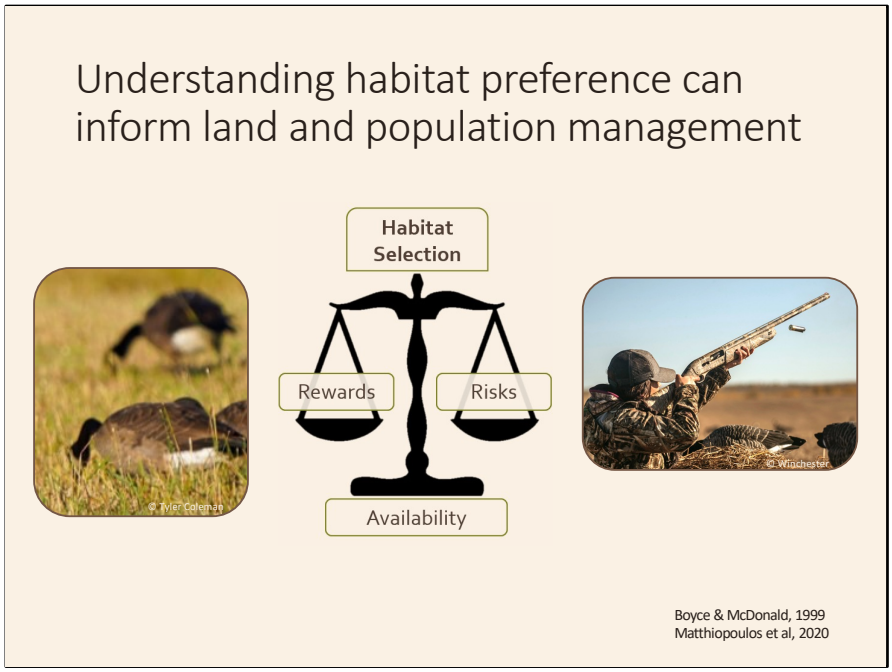
Hello everyone, my name is Karen Beatty and I'm a current masters student at Penn State advised by Dr. Franny Buderman
Today I'm going to speak about some research that was conducted in partnership with the Pennsylvania Game Commission, specifically Nate Huck and colleagues, specifically studying how hunting pressure can influence Canada goose landscape use and habitat selection

When managing game species, we aim to both *sustain* the population and provide ample *hunting* opportunities,
and to meet both these objectives, we need to understand what resources a species seeks….



If we understand which habitat characteristics a species prefers, we can adjust our land management to meet their needs, which in theory would help satisfy both the animals and hunters

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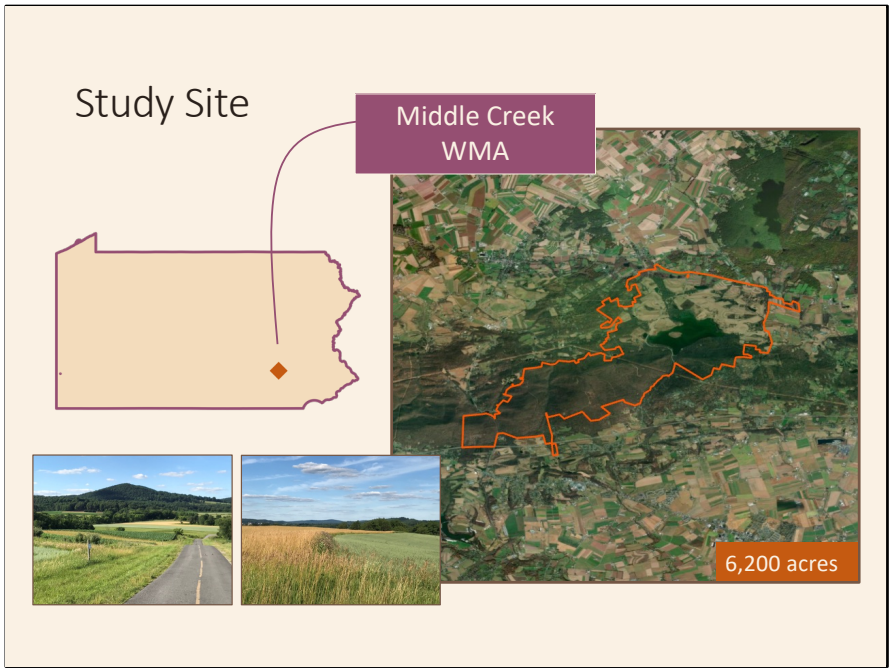
The process of habitat selection was defined by Boyce and McDonald as the process of choosing where to go by balancing access to resources against predation risk Recently, Matthiopoulos and colleagues refined this definition by emphasizing that habitat selection is limited by what environmental features are *available* to an individual at any given time.

On one had we have rewards, which are environmental features that are appealing to an individual because they support survival and reproduction.

On the other hand there are risks, which deter an animal from using a certain area.



In PA, the PGC manages WMAs for hunting, and one site called Middle Creek WMA is managed specifically for waterfowl hunting

It's located about 25 miles east of here &

Provides high-quality hunts through a highly controlled season

Maintains detailed hunting records

Hunting occurs exclusively from stationary blinds, shown with yellow pins on the aerial image

As you might notice, they're mostly placed in fields and field edges, and sometimes adjacent to a pond

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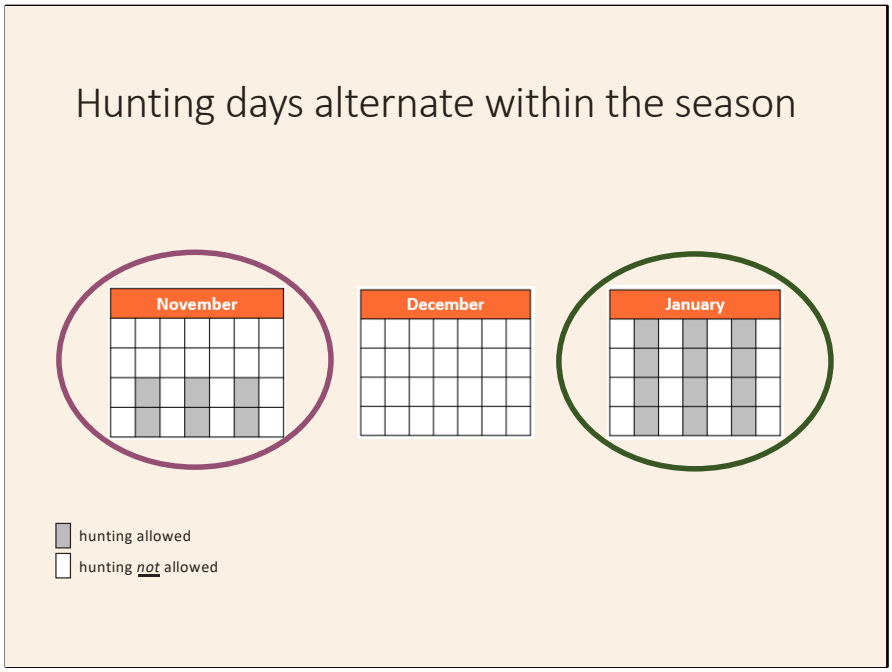
The blinds at Middle Creek WMA are pit blinds, which you can see in the photo



Hunting Canada geese is only allowed at Middle Creek WMA between about mid-Nov to late Jan.
And only on certain days – grey vs white. This totals only about 15 days of hunting per season, which is part of the reason it's appealing to hunters.
This temporal layout offers a natural experiment wherein the non-hunting days provide a control or reference and the hunting days act as a treatment.

If we're curious how geese perceive hunting, this provides an opportunity to look for daily patterns in goose behavior
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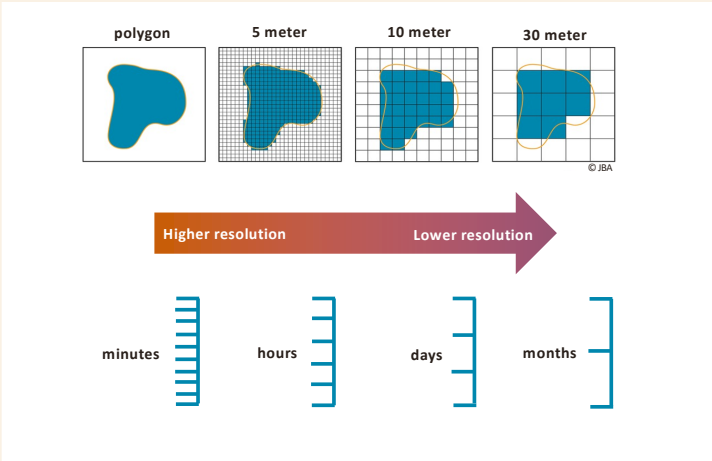
or group the hunting season into two 'periods' and compare them on a coarser time scale
I'll be referring to the day-by-day hunting as 'hunt days' and the grouped days as 'hunt periods'

So, this study design takes advantage of the existing hunting structure, both spatially and temporally…

…and uses the opportunity to better understand how geese are responding to the current level of hunting on the landscape.

And I'm going to focus on the question of how hunting affects Canada goose habitat selection.

Resolution and extent should be appropriate to answer the research question



When dealing with spatial data, it's important to consider resolution and extent.

Resolution is the area of land represented by a single grid cell
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or the time spanned during each timestep

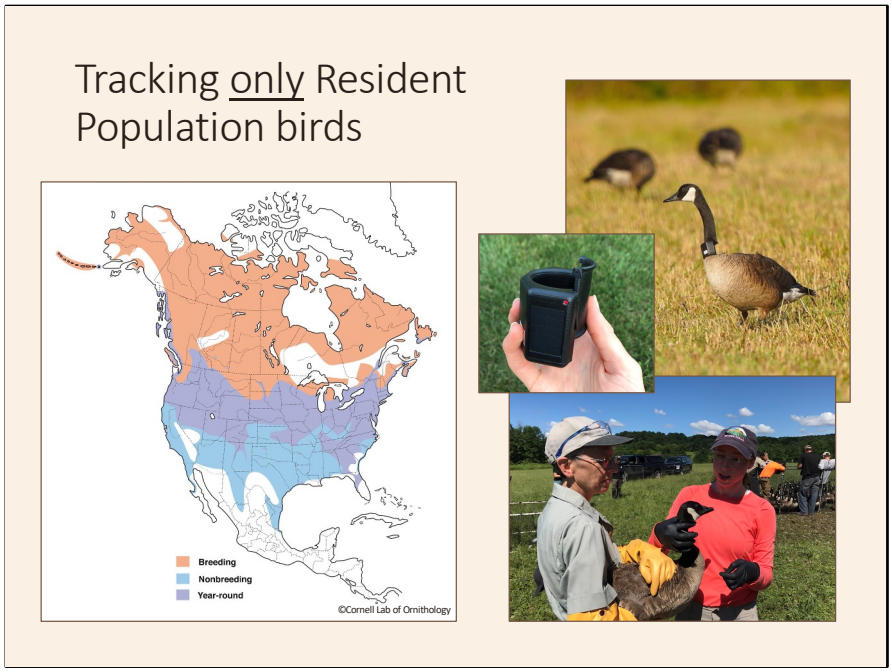
Extent is the spatial *or* temporal distance covered by the data
The resolution of the data should match the environmental variables, like land cover or weather measurements, which should be appropriate to answer the research question

For example, if you want to understand human food-buying preferences, you could use a town-level extent and see which grocery stores people prefer, or you could use a store-level extent with finer resolution to see which aisles they prefer. And you could choose a daily temporal extent or a weekly extent.

Similarly, because we know animals don't interact with their environment on a single scale, we can draw different habitat selection conclusions depending on our chosen scale of analysis.

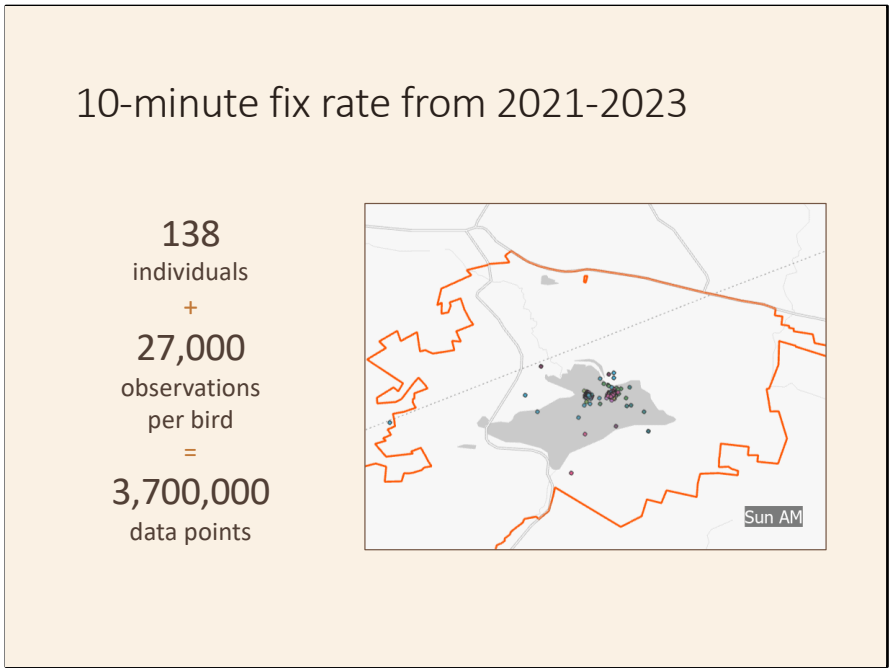
So, it’s important to be mindful about the scale we choose.

This study collected high-resolution data and we were able to coarsen it to compare our results at two analytical scales.



For those of you unfamiliar with Canada geese, their range is shown in this image.
The purple area is where they're found year-round
In eastern PA, where our study site is located, we have a resident population as well as migrants during winter

For this study we observed only resident population geese
We used Ornitela OrniTrack-N44 GPS-GSM receivers, which you can see in the photo
The birds were captured during the summer molt and only AHY females were collared



Like I said earlier, we collected high-resolution data - We marked bird locations every 10 minutes

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The animation shows bird movement spanning 1-week during a hunting period. The grey area is a lake. When you see them venture farther from the lake it's typically afternoon.

In total, over the two-year study period from 2021 to 2023, we tracked 138 individuals, recorded about 27,000 observations each, and accumulated about 3.7 million data points.

In this analysis, we used about 80,000 – 200,000 data points across 30-60 birds, depending on the scale of analysis

Resource Selection Function → logistic regression model

- Included random effect of individual to account for repeated sampling
- Availability is user-defined

  Habitat selection inference depends on definition of availability

Coarse Analysis Fine Analysis

The standard way to model habitat selection is using a method first proposed by Manly and colleagues, which is a resource selection function
It is essentially a logistic regression model, and we included a random effect of individual to account for repeat sampling, using a method introduced by Muff and colleagues

The model compares the environmental features at the observed goose locations, which we know from the GPS data, to the environmental features at all the locations within the study area where the geese could have chosen to be
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I mentioned that we fit the models at two spatiotemporal scales.
  At the coarser scale, we used a larger spatial extent, buffered the WMA by 7 miles
  At the finer scale our extent was the WMA boundary
You can see from the images that this comparison between where the bird is observed (green x) and what areas are available to it (black dots) are very different between the two extents we chose

What are they responding to in their environment?

	Coarse	Fine
Area	WMA + 7 miles	WMA
Duration	Aug 25 – Jan 29 (5 mon)	Nov 15 – Jan 29 (2.5 mon)
Observation Frequency	60 min	10 min
WMA Presence	On/Off	--
Habitat	NLCD	Ground-truthed
Hunting		
Season	Period	Day
Number of Hunters	per Day	per Blind
Proximity	Distance from blind	Distance from blind

I'll first summarize the scale differences between our two models:

The spatial extent was either the WMA boundary or the boundary buffered by 7 miles

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The temporal extent was either 2.5 months or 5 months

The temporal resolution for GPS data was either 10min or 60min timesteps

When creating the model, we considered which environmental factors they could be responding to.

Based on our research question, we noted whether a bird was on or off the WMA at the coarse scale

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Habitat type was derived from either NLCD land cover types grouped into 5 categories, or ground-truthed vegetative cover combined with NLCD at the fine scale

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We also wanted to capture certain hunting variables:

was there hunting → coarser=period, finer=day resolution

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magnitude of hunting (number of hunters) → coarser=across entire WMA, finer=blind-level resolution

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and proximity to hunting (distance to nearest hunting blind)

Habitat selection depends on availability

Portion (%) of Habitat Type within Study Area		
Coarse	Habitat Type	**Fine**
29	Forest	69
21	Grass	
	Cool grass	5
	Warm grass	9
<1	Open Water	7
37	Crop	
	Corn	5
	Wheat	3
	Hay	2
13	Developed	<1

Again, the spatial extent helps determine what is available to an individual, so it's helpful to know how the habitat proportions differ between our two scales

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You can see a drastic difference between the amount of forest in the broader area versus within the WMA

You can also see that across the broader area, there is a lot of agriculture (37%), but on the WMA crops comprise only 10% of the area

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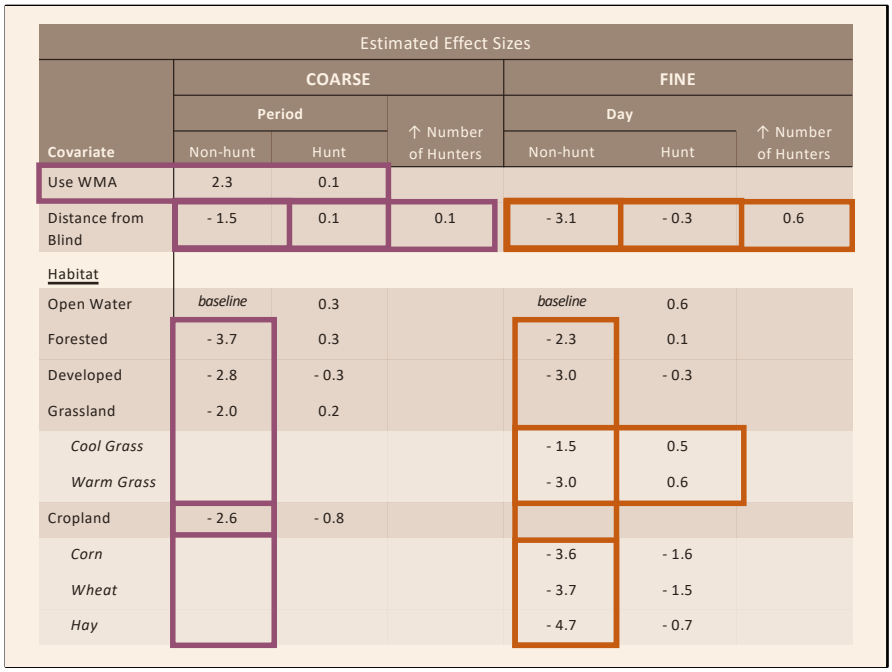
And lastly, there is generally not a lot of open water in the area, and the open water is clearly concentrated on the WMA



Estimated Effect Sizes

Covariate	COARSE			FINE		
	Period		↑ Number of Hunters	Day		↑ Number of Hunters
	Non-hunt	Hunt		Non-hunt	Hunt	
Use WMA	2.3	0.1				
Distance from Blind	- 1.5	0.1	0.1	- 3.1	- 0.3	0.6
Habitat						
Open Water	*baseline*	0.3		*baseline*	0.6	
Forested	- 3.7	0.3		- 2.3	0.1	
Developed	- 2.8	- 0.3		- 3.0	- 0.3	
Grassland	- 2.0	0.2				
Cool Grass				- 1.5	0.5	
Warm Grass				- 3.0	0.6	
Cropland	- 2.6	- 0.8				
Corn				- 3.6	- 1.6	
Wheat				- 3.7	- 1.5	
Hay				- 4.7	- 0.7	

I'll first orient us with the layout of the results table,
The covariates are listed on the left
We have our two scales of analysis: coarse & fine, which used different resolutions of hunting metrics, either hunting periods or hunting days

The values will be the relative selection of environmental characteristics,
so a negative number means the birds tend to avoid that feature
and a positive number means the birds prefer that feature
(selecting for or against relative to reference)

Much less preference for the WMA during hunting, switch from prefer WMA to fairly neutral
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The distance from blind measurement is a good example of matching scale and resolution. Because the blinds are only on the WMA, when we incorporate those values in the coarse 7-mile buffered model, we still see an effect, but the magnitude is less strong that the fine scale model
Here the negative value means that as we move farther from a blind, the bird is less likely to choose there. This makes sense because blinds are placed in appealing

habitat.

When we include the effect of hunting, at the coarse scale preference switches to staying farther from blinds (neg to pos), whereas at the fine scale we don't quite see a preference switch, but the birds are much closer to 'neutral'

For the habitat types, open water is reference habitat category
Because all the other habitat values are negative, it means "less likely to select these habitats compared to open water", which is the same effect across both models
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It's worth noting that there is a clear lack of preference for crops of each variety, with stronger avoidance for crops than for grassland
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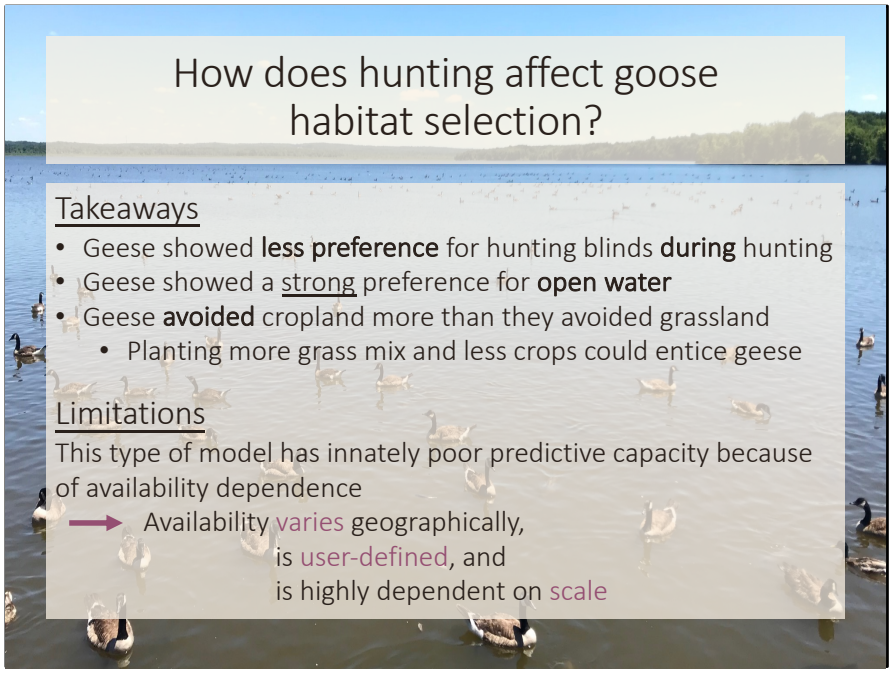
Interestingly, we can see more nuance with the high-resolution land cover data in the fine model, where preference for grasslands increases during hunting



Circling back to our research question of 'how hunting affects goose habitat selection'…

Geese appeared to show less preference for blinds during hunting

There was a strong preference for open water above all else

Preference for grasslands more than croplands, so planting more grass fields and less crops could help entice geese

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A general note for all habitat selection analyses:

These types of models have poor predictive ability because of availability dependence, so extrapolating results between sites and especially across regions is ill-advised

With that I'd like to thank the QWEL at Penn State
And all the PGC staff who helped with this project, both in the field and providing data and insights
And if you'd like to learn more about me and my research, or take a closer look at this presentation, you can scan the QR code