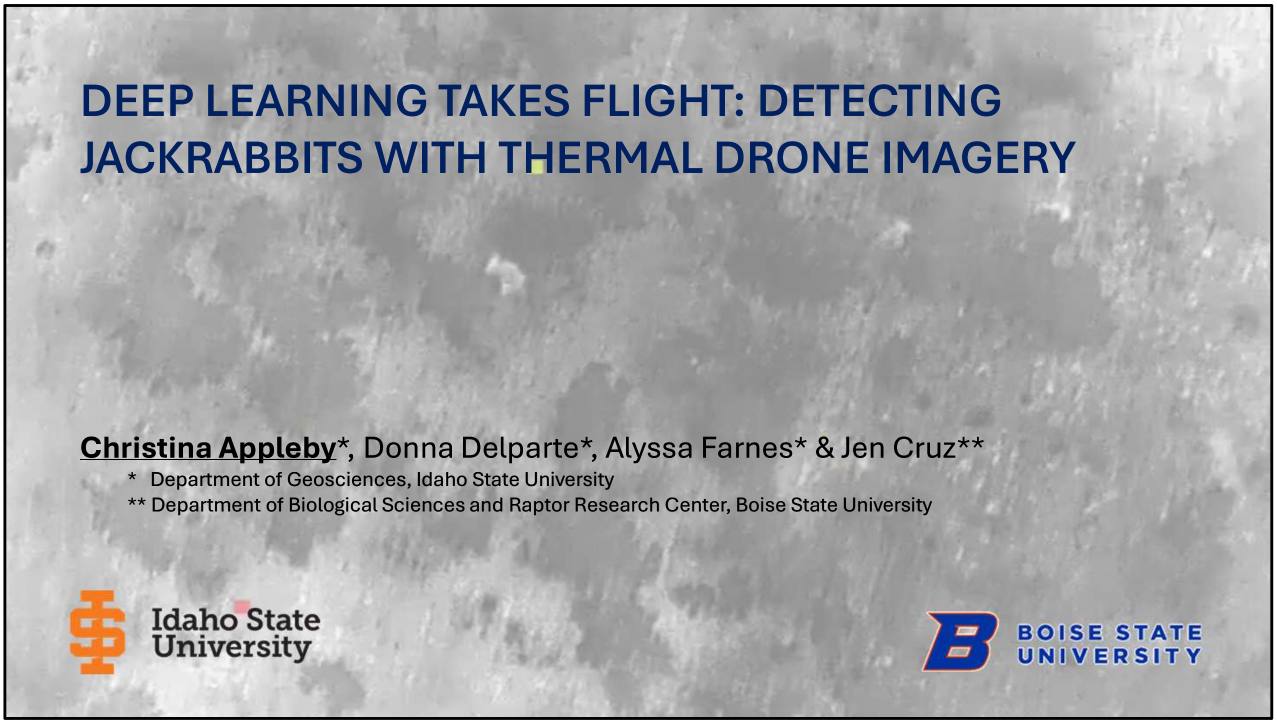


Good afternoon. Can anyone see through sagebrush, like say to do an abundance survey? We couldn't, which is why we decided to evaluate the effectiveness of using drones to detect jackrabbits. My name Christina Appleby, and last fall, as a graduate student at Idaho State University, I was brought onto this research to automate the detection of jackrabbits in thermal drone footage. Now, as a research assistant at Boise State University, I am continuing this work.

Background and Purpose

- Morley Nelson Snake River Birds of Prey National Conservation Area (NCA)

The Morley Nelson Snake River Birds of Prey National Conservation Area is nearly half a million acres and is home to many different species. Jackrabbits are an important prey species, especially to coyotes and golden eagles. They are the preferred prey for golden eagles, but recently, the golden eagle diet has shifted from primarily jackrabbits to other prey. Prey that carry diseases and parasites. As a result, less golden eagle chicks are surviving. Is their diet shifting because there are fewer jackrabbits at the NCA? We don't know because jackrabbit abundance hasn't been surveyed since 1997.

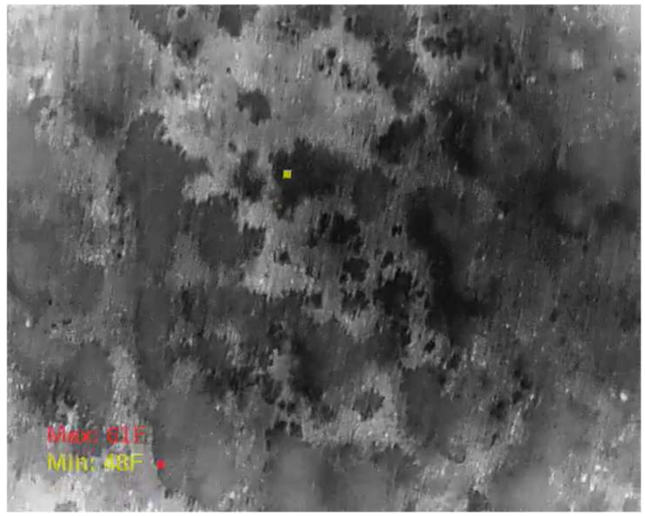
Background and Purpose

Spotlight surveys are as not effective in sagebrush steppes because the sagebrush limits visibility and can lead to inaccurate abundance estimations. We wanted to see if drones could be used to detect jackrabbits instead of spotlight surveys.

Drone Footage

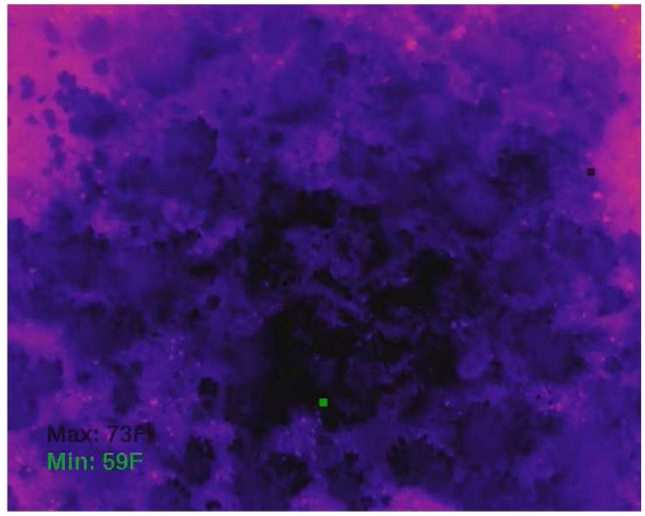
Here is a video clip from one of our drone flights. How easy do you think it would be to spot a jackrabbit in this video? Even with a clear video that is slowed down to one quarter of the speed, it is hard to spot jackrabbits in this environment.

Thermal Drone Footage

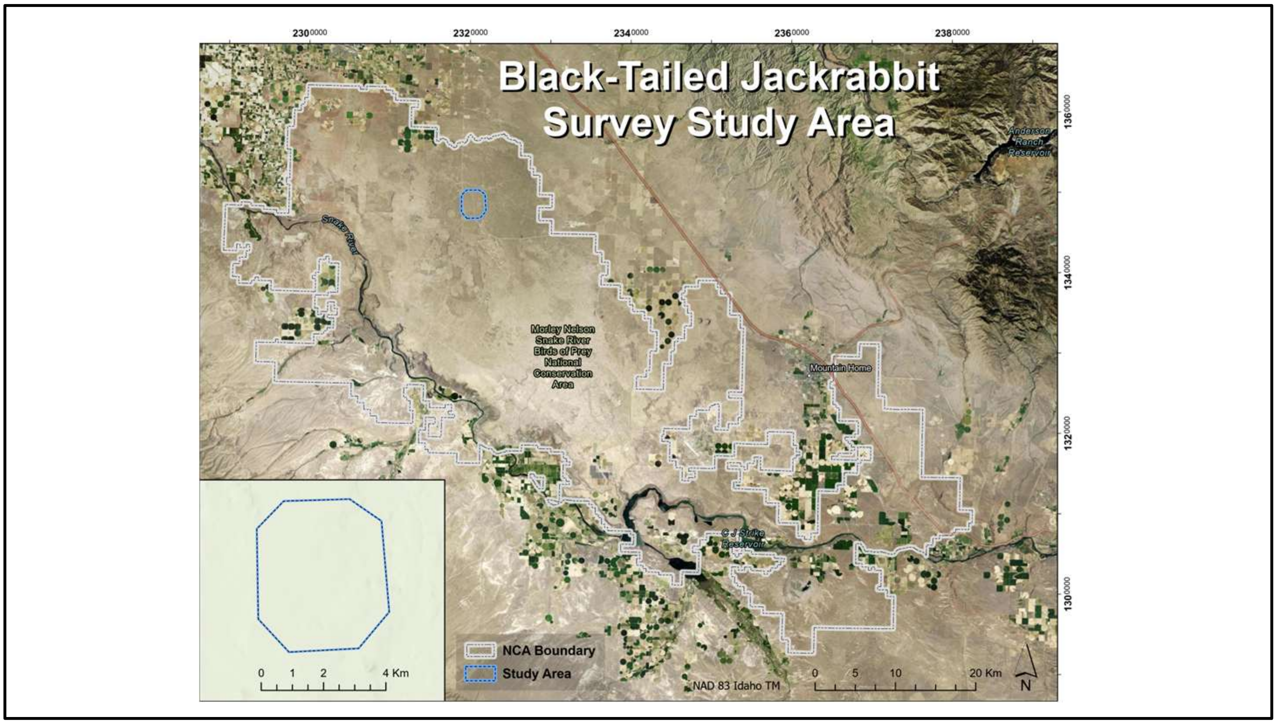


In thermal drone footage, the contrast between the jackrabbit’s body temperature and the background environment makes them easier to see. The thumbnail shows you what the stationary jackrabbit looks like in the thermal video, which will appear at the top of the frame and move down as the drone flies by. Are you ready to try to spot the jackrabbit? How easy was that? Are you feeling good? Ready for another one?

Thermal Drone Footage



Although the jackrabbits are easier to spot in the thermal videos, it is still hard for humans to try to spot a jackrabbit. We wanted to see if we could use deep learning to automatically detect the jackrabbits for us.



Our study area is the small blue bit in the northern part of the NCA. It might look small on the map, but our study area is almost 10 square kilometers. To maximize the contrast between the body temperature of a jackrabbit and the background environment, we flew during the dark, cooler hours. The goal was to fly 3 to 4 transects per night to try to cover the entire study each night. Spotlight surveys were also conducted at night, and this was done to try to determine if there was any road bias.

UAS Sensor and Platform

FLIR DUO PRO R Thermal Imaging Sensor:

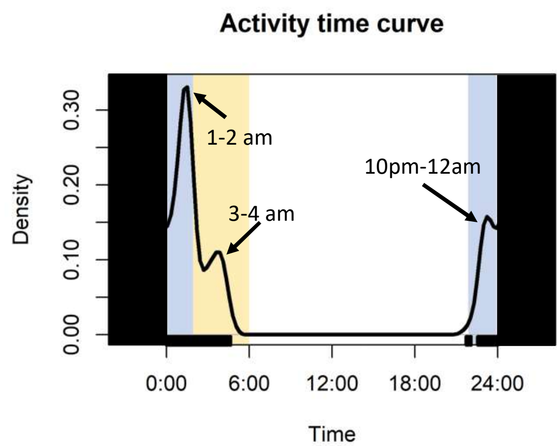
- 640 x 512 resolution
- 25 mm lens
- 25˚ x 20˚ FOV
- 30 frames per second
- 7.5 - 13.5 μm spectral band

Inspired Flight IF 750

- NDAA/Blue List Compliant Drone
- Wind resistance up to 10 m/s
- Flight time ~20 min

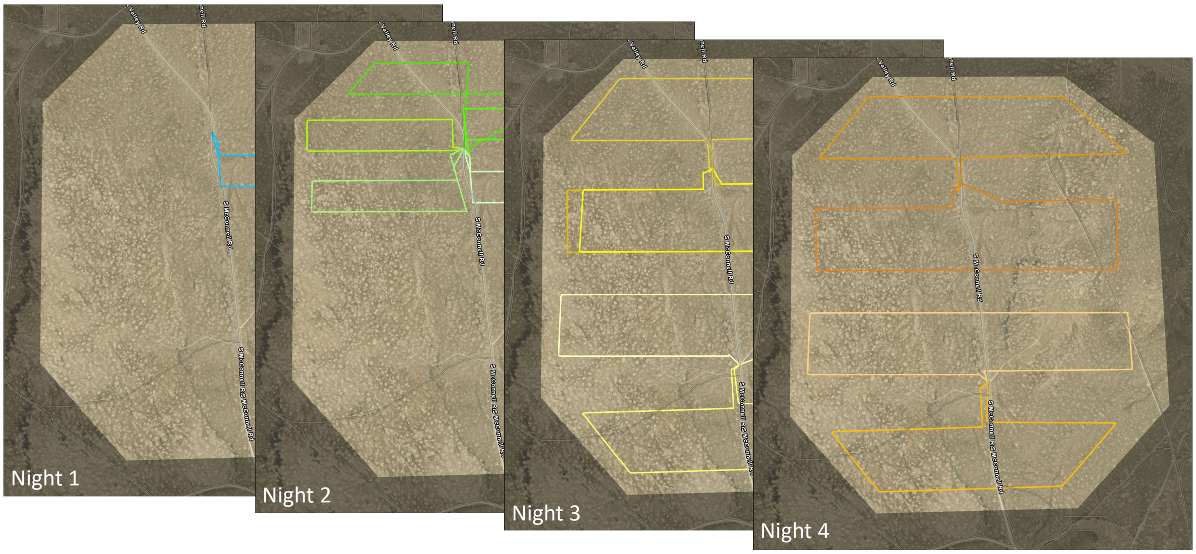
We used a Forward Looking Infrared, or FLIR, DUO PRO R thermal imaging sensor mounted on an Inspired Flight IF 750 drone. There's no need to really get into the specs, but it is important to note that the flight time of the drone is only about 20 minutes.

Pilot Study Spotlight Surveys - 2022



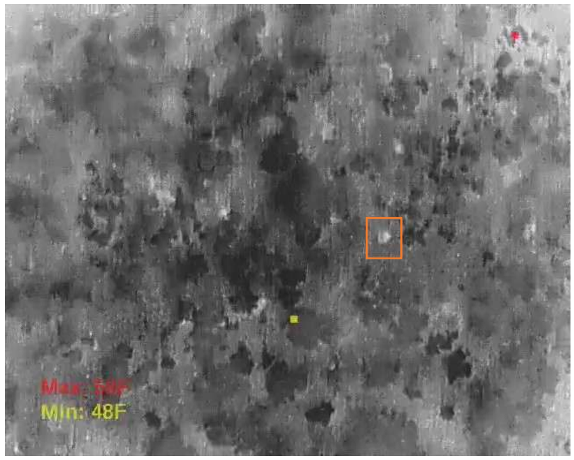
We conducted a pilot study in 2022 consisting of spotlight surveys and drone flights. We did the spotlight surveys to figure out when the jackrabbits were most active, so we knew the best time to do the drone flights. In this graph, the x-axis is the time of day, and y-axis is jackrabbit density. This shows that the best detection time is from 10pm to 2am. We did the drone flights to try to find the best altitude, speed, and transect distance for detection.

Flights - 2024



In 2024, we flew four different nights to collect thermal footage. All drone flights were 40 meters above ground level with camera pointed straight down. Due to wind, flights were flown at different times on different nights, although we tried to stick as close to the optimal detection window as possible. The first two nights were flown at slower speeds with shorter transects because of the 20-minute flight time. The flights for the last two nights were flown at a faster speed with wider transects, so we were able to survey the entire study area over multiple flights.

Manual Detections

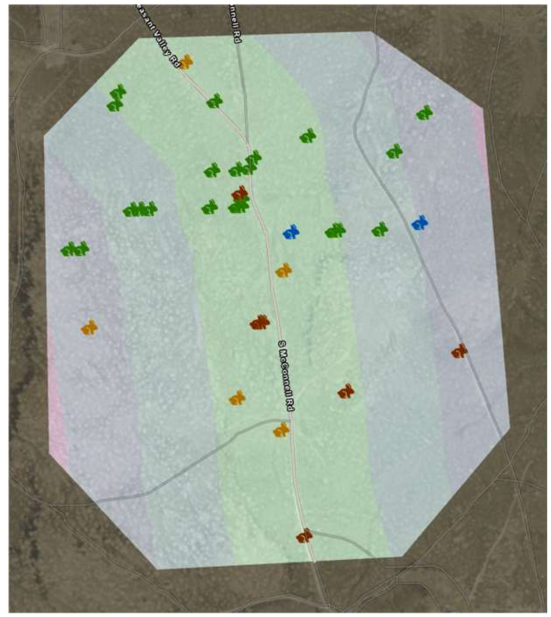


An observer went through five hours of drone footage with the videos playing at slow speed and manually identified jackrabbits. From the video clips you saw earlier, you know this was no easy task. It took her around ten hours to go through all the videos, record the start and end times of the detections, and take screenshots to mark the location of the detections.

Distance & Counts

Night	# Flights (times)	Jackrabbits
1	3* (11:30p – 2:30a)	2
2	5 (8:15p – 11:15p)	30
3	5 (3:45a – 7:15a)	6
4	6 (12a – 2:45a)	7

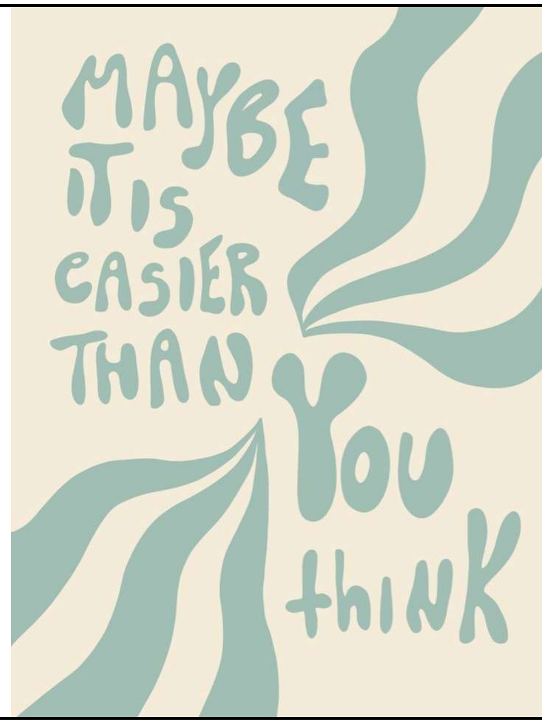
** BTJR detected during 1st flight only*



All her hard work paid off! We got the most detections during the second flight on the second night, which was flown at 9:30pm, close to the best detection time. The different flight speeds and transect sizes could have affected detections and highlights the importance of multiple night surveys. With the drone we were able to detect jackrabbits over 1200 meters from the road despite the sagebrush landscape, something that would not be possible with spotlight surveys. The week prior to the drone flights we performed spotlight surveys, recording jackrabbits within 5 meters of the road to look at road bias and found that there does not appear to be any.

Automating Detection

- YOLO model
  - Create datasets
  - Train the model
  - Run model on test dataset to evaluate model accuracy
  - If the model is good, use it to detect jackrabbits



Training a deep learning model to automate jackrabbit detections in thermal drone imagery can sound intimidating. It’s not. We chose a YOLO model, which means You Only Look Once, because the model is fast, it is accurate, and most importantly – it is easy to put into practice. First, we created datasets with boxes around the jackrabbits because you need to show the model what a jackrabbit is so it can learn to detect it. Thanks to the manual detections, this was a relative quick process and took about three hours. Then we used that data to train the model, and all we had to do was run a few a lines of code to make that happen. Next, we wanted to see how good the model was at detecting jackrabbits, so we ran the model on a test dataset. Depending how well the model does, it can be used on other videos or video frames to detect jackrabbits, so we don’t have to!

Model Accuracy

	Model Detections
True Positive (model found a JR that was there)	55
False Positive (model found a JR that was not there)	0
False Negative (model did not find a JR that was there)	2
True Negative (no JR, model did not find a JR)	8
Precision	1
Recall	0.965
F1 Score	0.982

We tested the model on 65 images, 57 had jackrabbits and 8 did not. The model detected 55 of the jackrabbits. It missed 2 jackrabbits, but it did not have any false detections, meaning it thought something was a jackrabbit that wasn't. This is important because most models that estimate abundance are designed to account for missing individuals, and in the case of the model detections, they account for the false negatives. However, the abundance estimation models cannot handle "extra individuals" aka false positives. Our model results show that this workflow can be used with traditional abundance models.

Summary

- Spotlight surveys less effective in sagebrush steppe
- Thermal drone footage is an effective alternative
- Using deep learning to automate jackrabbit detection speeds up the detection process in thermal drone footage

Next steps

- Quantify road bias in detection
- Develop a protocol for detecting jackrabbits using thermal drone footage and deep learning
- Use drone results with spotlight surveys as an integrated model that takes advantage of both methods

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Questions?

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- Drones, flights, and thermal camera
  - Donna Delparte - donnadelparte@isu.edu
- Object detection using machine learning
  - Christina Appleby - christinaappleby@isu.edu