Project Goals: Research has shown that 74% of grassland bird species are declining in North America1 . Several GISbased studies have shown the impact of landscape factors, such as human development and land cover type, on avian abundance and diversity 2,3,4 . However, a notable research gap exists in examining the impact these factors have on individual behaviors and fitness. We seek to fill this gap by examining the impact of landscape factors on Western Meadowlark song structure on the national-scale and the impact of landscape factors on Western Meadowlark song structure, individual body condition, and breeding success in the Pawnee National Grassland. With this multi-scale study, we hope to provide new insights to the immediate mechanisms underpinning population changes in grassland birds, enhance the conservation of Colorado's grassland birds, and offer land managers data useful to promoting diversity and abundance on their properties. Finally, we intend to provide research opportunities, mentorship, and ornithological skills training to undergraduate students who represent identities poorly represented in STEM and ornithology. Objectives: Obj. 1: Use 1,551 public song recordings, GIS-databases, and publicly available eBird abundance data to produce national and county models that clarify the relationship between landscape, song structure, and abundance in Western Meadowlarks. Obj. 2: Track the local abundance, body condition, song features, and nesting success of Western Meadowlarks in the Pawnee National Grassland to determine the impacts of landscape and song structure on individual fitness.

Location: The initial analysis of landscape and songs will occur on the national-scale, utilizing 1,551 Western Meadowlark song recordings and associated landscape data from across the United States. Field work will occur at the Pawnee National Grassland in Weld County, CO. This site includes 193,060 acres managed by the USDA Forest Service, contains a wide range of habitats, and is an internationally known hotspot for birds. We will select 30 field transects that represent a gradient of significant landscape factors identified in Obj. 1 with the guidance of Pawnee National Grassland scientist Vernon Koehler.

Research Methods: H1: Bird song features are altered at a landscape level by factors including road density, fragmentation, anthropogenic structures, land cover, and habitat variation. H2: Landscape and song features will predict individual abundance. H3: Anthropogenic landscape factors and their associated song features will negatively covary with body condition and reproductive success. H1 and H2 above will be tested with a modeling approach. The variables found to predict song features and abundance will form the basis of a field study to test H3. Study Species: Western Meadowlarks (Sturnella neglecta) are a flagship grassland obligate species and can be found throughout the western United States. Western Meadowlarks have shown annual population declines from 1966-20065 , mirroring general avian population declines in grassland habitat. The species is common in Colorado grasslands and there are 1,551 appropriate song recordings available in public databases. Modeling: We extracted 1,551 publicly available breeding season songs from the Macauley and Xeno-Canto song libraries and measured multiple song features. We used ArcGIS and public databases (such as the National Landcover Database) to extract song-localized data on landscape factors such as habitat fragmentation, land cover, anthropogenic structures, and road data at 100m, 500m, 1000m, and 1km buffer sizes. We are using those data to build models at the continental and county scales to test which landscape factors predict song structure features (min. and max. frequency, song inflection points, and peak frequency) and Western Meadowlark abundance per data from the Cornell Lab of Ornithology.

Field methods: At the Pawnee National Grassland (Weld County, CO), we will select 30 field transects that represent a gradient of significant landscape factors identified in H1 and H2 with P.N.G. biologist Vernon Koehler. Males will be captured and marked with colored bands for identification. We will record at least 20 songs from each banded male for analysis. We will locate nests using the ropedrag method on banded males' territories, band females and juveniles (at day 9 post-hatch), and track nest

fate. As feasible, we will minimize nest disturbance using nest cameras to get accurate fledge rates and record nest failures. We will collect blood for paternity analysis from all males and chicks. Blood from adults will also be used for endoparasite analysis. At banding, we will collect body condition data on all birds including mass, morphology, plumage intensity based on photographs with a color standard, and ectoparasite load. Finally, we will conduct stationary point counts on breeding territories per the Breeding Bird Survey methods6 . We will build a local model that utilizes the same landscape and song structure predictor factors identified in H1 and H2 as well as overall avian diversity to examine their impact on individual fitness through breeding success.