

Research Prospectus

Title: Why do the effects of temperature on nestling growth and survival vary across land uses?

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Introduction

The interactive effects of climate change and habitat conversion to agriculture constitute the primary threat to terrestrial wildlife (Travis 2003). Efforts to increase biodiversity in agricultural landscapes, such as planting polycultures, may allow more species to thrive in human-dominated landscapes (Kremen and Merenlender 2018). However, as climate change progresses, human-dominated landscapes may expose birds to new temperature extremes because converting forested land to agriculture removes trees that insulate the understory from ambient temperature (Suggitt et al. 2011, De Frenne et al. 2019). In bird species with altricial young, nestlings are ectothermic, so both low and high temperatures divert energy from growth to thermoregulation (Dunn 1979). The lethal effects of cold are well-documented (Shipley et al. 2020). But in the future, climate change will drive temperature increases globally and exacerbate the intensity of short-term temperature spikes. Especially in hot ecosystems, climate change-driven temperature spikes often induce nest failure and drive population collapse (Socular et al. 2017). For example, in the Putah Creek ecosystem near Davis, CA, warm temperatures during nesting are associated with lower nestling growth (and survival in some species) (Riggio et al. in prep). Furthermore, our preliminary results from an analysis of Cornell University's NestWatch database (N= 152,863 nesting attempts across 58 species) show that, across North America, temperature spikes lower nesting success in agriculture and urban environments. However, nesting success remains stable in grassland and increases in forested areas following temperature spikes.

For this project, we will investigate the two main mechanisms that could underlie the effects of heat waves: direct thermoregulation challenge for nestlings and food availability. Nestlings can survive heat waves by using more energy to thermoregulate, but this may increase stress, decrease growth, and lead to lower survival (Wingfield et al. 2017). Furthermore, heat waves may reduce food provisioning to nestlings, either by forcing adults to spend more energy thermoregulating or by reducing prey availability. For example, warming temperatures are driving lepidopteran declines across the U.S. (a key resource for young birds; Forister et al. 2021). Here, I propose to investigate the relative contributions of thermoregulation challenge and food provisioning to nestling growth under temperature spikes across four land use types: natural open canopy (grassland), natural closed canopy (riparian forest), agricultural open canopy (row crop), and agricultural closed canopy (orchard).

Questions

Question 1. How do ambient temperature and land use affect nest box internal temperature?

Hypothesis 1. In habitats that have closed canopies (i.e. closed riparian and orchard sites) we expect nest boxes to show fewer and less severe temperature spikes over the nesting season.

Forest canopies insulate the area below the canopy from both high and low macroclimatic temperatures, so we expect that more closed canopies will offer a higher buffering capacity (De Frenne et al. 2019).

Question 2. How do ambient temperature and land use affect food provisioning of nestlings?

Hypothesis 2. Temperature spikes will be more frequent and more severe in open lands (i.e., grassland and row crop (i.e., open lands)), decreasing provisioning rates. Additionally, parents may decrease foraging time to meet thermoregulatory demands or lower insect availability in agriculture may increase search effort.

Question 3. How does land use affect the relative importance of nest box internal temperature (Q1) versus provisioning rate (Q2) on the growth and fledging success of nestlings?

Hypothesis 3. In open land uses (i.e., grassland and row crop), the effects of internal temperature will dominate. Hyperthermia will drive cellular damage, forcing nestlings to expend more energy on maintenance, lowering their growth (Wingfield et al. 2017). However, because hyperthermia may also cause adults to decrease provisioning during temperature spikes, food-mediated effects may also be important in open land uses. In agricultural lands, low resource (i.e., insect) availability will drive dominant effects of provisioning rate on nestling growth rate. Therefore, we expect that growth and survival rate will be particularly low in row crop.

Methods

To address these questions, I propose to monitor Tree Swallow and Western Bluebird nest boxes in four land use treatments: row crops, orchards, grasslands, and high canopy cover riparian forests. We hope to monitor 36 boxes ($N = 4 \text{ land uses} * 3 \text{ sites/land use} * 3 \text{ nests/site}$) concurrently. After chicks fledge, we will move on to new nests. We expect to complete 2-3 rounds of sampling for a maximum of 108 nests monitored in 2021. We intend to visit the nests not more than once a week. Please see Figure 1 for a map of most sites I propose to monitor. I have installed three sets of 10 nestboxes each at the following row crop sites: (1) H.M. Clause Innovation Center, (2) Foundation Plant Services, (3) Russell Ranch Century Experiment. In addition, I have installed 10 nestboxes in orchards at (4) Foundation Plant Services. I have secured permission to access nestboxes previously installed in grassland at (5) Putah Creek Riparian Reserve (PCRR) and (6) South Fork Preserve (owned by the City of Davis), and installed 10 nest boxes in (7) PCRR's Experimental Ecosystem. I am requesting access to the following sites in the Museum of Wildlife and Fish Biology (MWFB)'s Putah Creek Nest Box Highway: (8) Mace Boulevard (MBN), (9) Picnic Grounds (PIC), (10) Russell Ranch (RRR), McNamara Orchard, and Barbour Ranch.

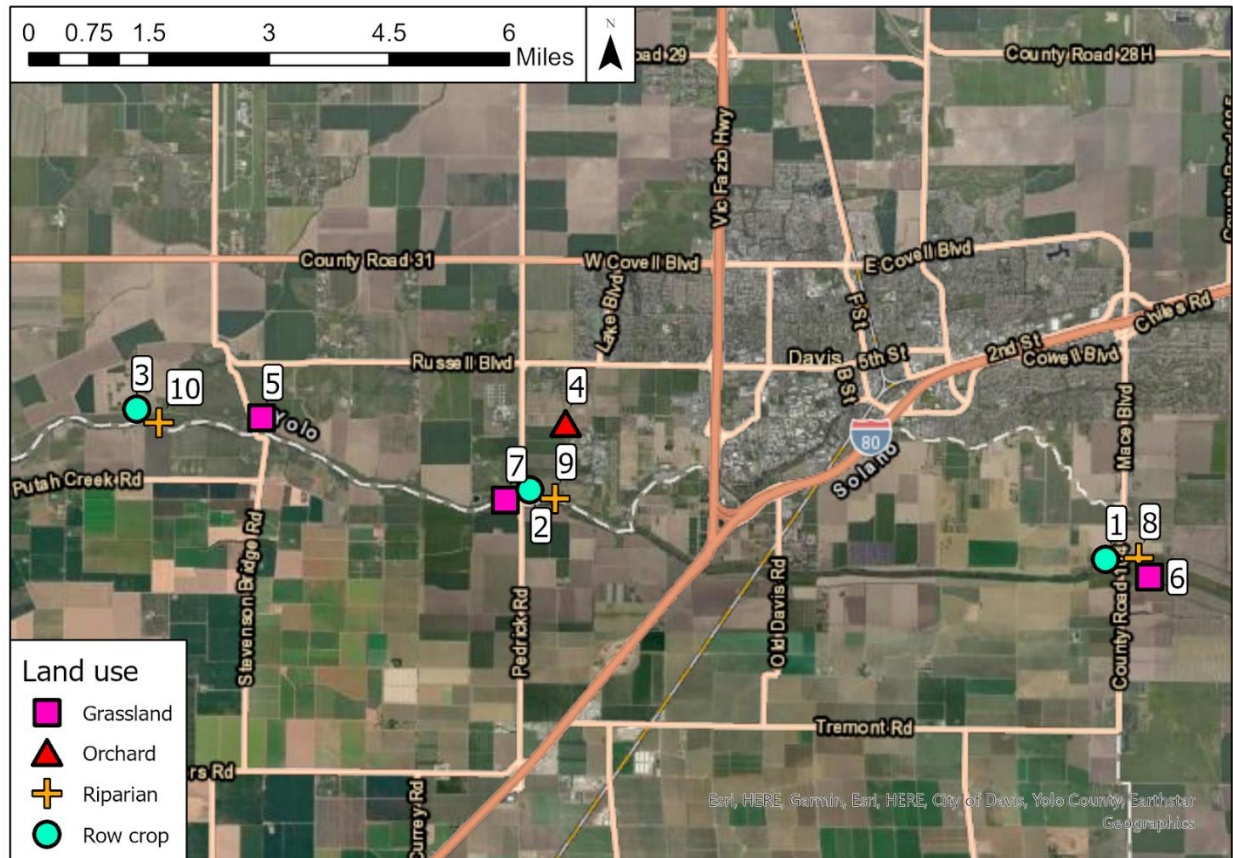


Figure 1. 10 of 12 proposed sites: three each of four land uses. Numbers refer to locations specified above in the text. I have not included McNamara Orchard or Barbour Ranch because I do not yet know the specific location of these sites.

To address question 1, we propose to use HOBO temperature loggers to track hourly temperature at three active nests at each site. One logger will be screwed onto the bottom of the nest box, and one will be placed inside, under the nest. We will place these loggers after egg laying, and to allow them to remain until after fledging to minimize the disturbance to the birds. Data will be offloaded after fledging, and the batteries do not need to be replaced over the course of the field season. We will use linear models to estimate the effect of land use and ambient temperature on nest box internal temperature.

To address question 2, I will use Raspberry Pi-based motion-activated cameras (Phillips et al. in review) that will record 30 seconds before and after motion activation to measure provisioning rate over the nestling period. I propose to place these cameras on top of selected nest boxes, facing down, so that they are compatible with the box lifting system employed in the Putah Creek Nest Box Highway. Box installation requires less than five minutes because the cameras are pre-assembled and then attached to the top of the boxes using Velcro. This year we propose to place one camera per site, with potential for expansion if the cameras perform well. We will place the cameras during the first visit to the nest during the fledging period and remove them during the second. If possible, we will then move the camera to an appropriate nest at the same site. We will use linear models to estimate the effects of land use and ambient temperature on provisioning rate.

To address question 3, I propose to partner with the MWFB to monitor nestling growth and survival. I and Katia Goldberg will record mass, tarsus length, bill length, and wing chord of nestlings in selected non-Putah Creek Nestbox Highway boxes twice (one week apart) during the nestling period and band them at the appropriate time. Currently, the MWFB measures the nestlings once during the nestling period, at the time of banding. I propose that I perform a second measurement either a week before or a week after banding, as appropriate. I am currently in the process of being certified as a sub-permittee of master bander Andrew Engilis. I will use GLMMs to compare the relative importance of internal nest box temperature (Question 1) and provisioning rate (Question 2) on nestling growth and survival among land uses.