

How do wind turbines and fracking affect birds?
Empirical evidence based on citizen-science data

Erik Katovich

Assistant Professor

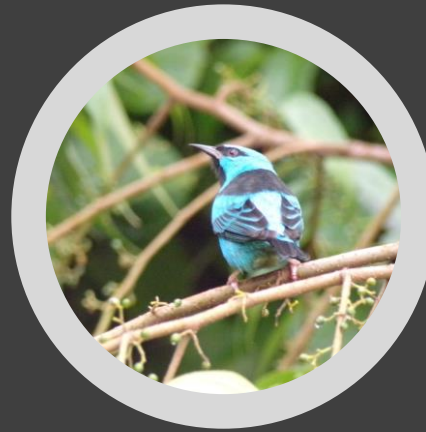
University of Connecticut

October 7th, 2024

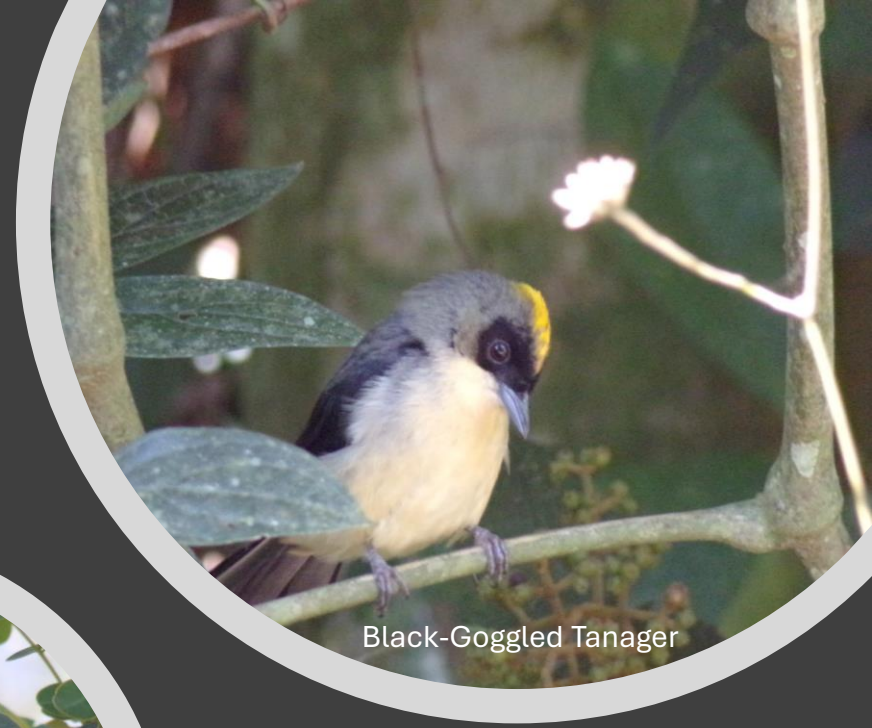
Bird Protection Quebec

About me

- Assistant professor in the Department of Agricultural and Resource Economics at the University of Connecticut
- I'm originally from Minnesota
- My research focuses on the environmental and socioeconomic impacts of natural resource sectors like oil, mining, and tropical agriculture
- I also love birds! I've been a birder my whole life, mostly in the US Midwest and Brazil, where I lived for several years and where much of my research is focused



Blue Dacnis



Black-Goggled Tanager



Brassy-Breasted Tanager



Glittering-Throated Emerald



Channel-Billed Toucan



Red-Necked Tanager

This project was inspired by citizen-science data

Read about the National Audubon Society's Christmas Bird Count in the newspaper



Recalled recent debates in the media about how wind turbines might harm wildlife



Idea: The Christmas Bird Count and my training in statistics might allow me to contribute some empirical evidence to this debate!



Source: Minneapolis Star Tribune (2014)

Energy generation from shale oil and gas extraction (fracking) and wind turbines increased rapidly in the US in recent decades

- Shale gas production increased 20-fold from 2007 to 2020
- Wind energy capacity increased 48-fold from 2000 to 2020



Wind turbines in Palm Springs, California

Image source: [CNBC \(2019\)](#)

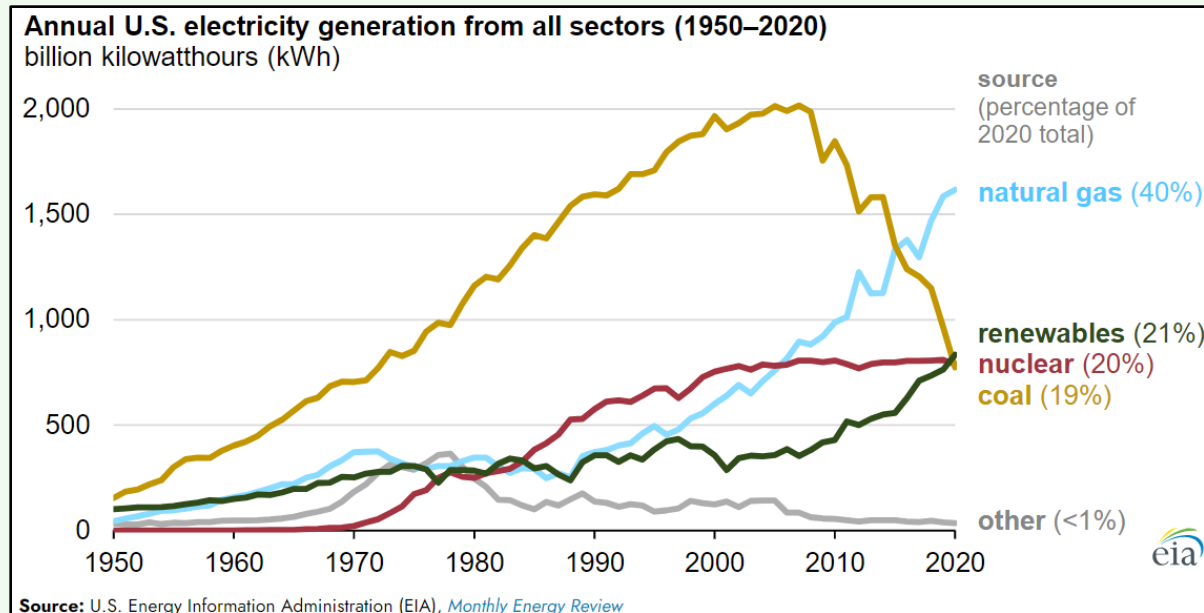


Fracking wells in Wyoming's Jonah gas field

Image source: [SkyTruth/EcoFlight \(2024\)](#)

Energy generation from shale oil and gas extraction (fracking) and wind turbines increased rapidly in the US in recent decades

- Shale gas production increased 20-fold from 2007 to 2020
- Wind energy capacity increased 48-fold from 2000 to 2020



MARCH 11, 2024

United States produces more crude oil than any country, ever

US Energy Information Administration (2024)



Wind turbines in Palm Springs, California

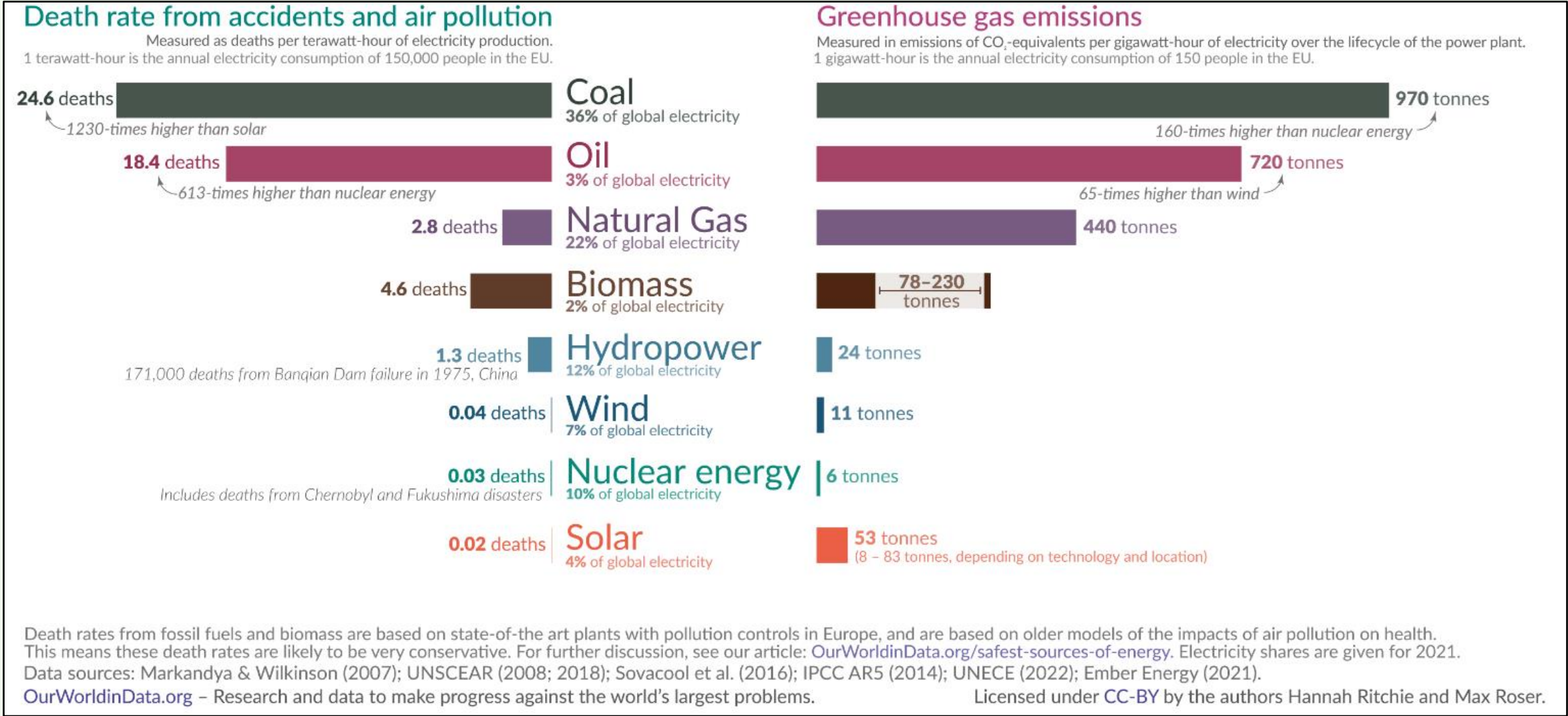
Image source: [CNBC \(2019\)](#)



Fracking wells in Wyoming's Jonah gas field

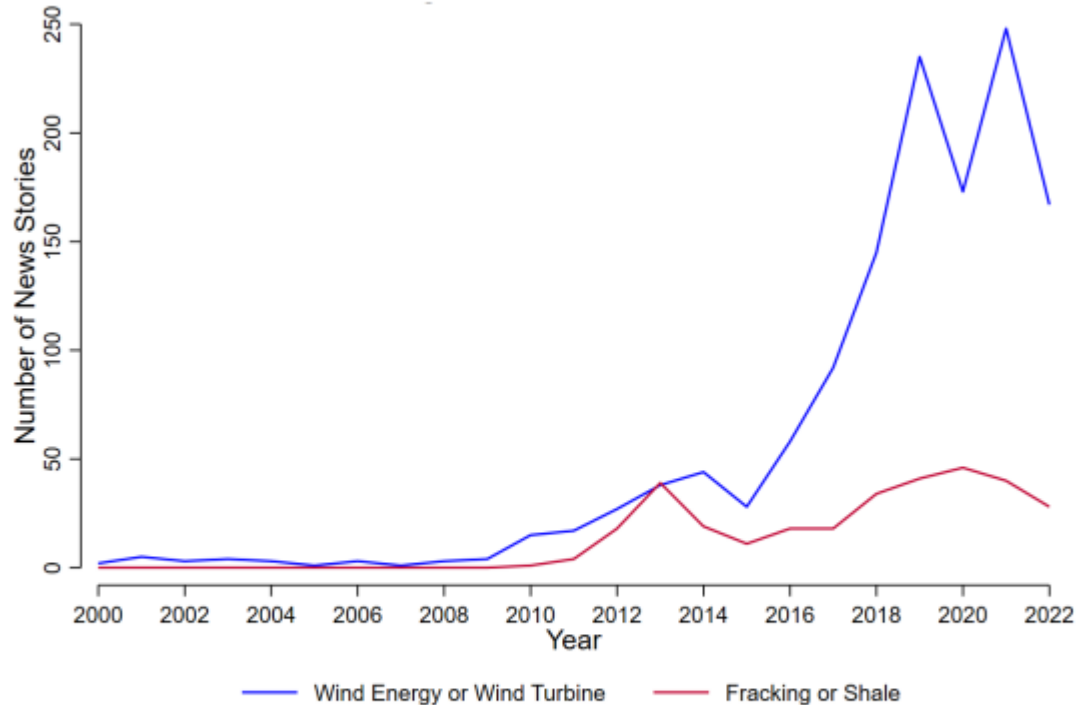
Image source: [SkyTruth/EcoFlight \(2024\)](#)

Society faces cost-benefit tradeoffs when thinking about the transition toward clean energy sources



Media coverage has focused overwhelmingly on the impact of wind turbines on birds

Figure A4: US News Coverage of Wind and Shale Effects on Birds



Note: Number of US news stories covering effects of wind or shale on birds, from the International Newsstream Database. Keyword searches were conducted for (i) "Birds" AND ("Fracking" OR "Shale") and (ii) "Birds" AND ("Wind Energy" OR "Turbines"). News stories were restricted to the United States between Jan. 1st 2000 and Dec. 31st 2022.

Trump rails against wind energy in fundraising pitch to oil executives

At a Mar-a-Lago dinner, Donald Trump doubles down on promises to derail a key form of clean energy that competes with fossil fuels

HEALTH & SCIENCE

Wind farms under fire for bird kills

Conventional Wind Energy – A Design Deadly for Birds

Should we be concerned? What do we know from the existing literature?

- Previous studies estimate that turbines kill between 140,000-679,000 birds per year in the US (Loss et al., 2013)
 - These studies are mostly based on counting bird kills under a few turbines and extrapolating
 - This method misses avoidance effects and impacts beyond the immediate site
- This is tiny compared to estimates of birds killed by building collisions (600 million/year) or cats (>1 billion/year) (Loss et al., 2013; Loss et al., 2014)
- Wind turbines result in an estimated 0.269 deaths per gigawatt-hour of electricity, compared to 5.18 per gigawatt-hour from fossil fuels (Sovacool, 2013)

Should we be concerned? What do we know from the existing literature?

- Previous studies estimate that turbines kill between 140,000-679,000 birds per year in the US (Loss et al., 2013)
 - These studies are mostly based on counting bird kills under a few turbines and extrapolating
 - This method misses avoidance effects and impacts beyond the immediate site
- This is tiny compared to estimates of birds killed by building collisions (600 million/year) or cats (>1 billion/year) (Loss et al., 2013; Loss et al., 2014)
- Wind turbines result in an estimated 0.269 deaths per gigawatt-hour of electricity, compared to 5.18 per gigawatt-hour from fossil fuels (Sovacool, 2013)

How does my study contribute?

- I measure and compare the effects of both wind turbine and fracking installations between 2000-2020 for the entire lower-48 United States
- I use the latest statistical methods to improve causal estimates – no extrapolations or modelling assumptions
- I use a high-quality citizen-science bird dataset that allows me to capture broader avoidance effects

Environmental impacts of wind turbines

- Wind energy is a key component of the energy transition – costs should be weighed against climate benefits



Image source: [Let's Talk Science \(2019\)](#)

Environmental impacts of wind turbines

- Wind energy is a key component of the energy transition – costs should be weighed against climate benefits
- Wind turbines may lead to bird avoidance behaviors during construction (Schuster, 2015).
- Collision risks are highest for migrant species and in previously undisturbed habitats (Kiesecker, 2011)
- Grassland birds exhibit avoidance behaviors within 300m of active turbines for several years after construction (Shaffer and Buhl, 2015)
- Turbines require extensive transmission lines and are sometimes located on hilltops or inside sensitive bird habitats



Image source: [Let's Talk Science \(2019\)](#)

Environmental impacts of fracking

- Air and water pollution, light and noise pollution (Black et al., 2021)
- Increased road traffic and dust (Spiess et al., 2020)
- Grassland bird species diversity declines as the number of shale wells increases (Maguire and Papeş, 2021)
- Birds exhibit avoidance behaviors within 350m of wells and 150m of roads (Thompson et al., 2015)
- Fracking causes landscape fragmentation, harming specialist birds (Tagliaferri et al., 2015)



Fracking pad in North Dakota

Image source: [Bradford \(2017\)](#)

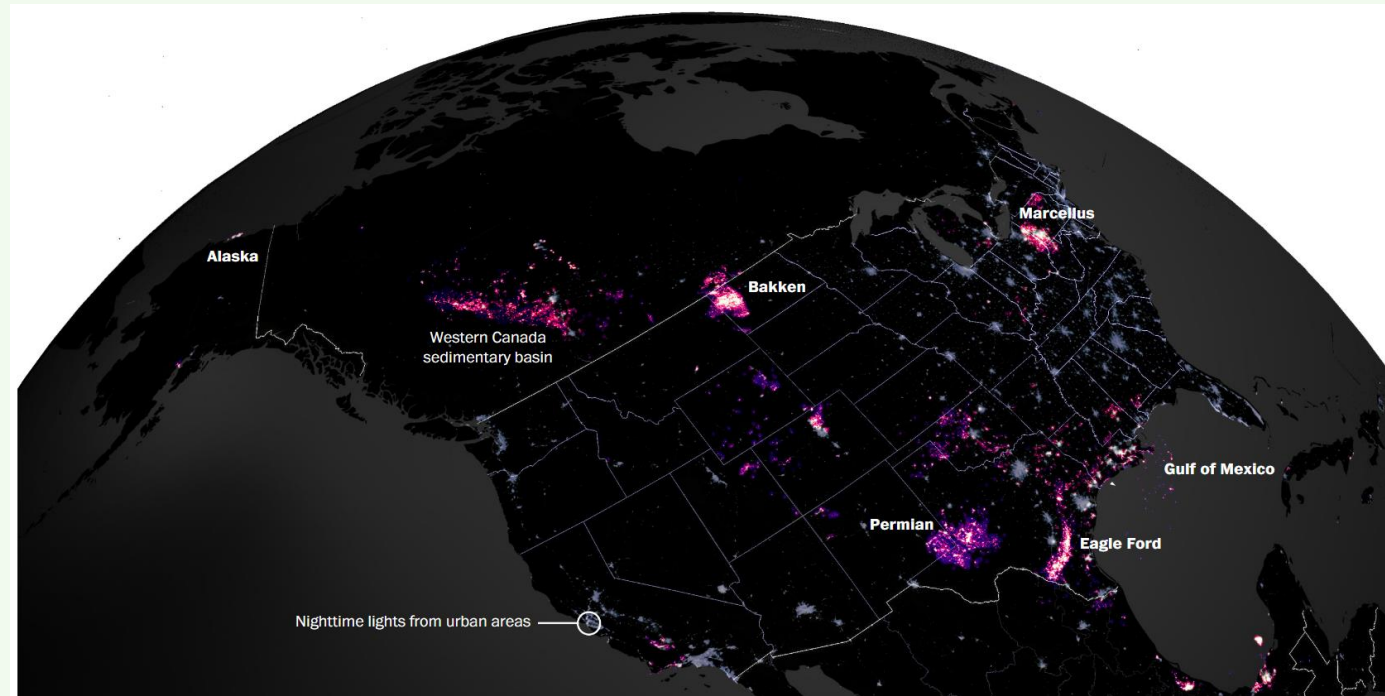
Environmental impacts of fracking

- Air and water pollution, light and noise pollution (Black et al., 2021)
- Increased road traffic and dust (Spiess et al., 2020)
- Grassland bird species diversity declines as the number of shale wells increases (Maguire and Papeş, 2021)
- Birds exhibit avoidance behaviors within 350m of wells and 150m of roads (Thompson et al., 2015)
- Fracking causes landscape fragmentation, harming specialist birds (Tagliaferri et al., 2015)



Fracking pad in North Dakota

Image source: [Bradford \(2017\)](#)



Flaring from oil and gas fields outshines the largest cities

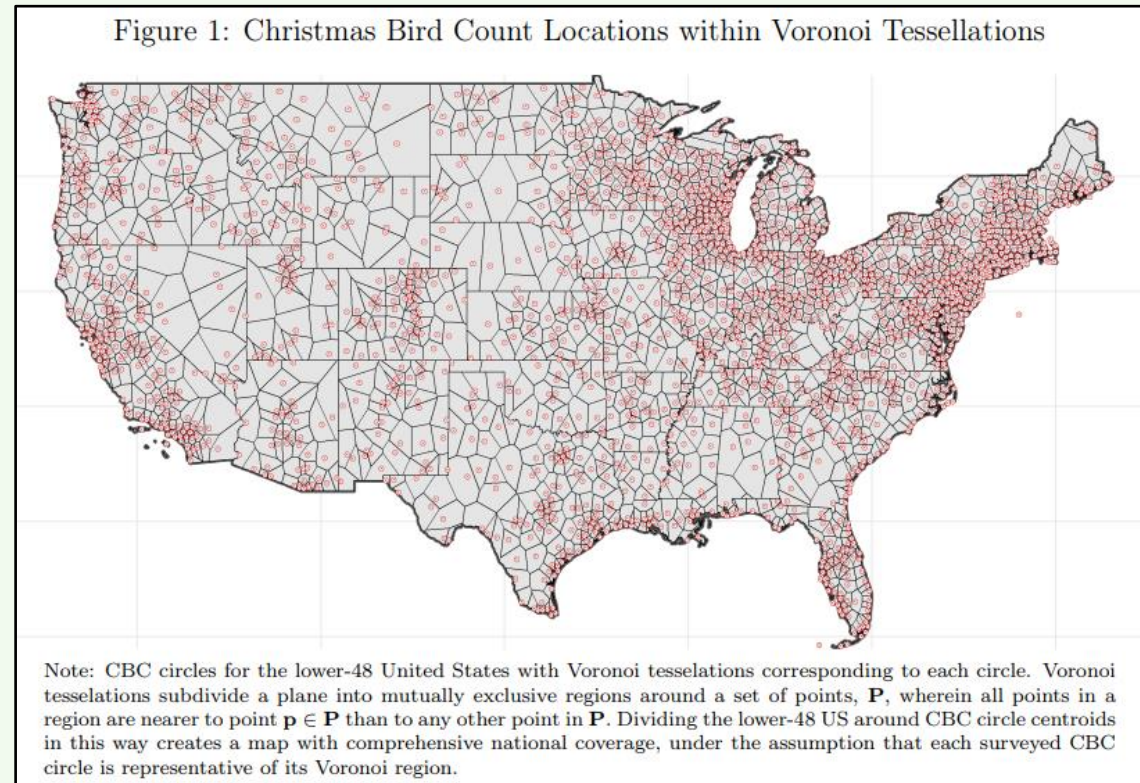
Image source: [Washington Post \(2017\)](#)

Research Question: How has the rapid expansion of wind turbines and shale oil and gas extraction infrastructure affected bird populations and biodiversity in the United States between 2000 and 2020?

Research Question: How has the rapid expansion of wind turbines and shale oil and gas extraction infrastructure affected bird populations and biodiversity in the United States between 2000 and 2020?

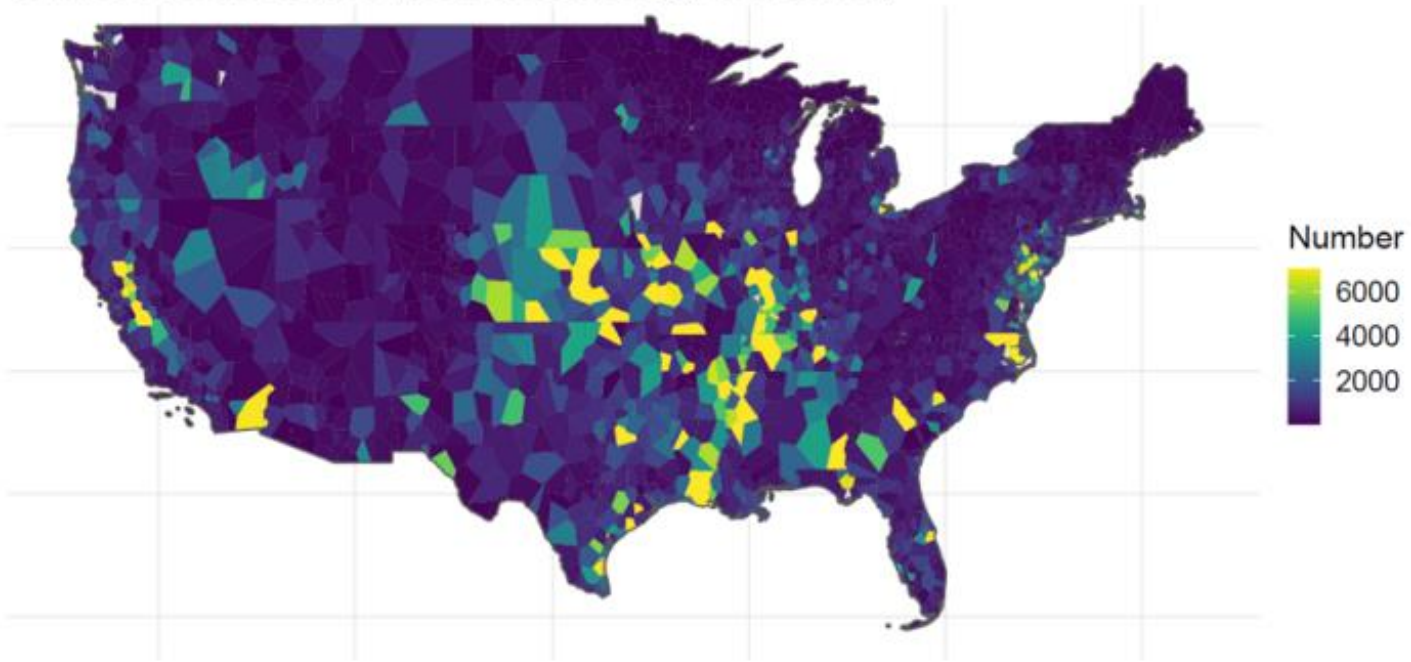
Data: National Audubon Society's Christmas Bird Count

- Annual bird census conducted on one day in December by citizen scientists
- Censuses are conducted in the same location (circle) each year
- Circles are divided into units and counters are coordinated by experienced volunteers
- Counting effort and weather conditions are recorded

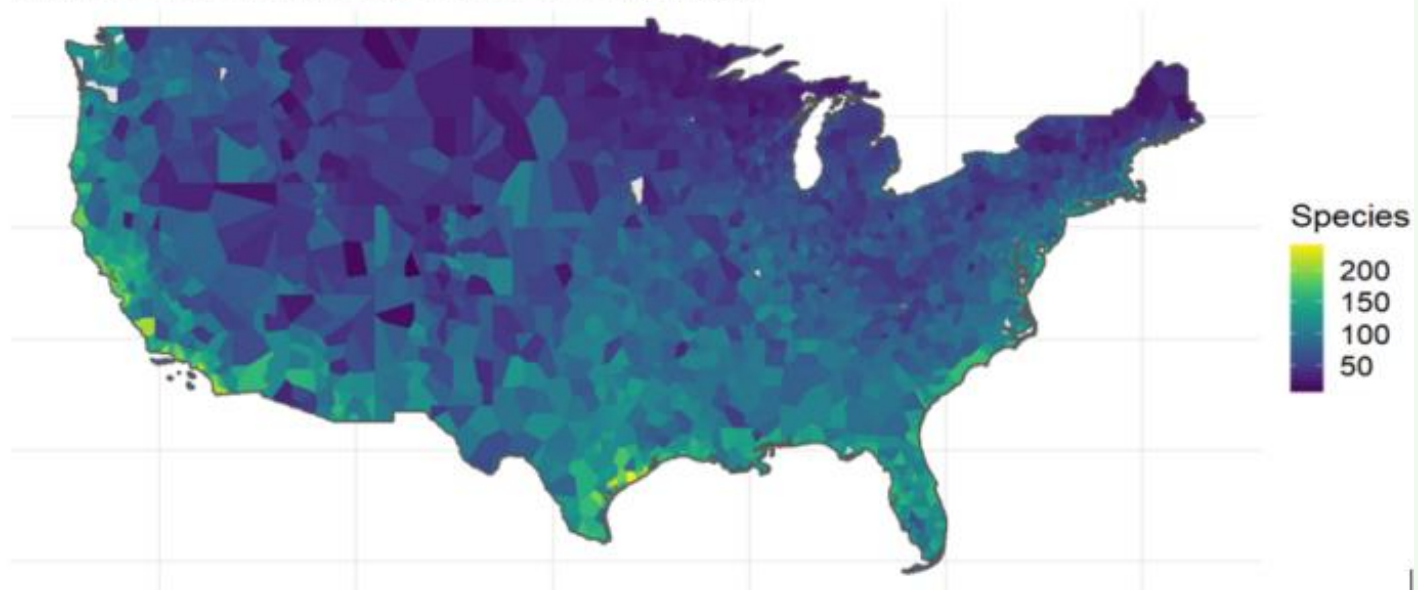


Data reflect bird abundance and biodiversity in the winter

Number of Birds Counted (2000-2020 Average, Winsorized)



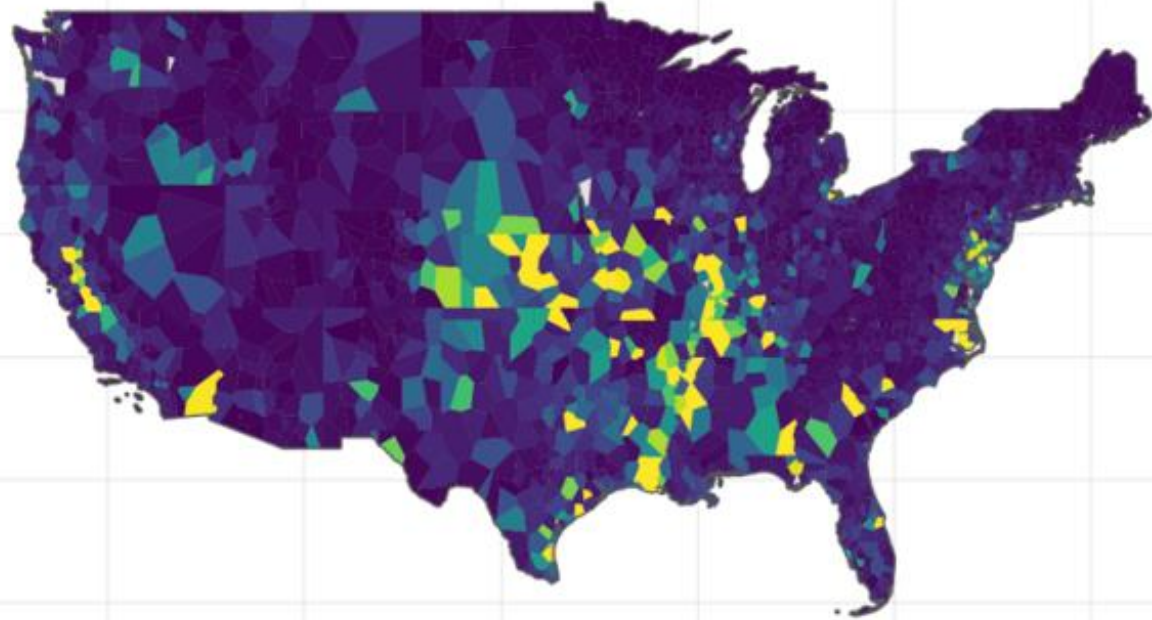
Number of Species Reported (2000-2020 Average)



This dataset misses summer bird biodiversity, which means real effects across the year are likely to be larger

Data reflect bird abundance and biodiversity in the winter

Number of Birds Counted (2000-2020 Average, Winsorized)

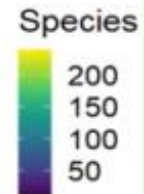
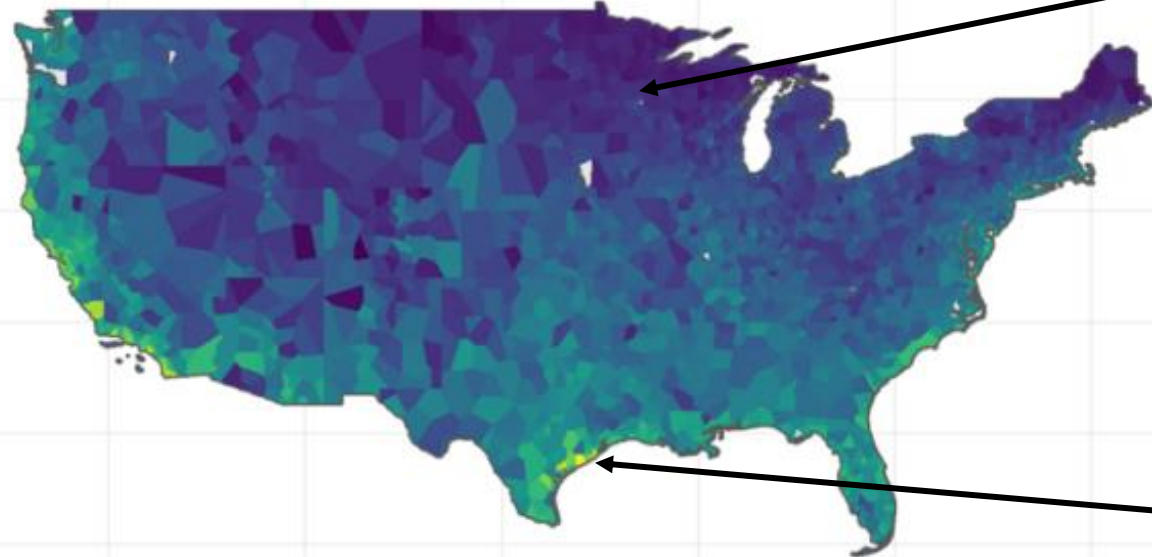


Snowy Owl



Great Gray Owl

Number of Species Reported (2000-2020 Average)



I'm from here.
Pretty quiet for winter birds 😞

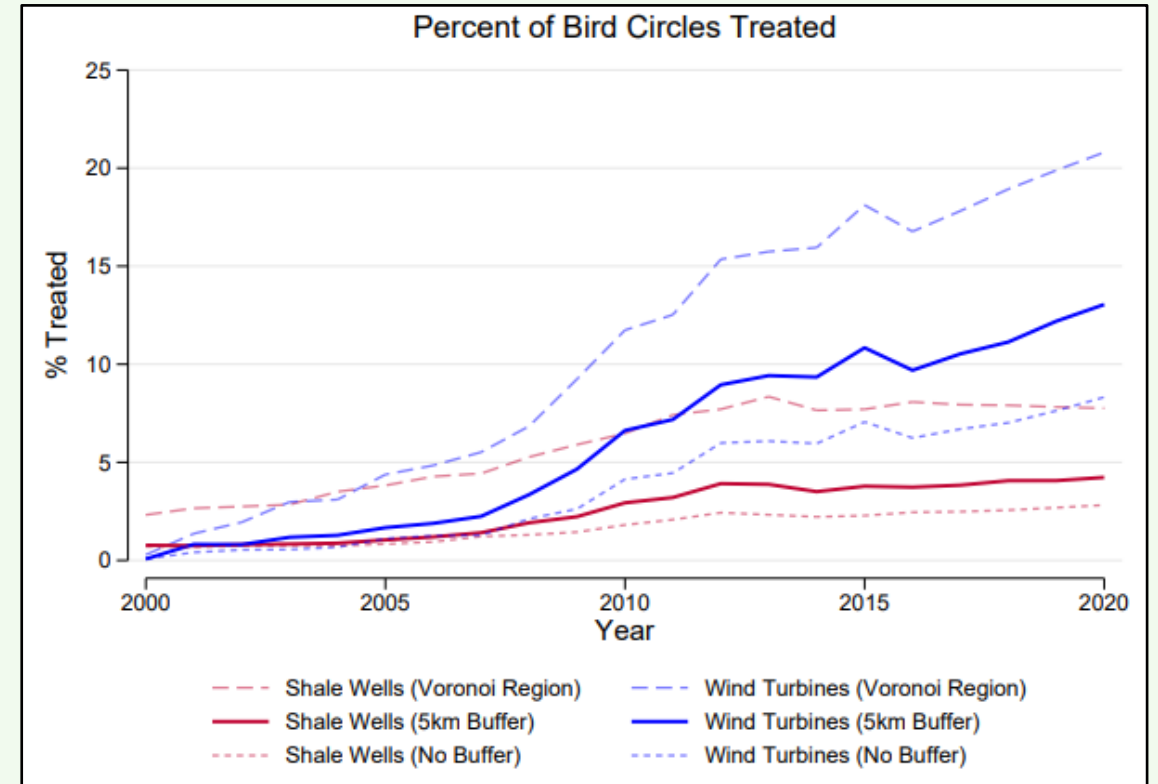
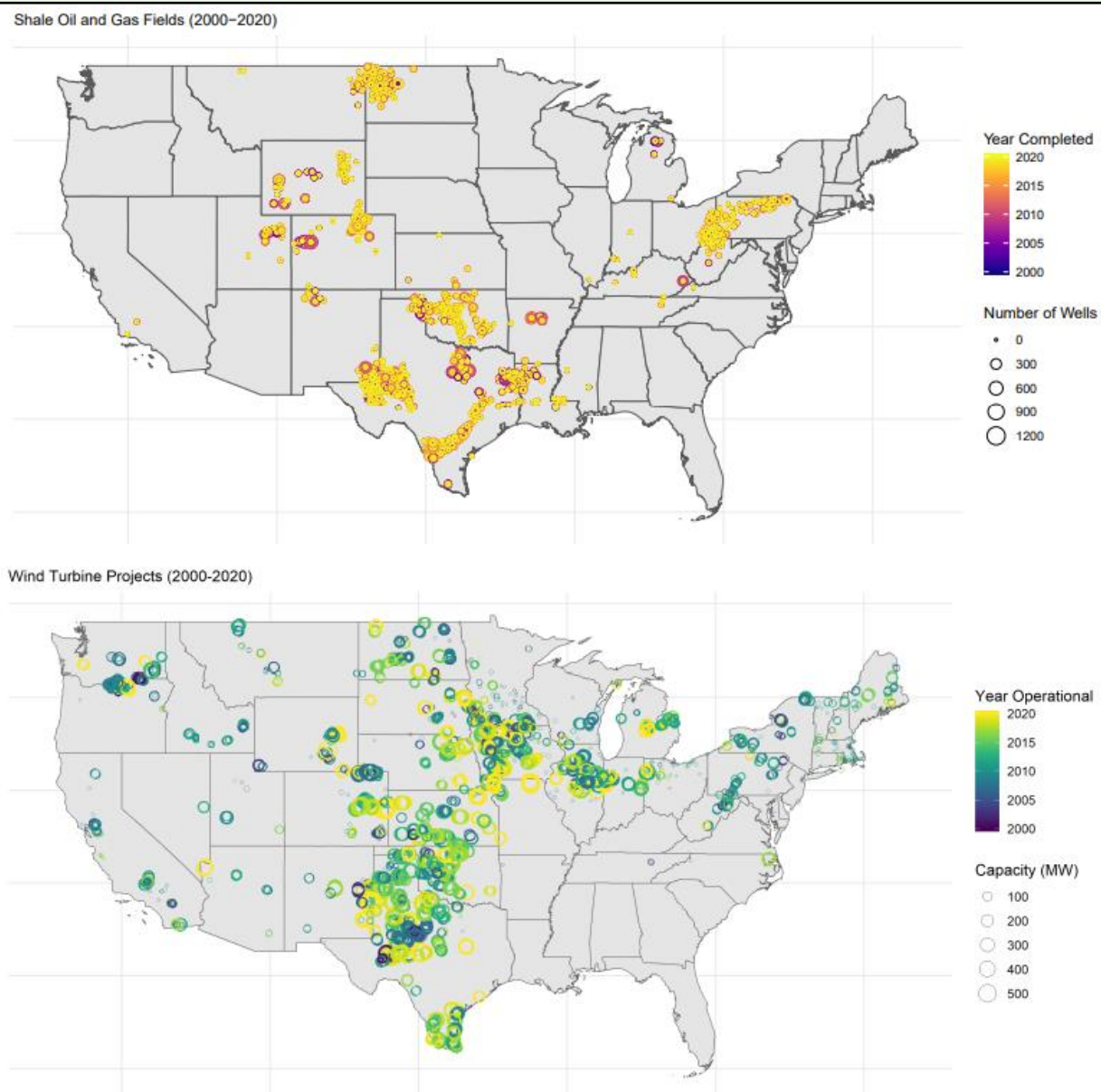


Boreal Owl

This dataset misses summer bird biodiversity, which means real effects across the year are likely to be larger

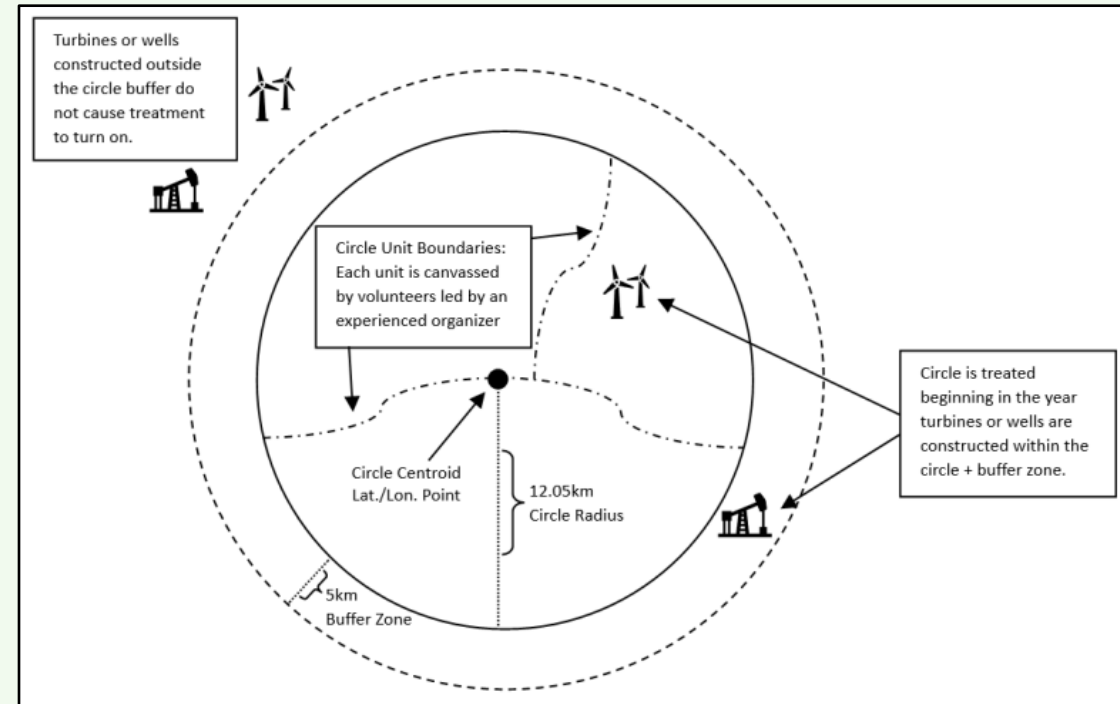
Nice winter birding location?

Data: Shale oil and gas fields (Rystad Energy, 2022) and wind farms (US Wind Turbine Database, 2022)



Methodology

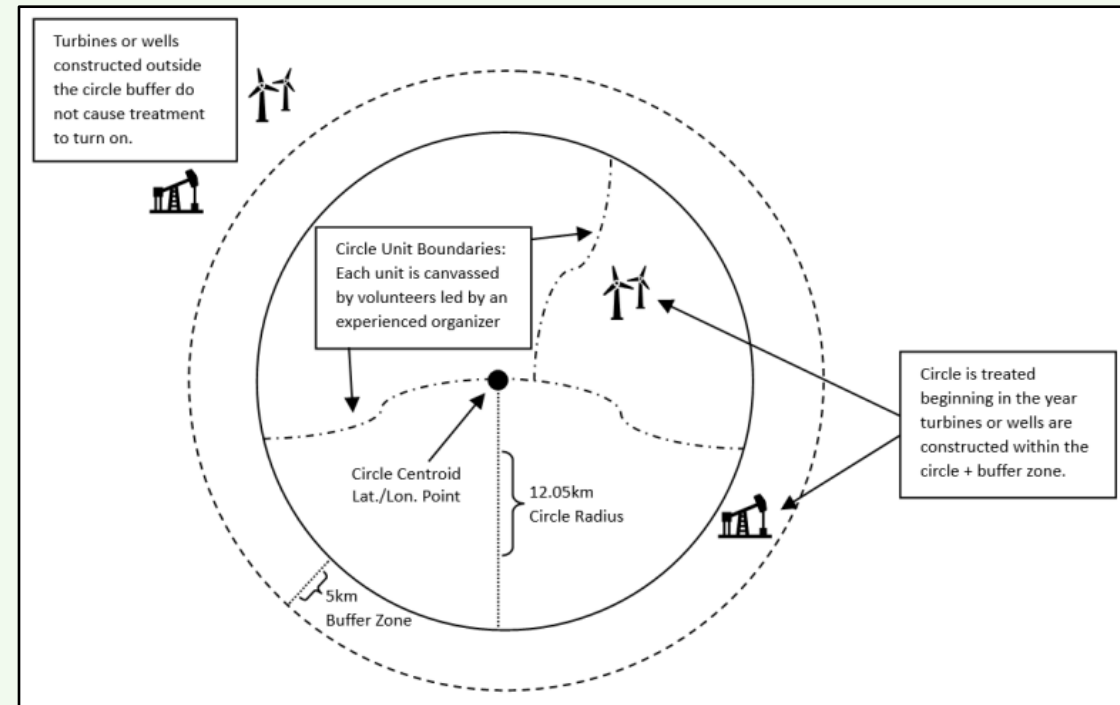
- Using a method called “**difference-in-differences**,” I compare bird population and species counts in “**treated**” circles where turbines or wells were built, relative to “**control**” circles where turbines or wells were not built



Methodology

- Using a method called “**difference-in-differences**,” I compare bird population and species counts in “**treated**” circles where turbines or wells were built, relative to “**control**” circles where turbines or wells were not built

I measure changes over time within a circle, before and after treatment. This controls for everything that is fixed at the circle level over time (e.g., biome). I also control for yearly changes that affect all circles (e.g., nationwide climate variations)

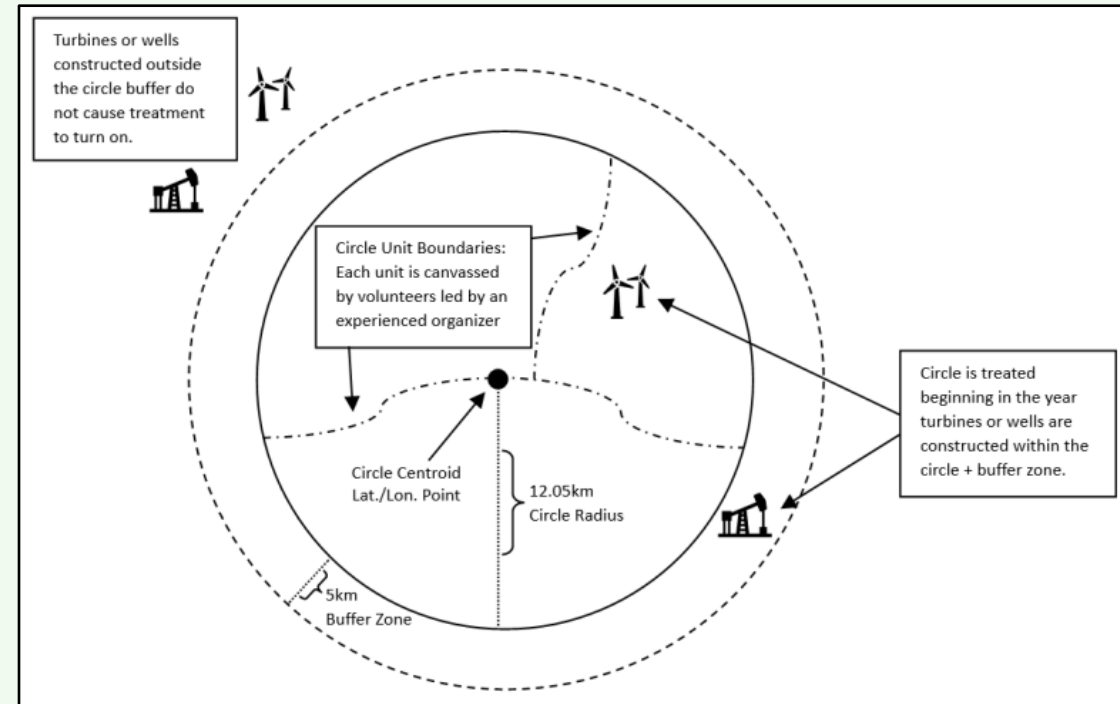


Methodology

- Using a method called “**difference-in-differences**,” I compare bird population and species counts in “**treated**” circles where turbines or wells were built, relative to “**control**” circles where turbines or wells were not built

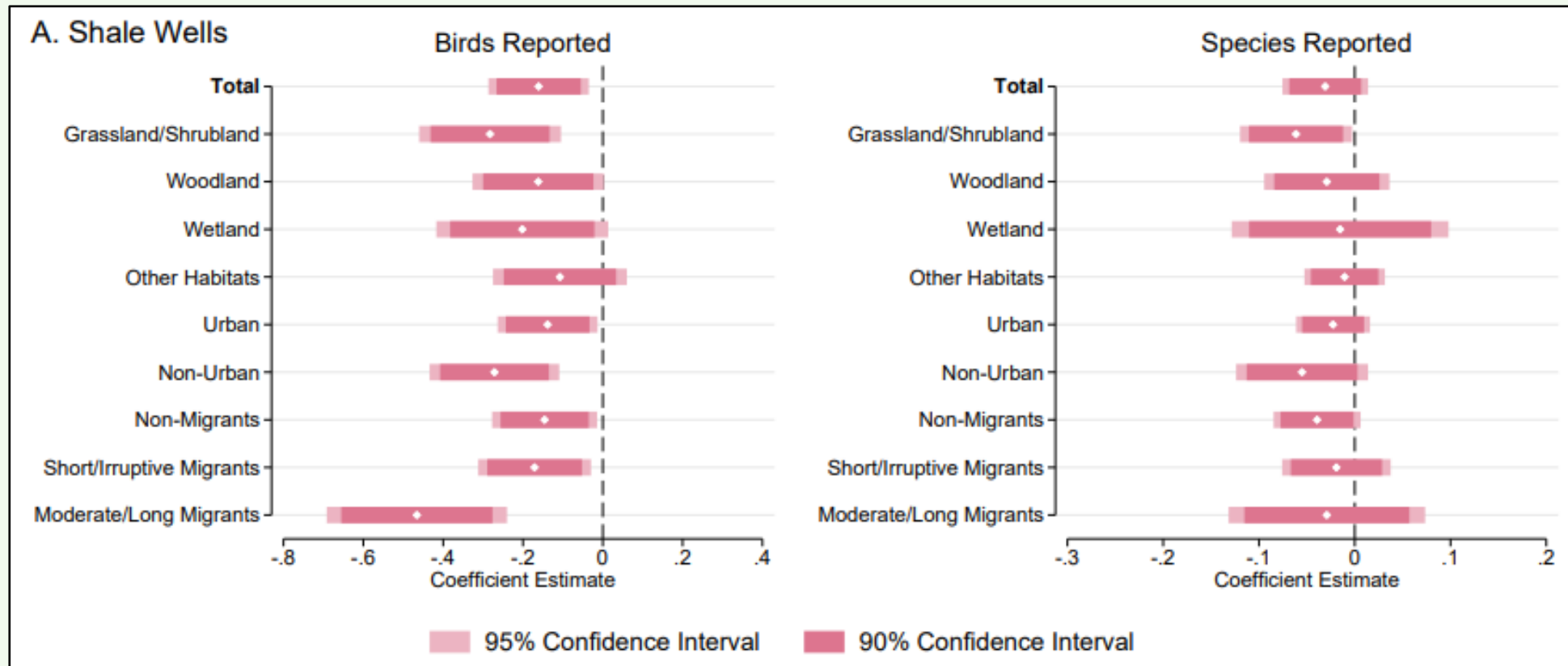
I measure changes over time within a circle, before and after treatment. This controls for everything that is fixed at the circle level over time (e.g., biome). I also control for yearly changes that affect all circles (e.g., nationwide climate variations)

Control variables: I also control for temperature, snowfall, and windspeed on the day of the count, number of counters who participated, and land-use changes within each circle



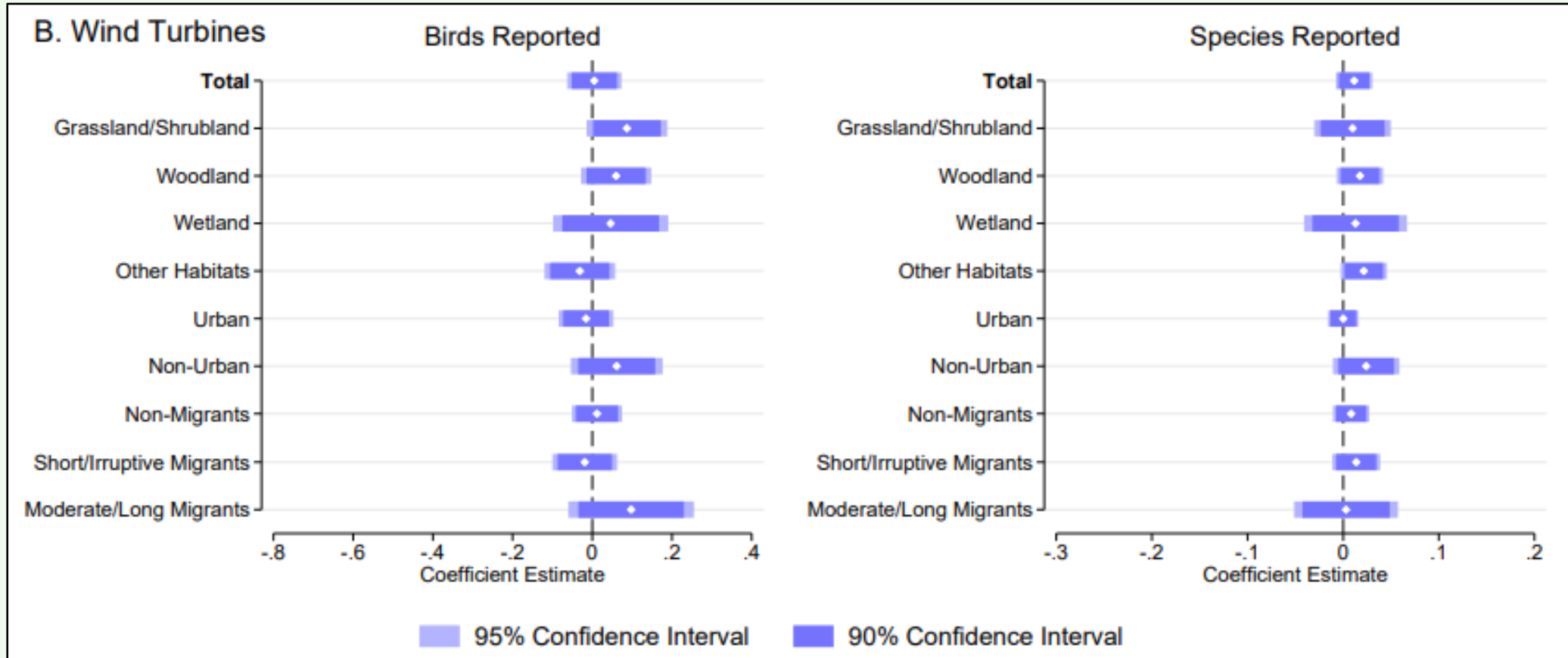
Results: effects of fracking wells

- Overall bird population counts decline by 15% in years following the construction of shale oil and gas wells near a bird circle
- Effects are largest for grassland/shrubland birds (-24%), non-urban birds (-23%), and migratory birds (-37%)



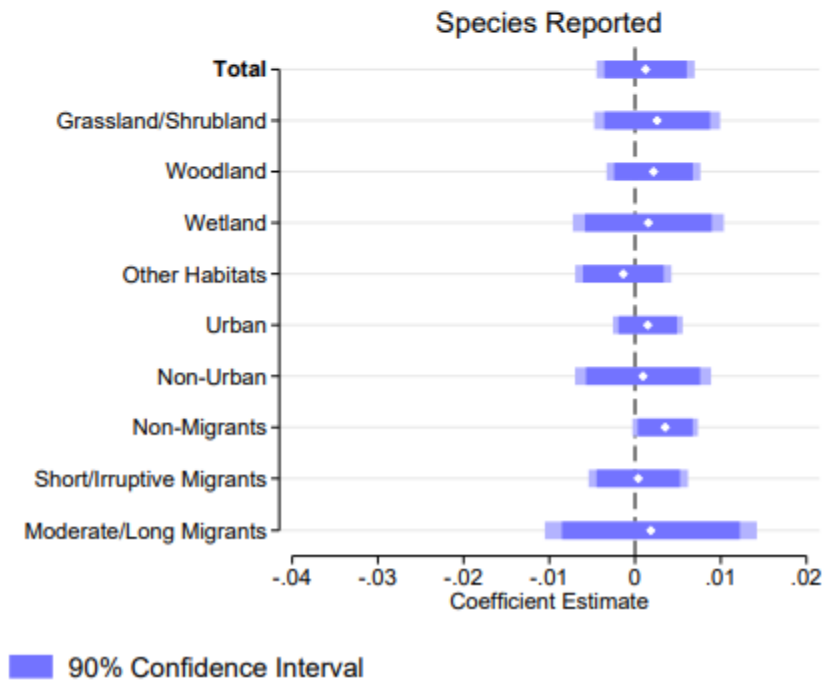
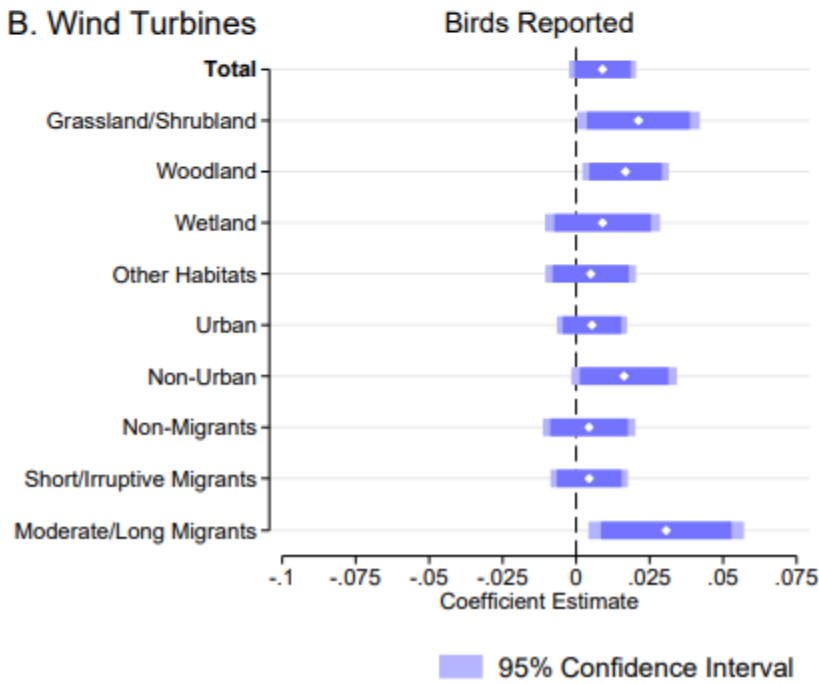
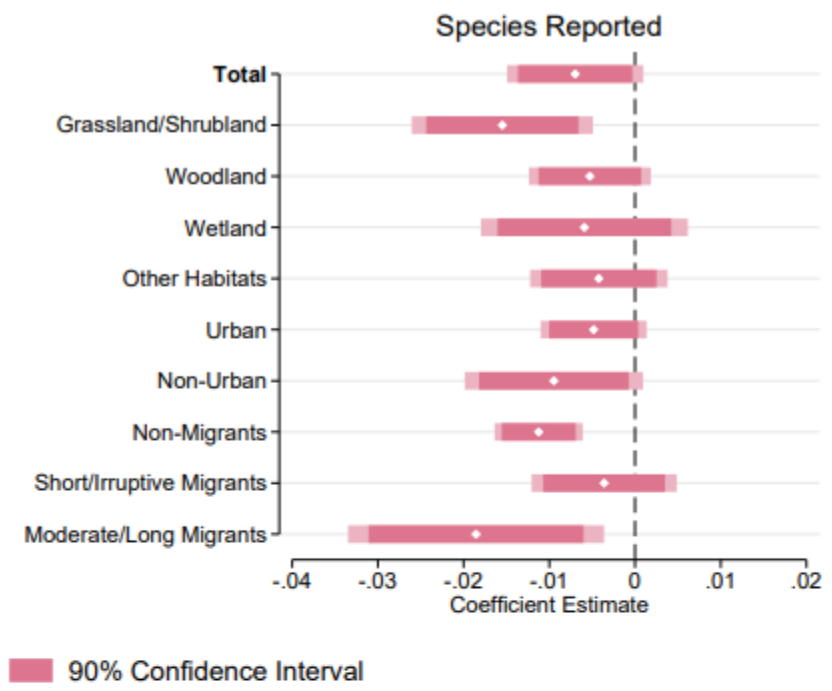
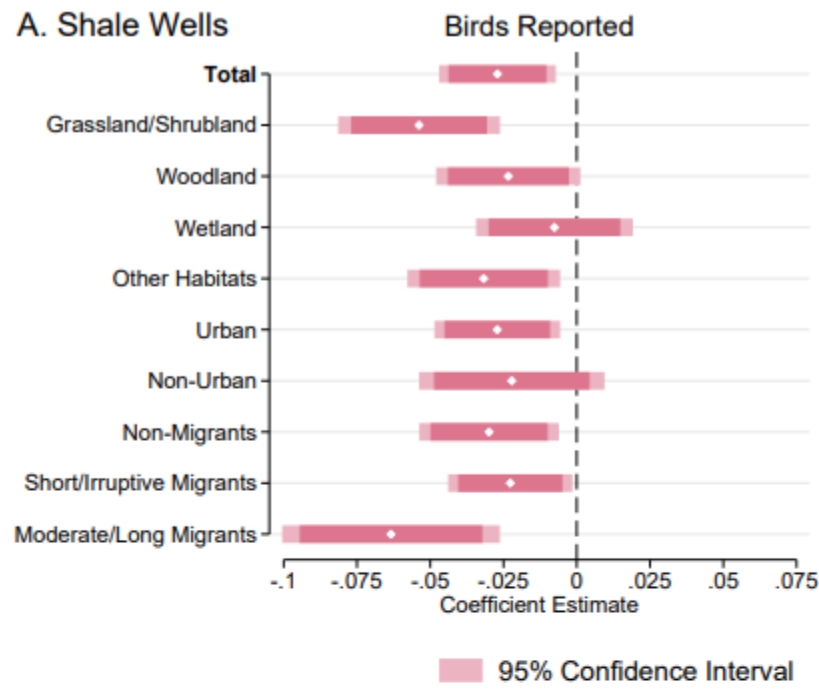
Results: effects of wind turbines

There are no statistically significant impacts of wind turbine construction on subsequent bird population or species counts, across all bird characteristics



The previous results showed effects of whether any turbines or fracking are present

*How do effects vary by the **number** of wells or turbines built?*

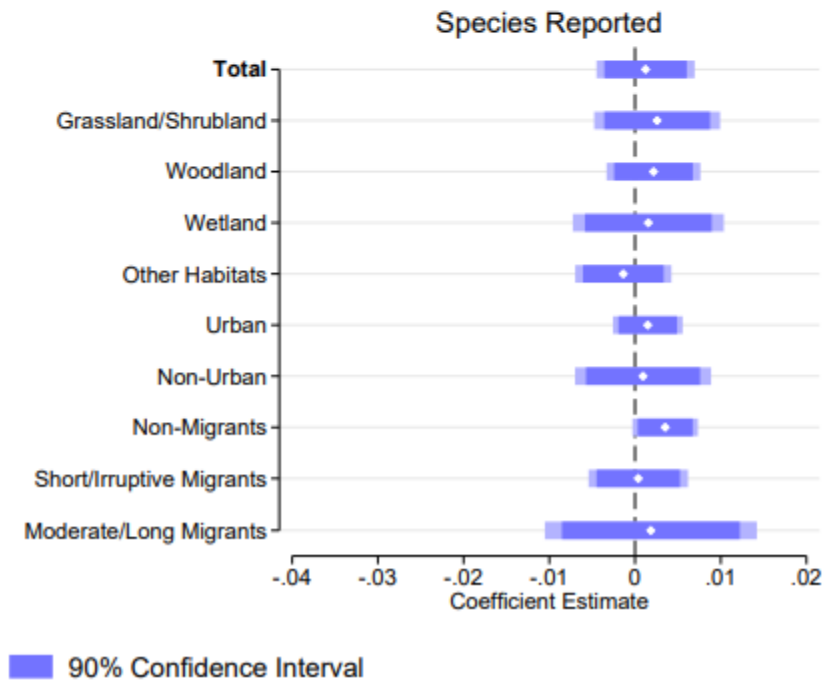
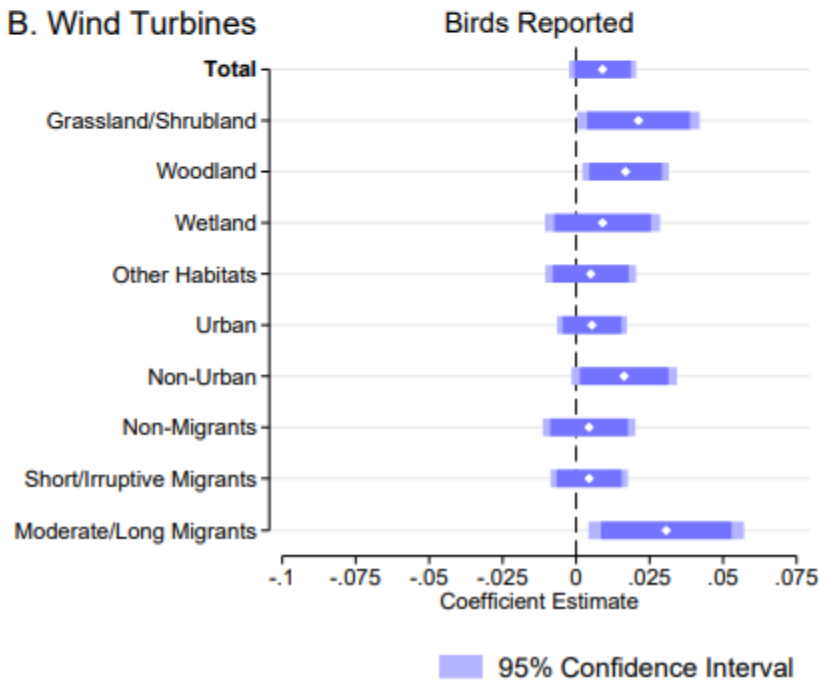
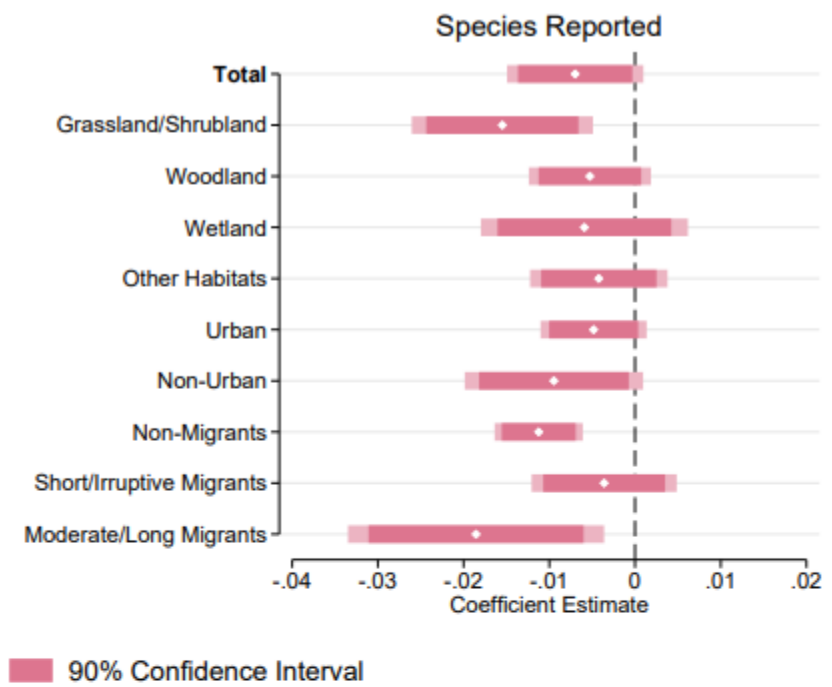
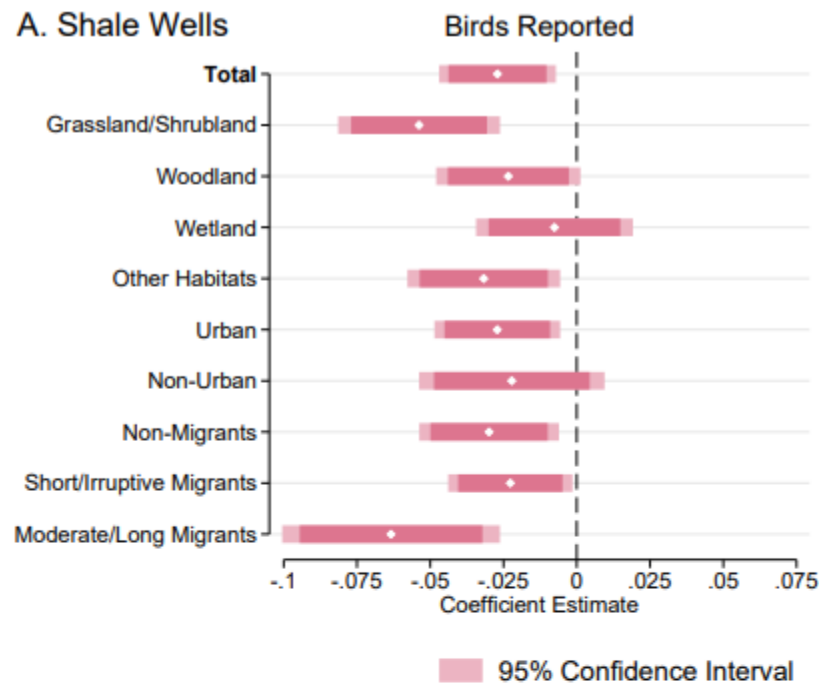


The previous results showed effects of whether any turbines or fracking are present

*How do effects vary by the **number** of wells or turbines built?*

Results look similar, but even more negative for shale – including negative effects on species diversity

A 10% increase in fracking wells reduces subsequent bird counts by 0.26%, or 3.6 birds per well drilled

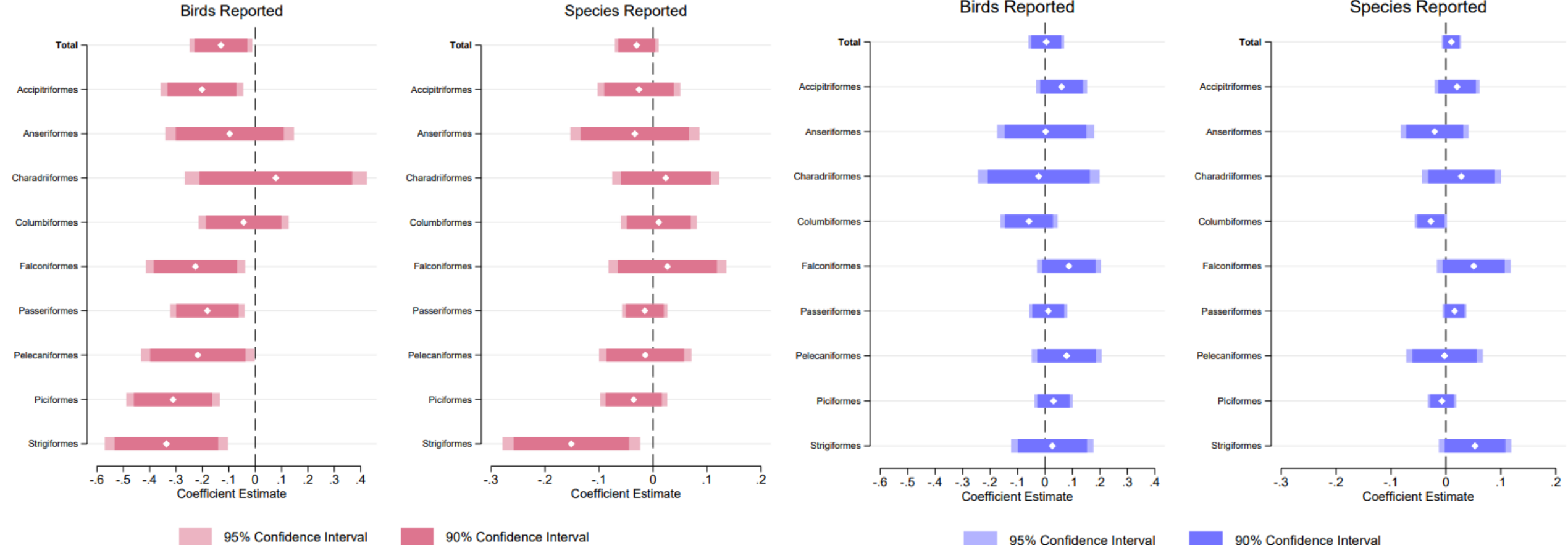


What if we break things down by taxonomic orders?

- Negative effects of shale are largest for *Strigiformes* (owls), *Piciformes* (woodpeckers), *Falconiformes* (falcons), *Pelecaniformes* (e.g., bitterns, herons, pelicans), *Accipitriformes* (e.g., hawks, eagles, vultures), and *Passeriformes* (i.e., perching birds)
- No effect of wind turbines even for *Accipitriformes*

Shale Wells

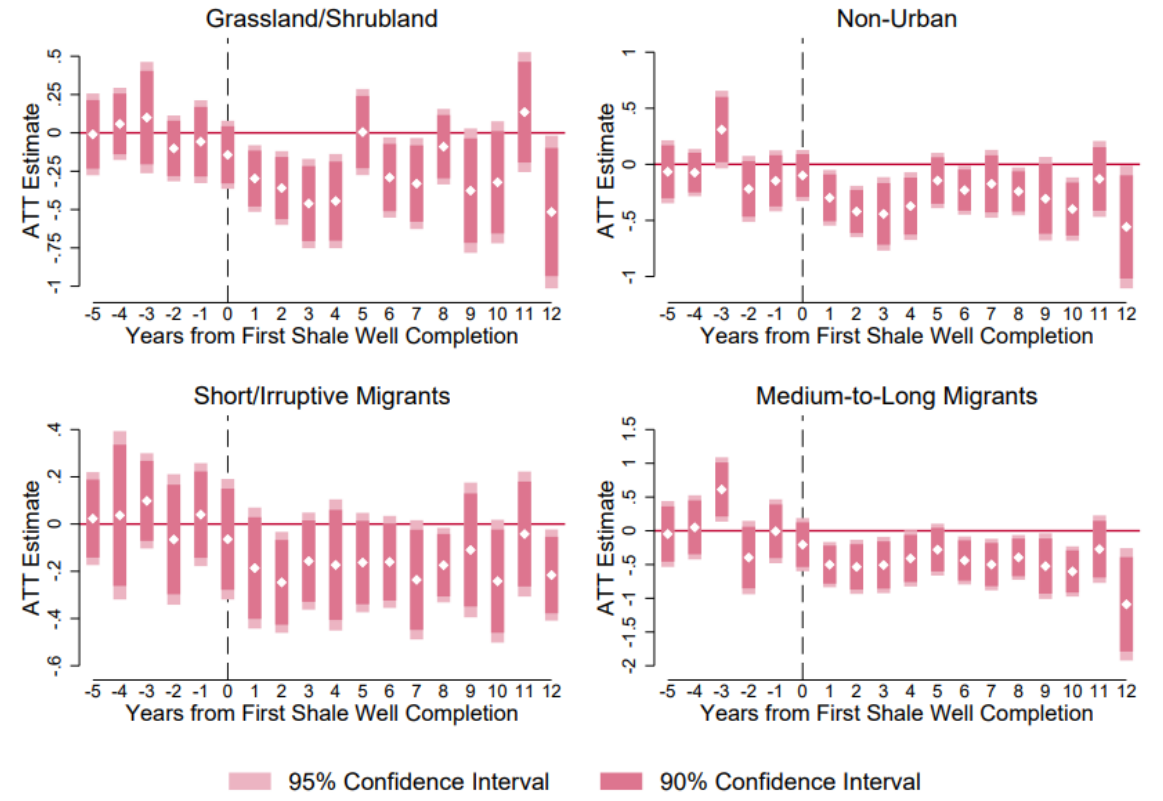
Wind Turbines



How do effects evolve over time?

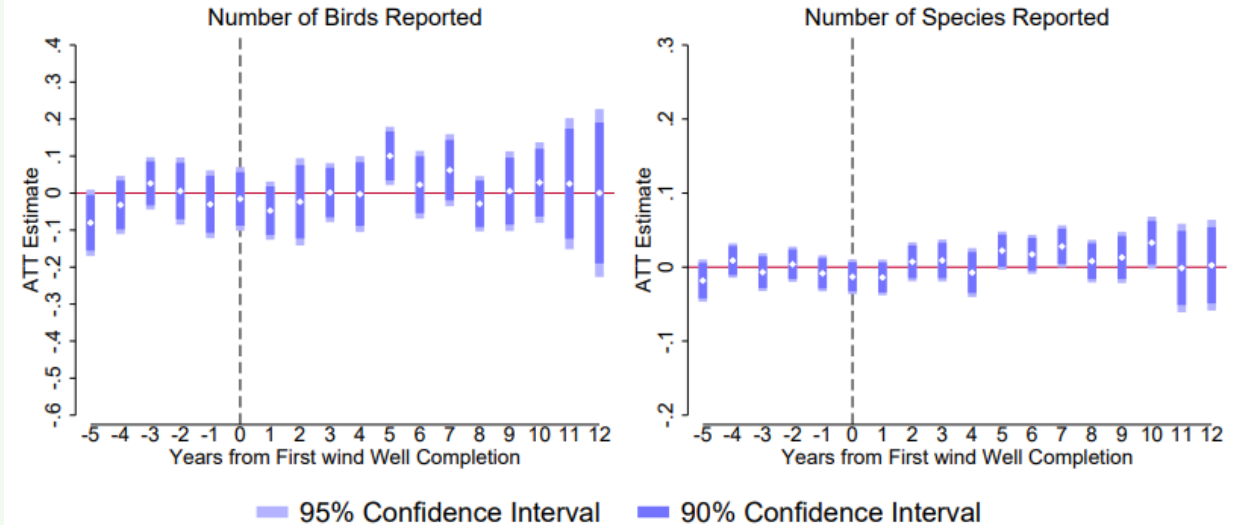
Negative effects of shale appear immediately after well construction and persist for many years

Shale Wells



No negative effects of wind turbines during or after the construction phase.

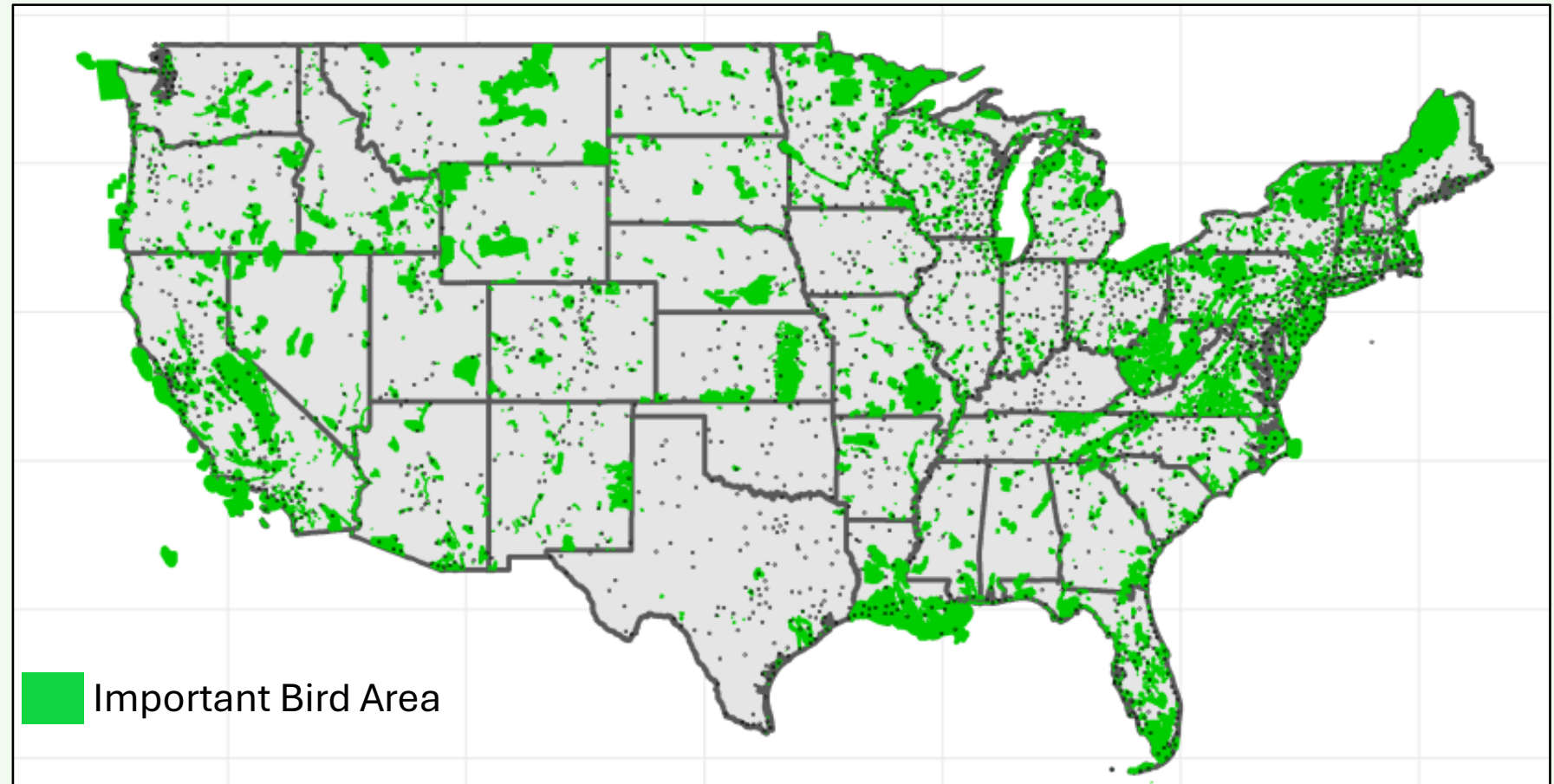
Wind Turbines



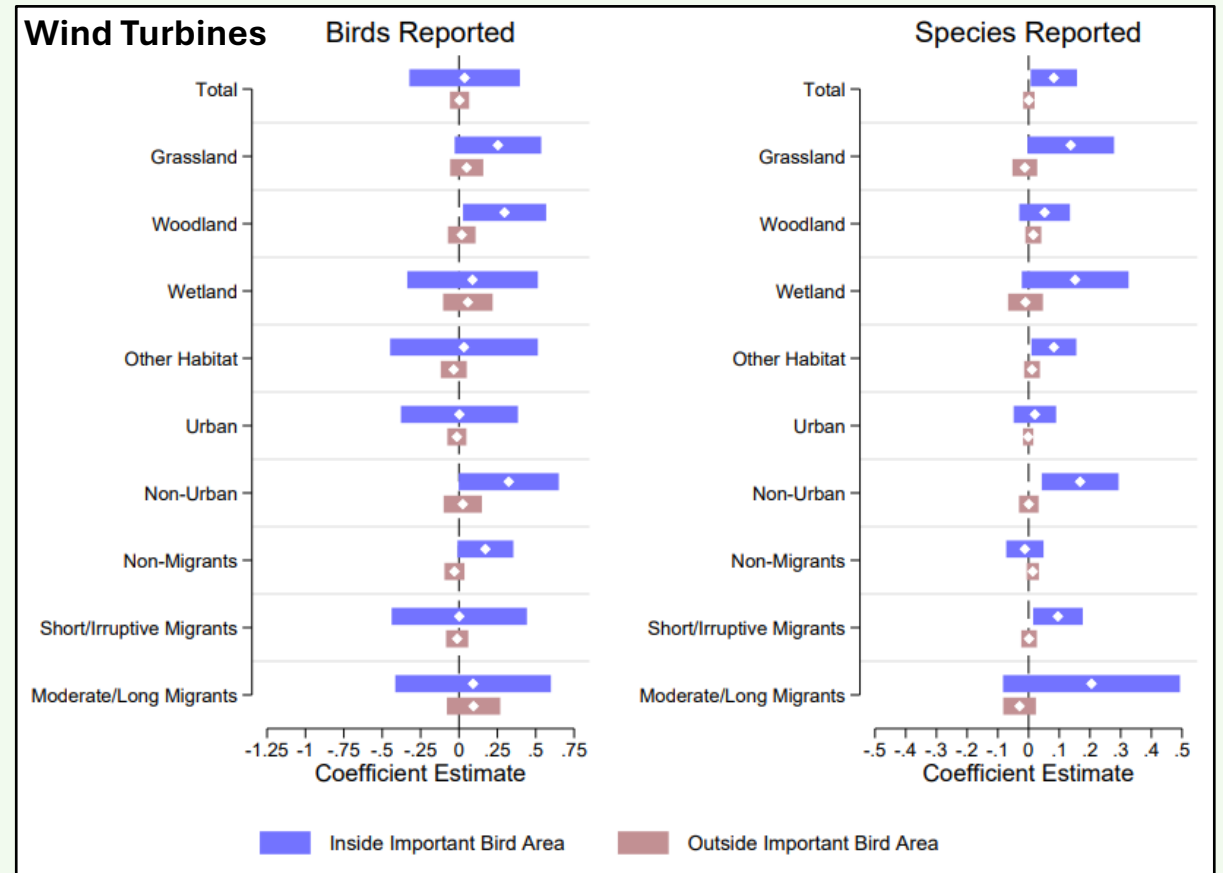
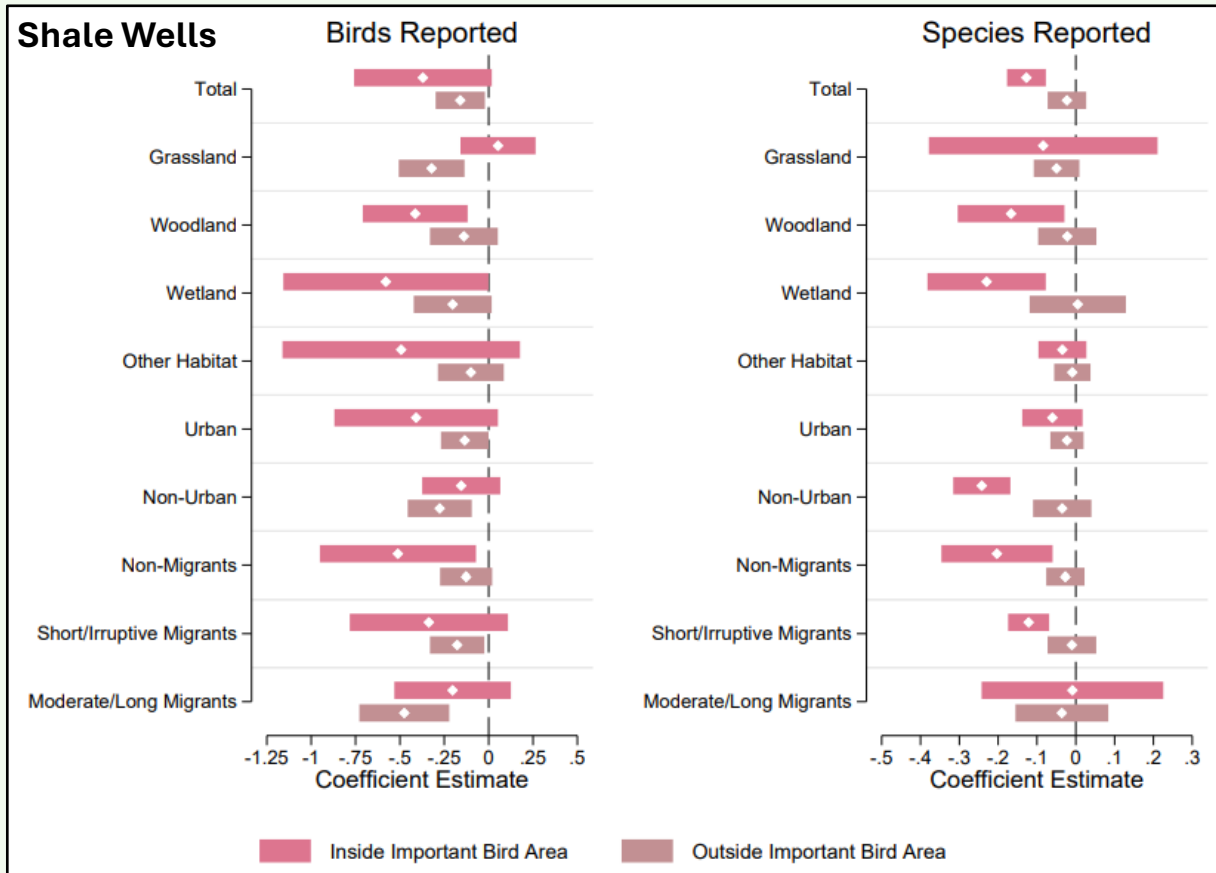
Are effects different in places with sensitive bird habitats?

I use a map from the National Audubon Society to determine whether each bird circle falls inside an “important bird area”

- Migratory stopovers
- Breeding grounds
- Biodiversity hotspots



- Negative effects of shale are even larger when wells are drilled inside important habitat areas. Species diversity also falls
- Still no effects (or even slightly positive effects) for wind



Key takeaways

Fracking significantly reduces bird populations, and reduces biodiversity as well when wells are drilled inside important bird habitats

Key takeaways

Fracking significantly reduces bird populations, and reduces biodiversity as well when wells are drilled inside important bird habitats

Wind turbines have no measurable impact on bird populations or biodiversity

- This doesn't mean wind turbines don't result in collision deaths. My study is looking at the population level and can't detect small numbers of collisions.

We should still aim to minimize impacts of energy infrastructure on wildlife!

We should still aim to minimize impacts of energy infrastructure on wildlife!

Wind Turbines

- Account for bird habitats, migratory patterns, and breeding grounds when choosing project locations
- Paying attention to bats: they might be more at risk from turbine disturbances than birds
- Adopt new technologies to minimize collisions and disturbances
 - Acoustic emitters
 - Cameras to detect incoming flocks and shut down turbines
 - Painting or marking turbine blades to increase visibility

Avoiding wildlife collisions with wind turbines

- 1 Curtailment**, which means shutting off turbines at lower wind speeds, is a very effective method to prevent bat collisions
- 2 Ultrasonic deterrents** emit disorienting noises to ward off bats, which can be a useful strategy for some species
- 3 Painting the blades black** can help make them more visible to birds that would otherwise not see them due to motion blur
- 4 Video surveillance** can be used to detect incoming bird life, and either turn the blades off or emit acoustic deterrents
- 5 Tweaking the space between the ground and the blades** can create more space for birds to fly through underneath



SOURCE: REPORTING BY K. ZIMMER

KNOWABLE MAGAZINE

We should still aim to minimize impacts of energy infrastructure on wildlife!

Wind Turbines

- Account for bird habitats, migratory patterns, and breeding grounds when choosing project locations
- Paying attention to bats: they might be more at risk from turbine disturbances than birds
- Adopt new technologies to minimize collisions and disturbances
 - Acoustic emitters
 - Cameras to detect incoming flocks and shut down turbines
 - Painting or marking turbine blades to increase visibility

Fracking

- Avoid drilling inside important bird habitats
- Concentrate wells to avoid habitat fragmentation
- Limit night-time lights
- Restrict gas flaring and surface water pollution
- Ultimately, transition away from fossil fuels by accelerating adoption of renewables

Avoiding wildlife collisions with wind turbines

- 1 **Curtailement**, which means shutting off turbines at lower wind speeds, is a very effective method to prevent bat collisions
- 2 **Ultrasonic deterrents** emit disorienting noises to ward off bats, which can be a useful strategy for some species
- 3 **Painting the blades black** can help make them more visible to birds that would otherwise not see them due to motion blur
- 4 **Video surveillance** can be used to detect incoming bird life, and either turn the blades off or emit acoustic deterrents
- 5 **Tweaking the space between the ground and the blades** can create more space for birds to fly through underneath



SOURCE: REPORTING BY K. ZIMMER

KNOWABLE MAGAZINE