Scope of Work: Extreme heat reduces nest success in agriculture

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Background: Habitat conversion to agriculture and climate change will determine the fate of biodiversity in the Anthropocene. Habitat conversion (e.g., agricultural expansion, urbanization) often removes shaded tree canopies, thereby exposing organisms to ever more extreme heat caused by climate change. Increased heat and less vegetation cover also accelerate evaporation, reducing water available to organisms for thermoregulation. Correspondingly, after analyzing a database of >150,000 bird nesting attempts across the United States, we found that temperature spikes dramatically reduce bird reproductive success in agriculture but not in shaded forests (Lauck *et al.* In revision *Science*). Understanding exactly ***how*** temperature spikes affect birds is critical to developing forward-looking conservation plans in human-dominated landscapes. Extreme heat may cause nestlings to overheat and/or reduce their food supply. In contrast, irrigation and other sources of water may increase growth and survival of nestlings during hot periods by facilitating thermoregulation.

Completed work: Our ongoing studies along Putah Creek and adjacent agricultural lands seek to assess the mechanisms by which temperature spikes affect bird reproduction, and thus identify specific conservation interventions that could make working landscapes more hospitable for birds. Specifically, we are leveraging a network of 165 songbird nest boxes established by the UC Davis Museum of Wildlife and Fish Biology (MWFB) in riparian forest, supplemented with 120 additional boxes that we placed in grassland, row crops, and orchards adjacent to Putah Creek. Our focus is on the two most common nest box species: Tree Swallow and Western Bluebird, both of which nest in nest boxes in all four studied land uses. In April-August 2021 and 2022, we recorded growth for nestlings, canopy cover at the nest, and nest temperatures throughout the nesting period at 231 boxes. We also tracked relative humidity at each site as a proxy for water availability. To quantify effects on avian stress physiology, we collected blood samples from adults and nestlings (N = 161 nests). Finally, we built custom Raspberry Pi-based motion-activated cameras to quantify parental food delivery rate at 48 nests.

Proposed work: We are proposing to conduct a third field season in Spring and Summer 2023 to double the sample size of parental food delivery rate. In Fall 2023 and Winter 2024, Katie Lauck will use ELISA assays to quantify corticosterone content in the resulting nestling blood samples. In addition, they will use image recognition to quantify parental food delivery rate documented by the Raspberry Pi-based cameras. In Winter, Spring, and Summer 2024, they will write up our findings for publication and complete their dissertation.

We anticipate that our findings will suggest concrete avenues through which working landscapes in the Central Valley could be modified to better accommodate birds. If the direct effects of heat are more important than food-mediated effects, providing shade trees in agriculture or modifying nest boxes to reduce their internal temperature may increase nestling resilience. If food-mediated effects predominate, then maintaining patches of non-crop habitats in working landscapes to support food resources and provide thermal refuges for parents may be effective. Furthermore, understanding the role that irrigation may play in mediating the effects of heat on wild birds living in agriculture could inform management of water resources for wildlife and people.

Budget and Justification

Total: $73,174

Salary: $38,160 To date, Katie Lauck has self-funded the majority of their research program, supporting themself through a combination of fellowships and serving as a Teaching Assistant (TA) seven times. While they have enjoyed teaching, they have now taught enough to be prepared for future teaching responsibilities as a member of university faculty and would like to thus focus on their research for their final year of graduate school. Salary support would allow Katie to re-allocate time spent teaching towards research and mentoring activities, allowing them to efficiently prepare for a career as a research scientist.

We thus request two summer quarters (Summer 2023 and 2024) and two academic quarters (Winter and Spring 2024) of Graduate Student Researcher (GSR) support at 49% time for Katie Lauck. Katie has already secured a GSR position for Spring 2023 and a TA opportunity for Fall 2023 (of course, if more money were available, Katie could forego the TAship to focus exclusively on their research).

Given Katie's rank and step, GSR salaries are estimated at $8948, $9641, $9641, and $9930 for Summer 2023, Winter 2024, Spring 2024, and Summer 2024, respectively.

Benefits: $849 Benefit costs were calculated with composite benefit rate for the Graduate Student Researcher title; specifically, 2.2% and 2.3% for the periods of 7/1/2023-6/30/2024 and 7/1/2024-9/30/2024, respectively.

GSR Tuition and Fee Support: $10658 Tuition and fee support is requested for Katie Lauck in Winter 2023 ($5329) and Spring 2023 ($5329).

Indirect Costs: $23,507 Costs were calculated at 60% and 60.1% of the indirect cost base for the periods of 7/1/2023-6/30/2024 and 7/1/2024-9/30/2024, respectively.