# Coyote behavioral response to potential prey across space and time

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IACUC: approval will be sought

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# Abstract

Coyotes (*Canis latrans*) are an apex predator in many Florida landscapes, and as such, can a have large impact on community dynamics. Yet, our understanding of coyote space use and how these choices are related to the underlying landscape is often murky. This lack of clarity could be driven by a poor mechanistic understanding of what drives coyote behavior in space and time. We hypothesize that coyote behavior is more strongly driven by the actual prey landscape than landcover features. To test this, we will capture, collar, and track coyotes at the DeLuca preserve, while simultaneously estimating the prey landscape by building on our current biodiversity surveys at DeLuca. Beyond these fundamental endeavors, our project will address applied issues that are highly salient to many potential funders. For example, we will collaboratively address coyote impacts on wild turkey reproductive behavior and how coyotes respond to different cattle and grazing management strategies. By building on and collaborating with current projects at the DeLuca Preserve as well setting the stage for future projects that are likely to be seen favorably by both state and federal-level funders, we will continue to fulfil the promise of the DeLuca Preserve being a living laboratory.

Introduction(*This research is targeting DeLuca Preserve funds*)

Understanding animal space use and how these choices are related to the underlying landscape are core principles of ecology. Testing relationships and theories related to both animal behavior and predator-prey dynamics are key to understanding these processes. Yet for generalist species that tend to occur in a variety of landscapes, we do not always have a clear picture of how they use space or the consequences of their space-use choices. For one generalist predator in particular, the coyote (*Canis latrans*), this lack of clarity often manifests as either inconclusive or contradictory results (e.g., [1,2,3]). Our limited understanding of the drivers behind the decisions that generalist predators make in space and time is unfortunate because these species are often common on the landscape and thus can have a large impact on ecosystem function. In addition, their abundance makes them more likely to be involved in human-wildlife conflict. Indeed, in many systems, including most terrestrial landscapes in Florida, coyotes are considered an apex predator. As an apex predator, coyotes can drive ecosystem dynamics such as mesopredator release [4], can have a significant impact on species of conservation concern (e.g., caribou (*Rangifer tarandus*) [5]), and can impact population abundance of important game species (e.g., wild turkey (*Meleagris gallopavo*) and white-tailed deer (*Odocoileus virginianus*) [6,7]). Furthermore, coyotes can be involved in conflict directly with humans, especially in urban areas [8] and indirectly as a potential predator of livestock [9]. Here, we propose a study that will use cutting-edge technology and recent advances in analytical methods to fill both fundamental and applied knowledge gaps.

The knowledge gaps. Coyotes are a generalist predator and will consume a wide variety of plant and animal material [10]. Generalist predators are often assumed to be adept at prey switching (where predators dynamically switch among targeted food sources in response to their availability or density on the landscape). Thus, while primary consumers are often linked with vegetation types reflective of their preferred food resource [11] and specialist predators are linked to specific prey species which are themselves linked with vegetation types [12], the mechanistic pathway to support definitive links between vegetation types and generalist predators is murky. Ultimately, it is hypothesized that predator behavior is driven by the prey landscape rather than underlying vegetation. Furthermore, when a predator has a highly flexible diet, the links between predator and underlying vegetation types are expected to be weak. Yet, due to the easy availability of landscape level data on vegetation types (satellite-derived landcover data), most research has focused on interpreting coyote space use and behavior relative to vegetation types instead of prey availability. Coyotes have recently expanded their range into Florida – it wasn’t until the mid-1990s that coyotes were well established in central and southern Florida [13]. Despite the new and growing coyote population in the state, there have been relatively few studies of coyote behavior in Florida (but see, [14,15]). As such, we have only a cursory understanding of the drivers of coyote space use in Florida, and the role of the prey landscape. We can take advantage of recent advances in GPS telemetry equipment and accelerometers to simultaneously monitor both coyote behavior (resting, foraging, traveling) and resource selection in both space and time [16].

Opportunities to collaborate and leverage data. As a generalist predator, coyotes can have an impact on important game species like bobwhite quail (*Colinus virginianus*), white-tailed deer, and wild turkey. By collaborating with the *Wild Turkey Breeding Behavior 1* project (co-PIs; Lashley, Baruzzi, and in collaboration with FWC), we will be able to directly address the predator-prey dynamics between coyotes and wild turkeys. By combining our behaviorally specific models of coyote resource selection (prey and landscape-based) with spatial and temporal models of turkey gobbling, we will be able to determine how coyotes respond to turkey gobbling on the landscape and how that response is mediated by coyote proximity, behavior, and underlying availability of other resources. Applied questions such as these are appealing to state- and federal-level funding sources (see *Future Funding Plan*).

Addressing human-wildlife conflict. Coyotes are perceived by many livestock producers as a source of mortality for their young cow calves. Indeed, livestock producer surveys conducted by the USDA estimated that 25% of calf loss in Florida is attributed to predation and coyotes are commonly thought to be the culprits [17]. While field studies have been inconclusive on the direct predation impacts of coyotes on cow calves [18], coyotes do spend time in pastures and thus could be having either a direct (predation) or indirect (increased stress, reduced growth rate) impact on cow calves. Given the potential for human-wildlife conflict between livestock producers and coyotes, it is important to understand how coyotes use pastures (traveling, foraging, etc.) and whether that use is modulated by other spatial and temporal factors, including the presence of cows, the natural prey landscape, and the surrounding landcover features. Ultimately, a more complete picture of how coyotes behave and move in time and space in Florida’s rangelands relative to grazing management strategies is an important first step in being able to understand the impact of coyotes on livestock production and to develop strategies that reduce the risk of human-wildlife conflict.

## The DeLuca Preserve: a living laboratory. Our proposed project builds on several ongoing projects at the DeLuca Preserve. For example, we will be able to link coyote behavior and resource selection to presence of cows and other grazing management decisions because we have established relationships with cattle lessees and developed a protocol for collecting this information as part of the *Grazing and Avian biodiversity2* project jumpstarted by the UF|IFAS DeLuca funds in 2021. The support of the *Grazing and Avian biodiversity* project by the UF|IFAS DeLuca funds in 2021 also allowed us to leverage funds for the ongoing *Florida Wildlife Corridor Observatory*3 project funded by private donation at the DeLuca Preserve, where we have been monitoring biodiversity with a network of 48 trail cameras and 48 acoustic recording devices for over 6 months. Data collected from both the *Florida Wildlife Corridor Observatory* project and the *Grazing and Avian Biodiversity* project will form the basis of our predicted prey landscape (which is a key component to our proposed project) with key collaboration and assistance from the *Mosquito Blood Meal-derived Vertebrate Surveys*4. Our proposed project is also intertwined with the proposed *Wild Turkey Breeding Behavior* project (which has its own pedigree of 2021 DeLuca jumpstart funds leading to extramural support), allowing us to simultaneously address questions about how coyote predation behavior influences turkey reproductive behavior. These interconnections are what helps to fulfill the promise of the DeLuca Preserve as being a living laboratory, where we can deepen our knowledge of ecological relationships and reveal the applied impacts of wildlife ecology, game management, and agricultural production.

# Proposed Research

### Objectives.

1. Estimate the prey landscape at DeLuca. We will estimate prey landscapes of both specific prey species (e.g., wild turkey, white-tailed deer) and the general prey base using data derived from the cameras and acoustic recording units currently deployed at the DeLuca Preserve using an occupancy model framework [19].
2. Determine the relationship between coyote behavior and the estimated prey landscapes at the DeLuca Preserve. We will estimate coyote behavioral states using hidden Markov models of coyote movement data derived from high frequency fix rate GPS collars (following [20]). We will estimate relationships between these behavioral states and the prey and vegetation landscapes using integrated step selection functions [21].
3. Determine the relationship between coyote foraging behavior and turkey reproductive behavior. We will expand the models used in objective 2 by collaborating with the *Wild Turkey Breeding Behavior* to deepen our understanding of coyote response to specific wild turkey behaviors in space and time.
4. Determine the relationship between grazing management and cow presence in pastures and coyote behavioral state and resource selection. We will expand the models used in objective 2 by including specific grazing and cattle management data in both the improved and semi-native pastures at the DeLuca Preserve.

Methods. We will capture and place GPS collars on coyotes (target sample size = 10 per year) at the DeLuca Preserve. Capture methodology will follow protocols established by [20] and we will obtain IACUC approval. We will predict the prey landscape of the DeLuca Preserve using occupancy models generated from camera, acoustic data, and other survey methods collected by existing projects at DeLuca (see “The DeLuca Preserve: a living laboratory). Turkey movements and gobbling activity will be monitored by the *Wild Turkey Breeding Behavior* project. We will collect grazing and cattle management data in partnership with the DeLuca Preserve’s land management and cattle lessees.

Anticipated schedule. This ambitious project is well suited for a PhD student. We will recruit a PhD student to begin working on the project in January 2023 (starting coursework in August 2023). We will begin coyote collaring effort in early 2023. Camera and ARU arrays are already deployed. The schedule for the wild turkey component of this project is discussed in its own proposal.

Data accessibility. We currently store camera and acoustic data locally at the Range Cattle REC and it is available for other researchers as needed. Coyote GPS telemetry data will be stored locally at the Range Cattle REC and will be available for researchers as needed.

# Future Funding Plan

This project builds on previous funding from the DeLuca Seed grant; a grant that allowed us to collaborate with Archbold Biological Station and secure funding for the Florida Wildlife Corridor Observatory ($692,402 over 3 years [$183,522 to PI: Ellington]). We have been in discussion with colleagues at the USDA-APHIS NWRC about our proposed project and they are excited about the possibilities to explore how coyotes react to different grazing management strategies, as these responses could have impacts on human-wildlife conflict. We have a verbal commitment of 80 hours of agency personnel support from USDA-APHIS NWRC-Florida for coyote trapping and handling training and assistance. Furthermore, preliminary discussions with USDA-APHIS NWRC-Florida identified interest and potential support for future projects along the urban-rangeland interface in Florida, especially as they relate to human-wildlife conflict. The applied concepts that we propose (i.e., coyote interaction with cattle and game species) mean it is well-suited to garner additional interest from funders such as the Florida Cattle Enhancement Board and the Florida Fish and Wildlife Commission.

Beyond the applied concepts of our proposal, understanding how generalist predators behave and use the environment and respond to differences in prey availability across space and time will advance our knowledge of ecological concepts such as predator-prey dynamics and optimal foraging. By using cutting edge technology and innovative analytical techniques, our project will be on the leading edge of the field of movement ecology and will be poised to expand into other emerging areas of wildlife ecology research, such as the role of cognition and memory in determining behavior and resource use in space and time. These more fundamental research questions in wildlife ecology will lend themselves well to federal funding sources.

# Budget and Justification

Funds will be used to support a PhD student (Autumn 2023) and OPS technician to oversee and assist in coyote capture and monitoring and support year-long camera and acoustic survey monitoring. For the PhD student we also request a tuition waiver for Autumn 2023. Funds for equipment and travel will support the coyote capture and monitoring efforts.

|  |  |  |  |
| --- | --- | --- | --- |
| Description of item | Units | Unit cost | Amount |
| **Salary** |  |  |  |
| PhD student (annual salary = $28,000) reported as months | 5 | $2,333.33 | $11,666.67 |
| PhD student benefits (12.4%) | 5 | $289.33 | $1446.67 |
| OPS technician ($15/hr) reported as hours | 2080 | $15.00 | $31,200 |
| OPS technician benefits (7.2%) | 2080 | $1.08 | $2,246.40 |
|  |  |  |  |
| **Tuition** |  |  |  |
| PhD student (fall 2023) | 1 | $6,571 | $6,571 |
|  |  |  |  |
| **Equipment (*Coyote monitoring)*** |  |  |  |
| Lotek Iridium GPS collars with drop-off and accelerometer | 10 | $2,000 | $20,000 |
| Remote download annual fees | 10 | $932 | $9,320 |
| VHF receiver and antenna | 1 | $2,100 | $2,100 |
| GPS collar download link connecter | 1 | $300 | $300 |
| Ear tags (package of 25) | 4 | $24 | $96 |
| Ear tag applicator | 1 | $28 | $28 |
| Live catch snares (dozen) | 10 | $27 | $270 |
| Miscellaneous capture and handling supplies | 1 | $500 | $500 |
|  |  |  |  |
| **Travel (fuel and mileage reimbursement)** | 1 | $2,000 | $2,000 |
| **TOTAL** |  |  | **$87,744.73** |

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