Spatiotemporal Changes in the Distribution of Ferruginous Hawks in North America



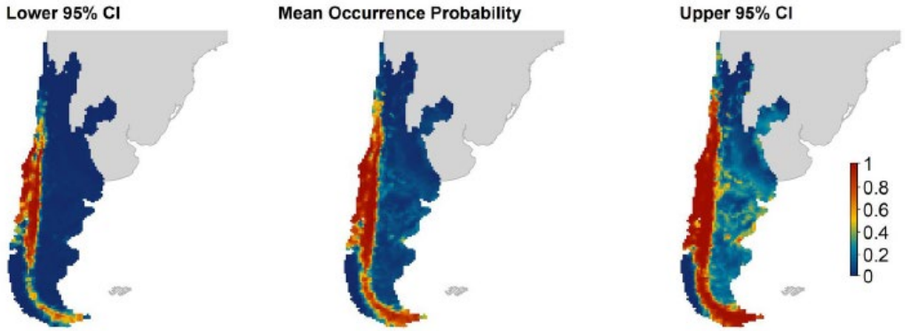
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GRADUATE DEGREE PROGRAM IN ECOLOGY
COLORADO STATE UNIVERSITY

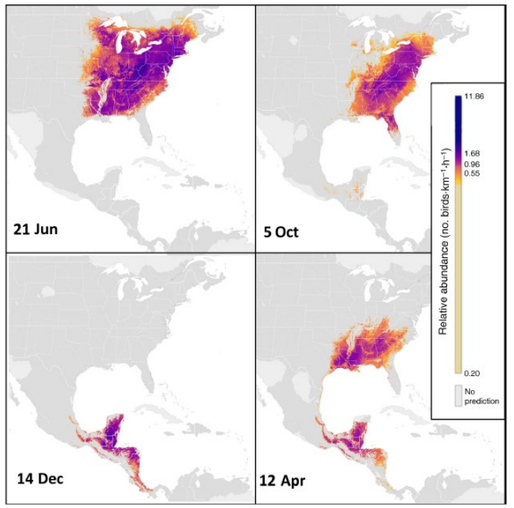
FISH, WILDLIFE, AND CONSERVATION BIOLOGY
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Why model species distributions?

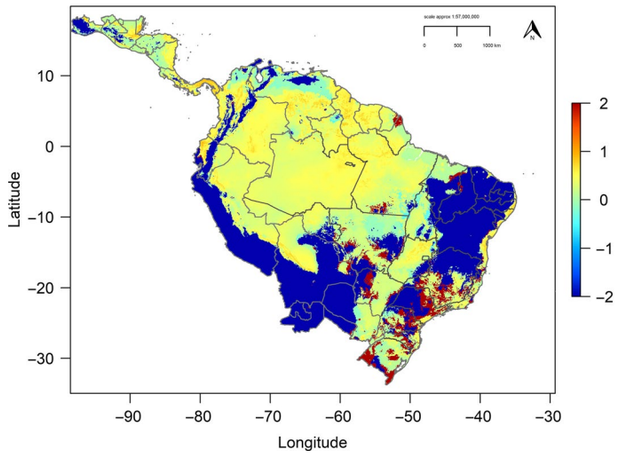
- SDMs: tools to understand how species are distributed geographically and within environmental space
  - Range boundary changes
  - Policy/regulatory maps
  - Climate impacts
  - Species invasion
  - Stable occupancy through time



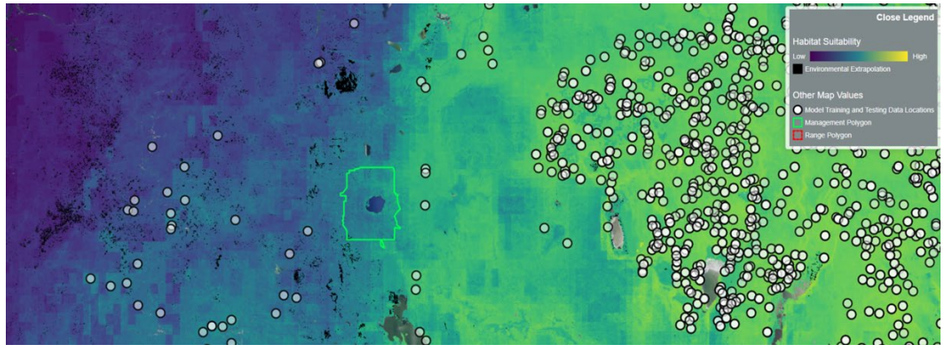
McCabe et al. 2026 Austral Pygmy-Owl



Fink et al 2020 Wood Thrush



Sutton et al. 2020 Harpy Eagle refugia



USGS INHABIT *Bromus tectorum*

Ferruginous Hawk Distribution

- Habitat Changes
  - Irrigation expanded in Great Plains and Deserts ~1900, center pivot pumps ~1930s
  - Gas and oil extraction
  - Wind energy facilities
  - Urban expansion, roads
  - Livestock and range management
  - Prey persecution
  - Invasive grasses, shrub loss
  - Increased warming and drying periods predicted



Black-tailed Jackrabbit, Peter Pearsall/USFWS



NCSU



WY Ground Squirrel, Koerner, Tom/USFWS

- Prey populations shifting
  - Ground squirrel declines and local extirpations from drying climate Nash and McCain 2024
  - Jackrabbit declines (cheatgrass invasion, wildfires, hemorrhagic disease) Woffinden and Murphy 1989, Heath et al 2021, Ringenberg et al 2024
  - Plague and drought impacting prairie dog survival Eads and Biggins 2017
- Hawk distributions shifting
  - “with settlement and the spread of agriculture, the Ferruginous Hawk started a decline and by 1928 was less common than in 1890” Bechard 1981, Criddle 1929
  - “Ferruginous hawks are now absent from the northern 40% of their former range in Alberta” Schmutz 1984
  - “this local population failed to respond positively to increasing prey numbers, and the ferruginous hawk may currently be extirpated from the area [in Utah] as a nesting species” Woffinden and Murphy 1989

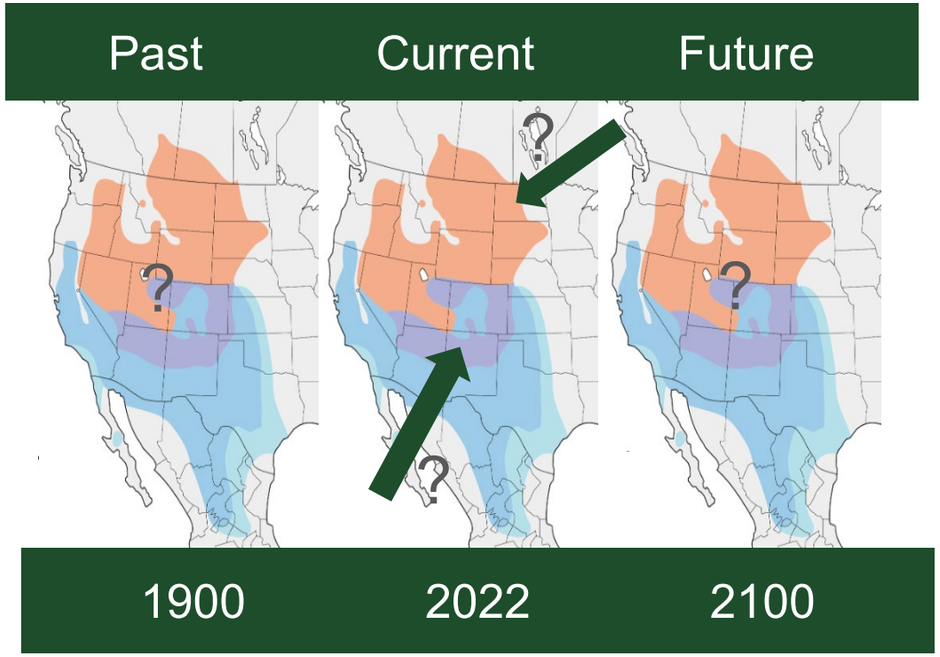
Are Ferruginous Hawk distributions shifting over time in response to land use and climate changes?

Objectives:

(1) identify the environmental factors associated with current breeding and wintering distributions

(2) quantify the direction and magnitude of distributional change from 1900-2100

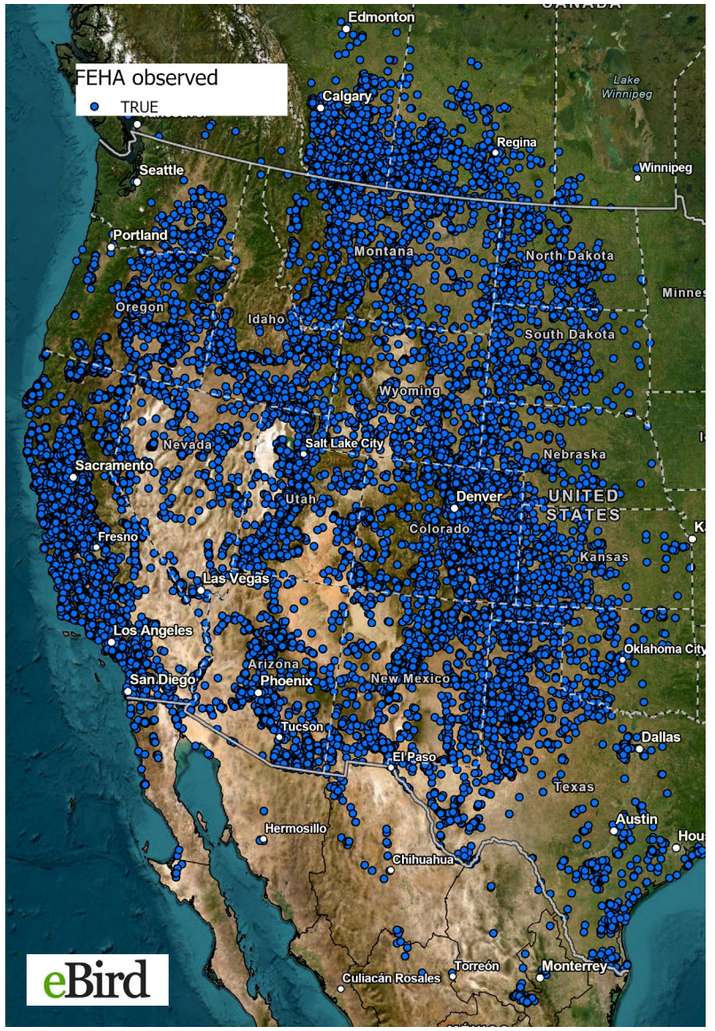
(3) determine how these distributions vary among seasons and regions.



Birds of the World, Ng et al 2020

Ferruginous Hawk Distribution

- Occur at low-densities
- Avoid human activity
- Low detection rates in all available datasets: BBS, IMBCR, CBC, eBird
- Selected eBird for the SDM



METHOD

Diversity and Distributions WILEY

Analytical guidelines to increase the value of community science data: An example using eBird data to estimate species distributions

Alison Johnston | Wesley M. Hochachka | Matthew E. Strimas-Mackey | Viviana Ruiz Gutierrez | Orin J. Robinson | Eliot T. Miller | Tom Auer | Steve T. Kelling | Daniel Fink

Best Practices for Using eBird Data
ebird.github.io/ebird-best-practices/

U.S. State-Level eBird Data Summaries

An eBird data portal for use in State Wildlife Action Plans

Get Your State Data

Model setup

Response

- Detection/non-detection eBird observations
- Filtered + spatio-temporal subsampled to reduce biases
- 13.9 million checklists (2004–2022)
- 61,000 FEHA detected(<1% of data)



Predictors

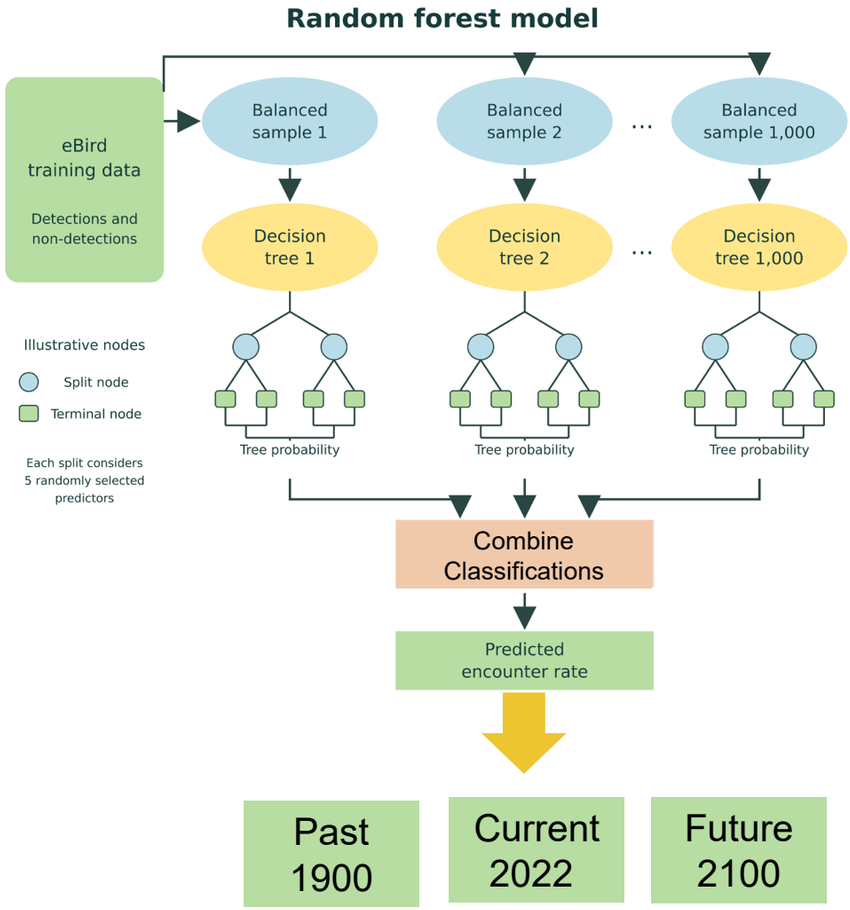
- Effort: observation year, day of year, time, number observers, observation distance, speed, survey length (Johnston et al 2021)



- 1-3km resolution
- landcover (Olson et al 2017)
- climate (Cohen and Jetz 2025, Olson et al. 2017, Squires et al. 2020, Ng et al 2022, Sohl 2014)
  - CMIP6 SSP2-4.5
- irrigation (Isted et al 2023)
- energy production/ extraction (Ramirez et al 2025, Kolar and Bechard 2016, Watson et al. 2025)
- lat/lon
- soil (Ng et al. 2022)
- topography (Olson et al. 2017, Ramirez et al 2025, Cohen and Jetz 2025,Squires et al 2020)

Model setup

- Random forest algorithm
  - Balanced forest design, tuned with 1000 decision trees trained on bootstrapped samples, ‘ranger’ R package
  - Top variables of importance
  - Withheld 20% data for OOB model testing
- Modeled by breeding (Mar-Jun) and wintering (Nov-Feb) seasons (Watson et al 2018)
- Predicted 3 time periods using a shared 3km x 3km prediction grid
- Encounter rate: probability of FEHA detection on a standardized eBird checklist

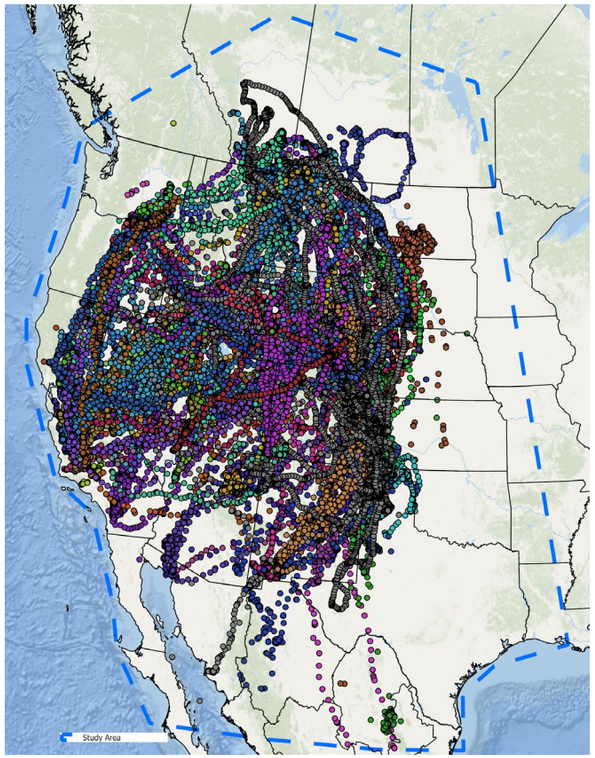


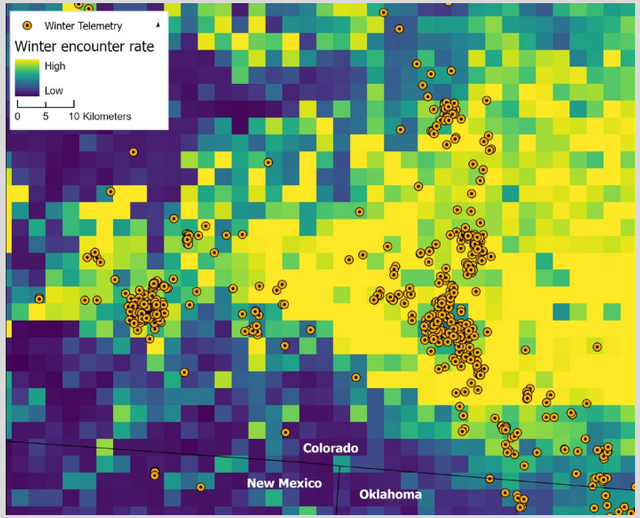
Model Validation

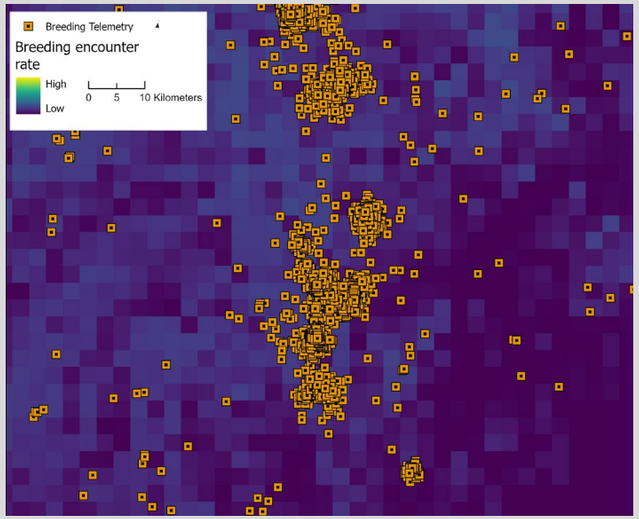
1) Out-of-bag sample (eBird)
- Stronger predictive power in winter than breeding season

Season	Breeding	Wintering
Mean squared prediction error	0.01	0.02
Sensitivity (true positive)	0.36	0.56
Specificity (true negative)	0.99	0.97
OOB prediction error	0.09	0.09

2) Telemetry (n= 100 hawks)
- Selected 1 loc/hawk/day during peak eBird detection periods (~10am-12pm)
- Assessed the predicted raster maps with telemetry (presence) and random points (psudeo-absence)
- Smoothing-based Boyce Index supported eBird trained models



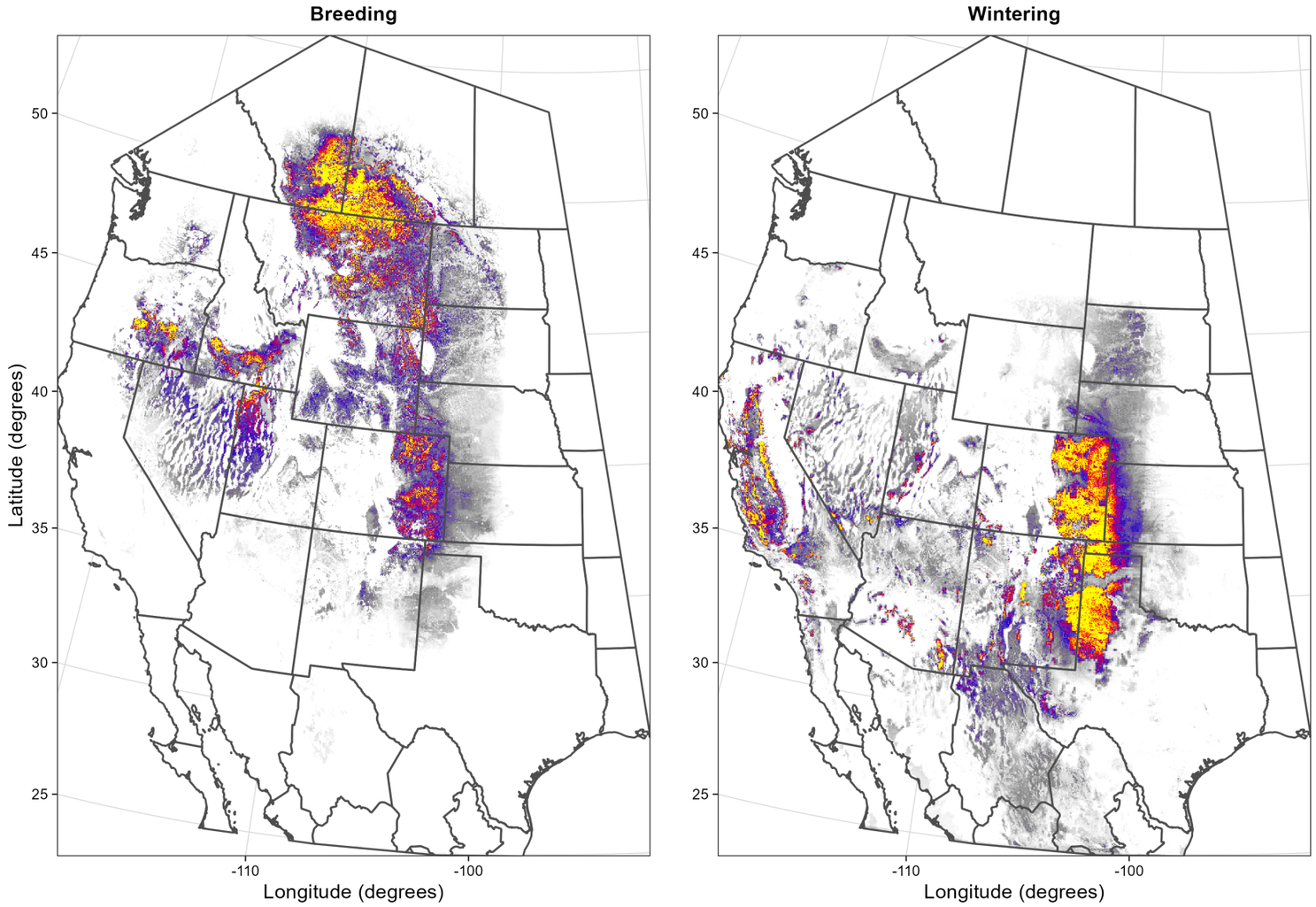




+ Winter season prairies and cold deserts
+ Breeding season prairies
- Breeding season cold deserts

Current Distribution

- Random forest model predicted well
- Patterns match documented concentrations and migration movements (Ng et al. 2020, Watson et al. 2018, 2019)
- Top variables of importance for random forest models:



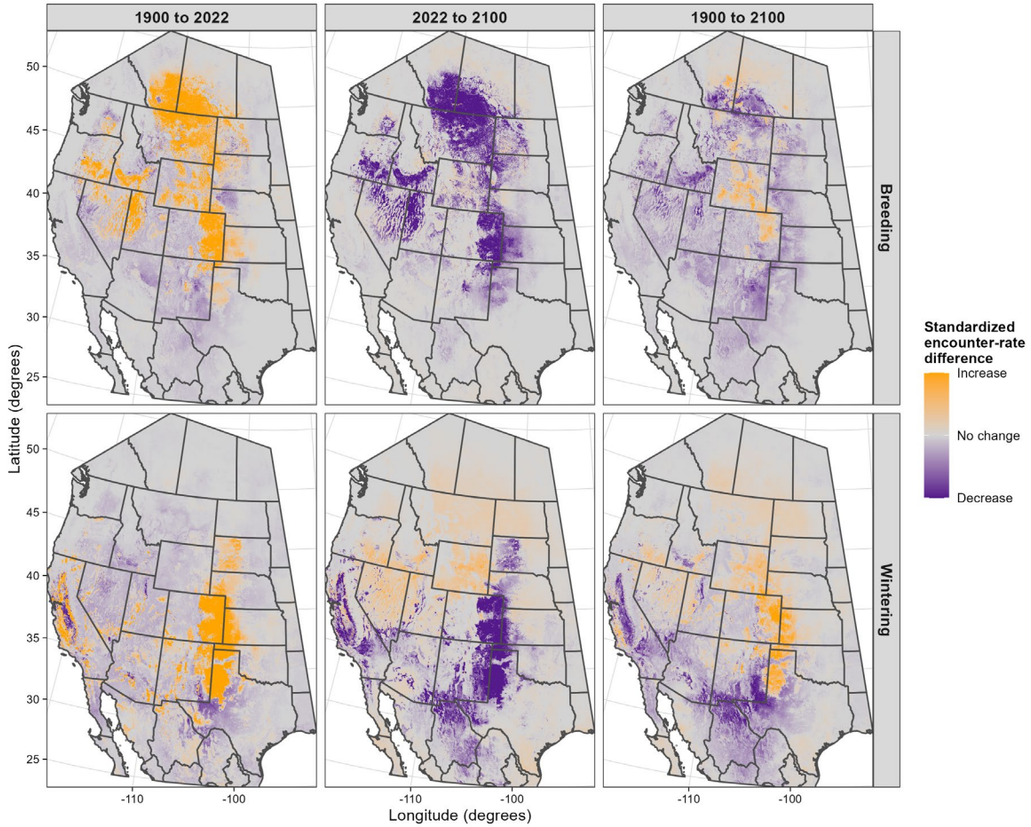
Encounter rate: probability of FEHA detection on a standardized eBird checklist

Breeding
- Elevation
- % Forest
- Roughness
- Longitude
- Min. temp. cold mo. bio06

Winter
- Latitude
- Longitude
- Irrigation
- Annual mean temp. bio01
- Distance surveyed

Conclusions

- Maps are at the continental scale and can't replace local monitoring of both Ferruginous Hawks and their prey.
- SDMs describe general patterns about occupancy, not demography
- Current species distribution likely influenced by a century of change and potentially could continue to change into the future









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Thank you

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