Wintering Ecology, Migration Tracking, and Pairing Behavior of American Kestrels (*Falco sparverius*) in North Central Texas

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Dissertation Proposal Defense

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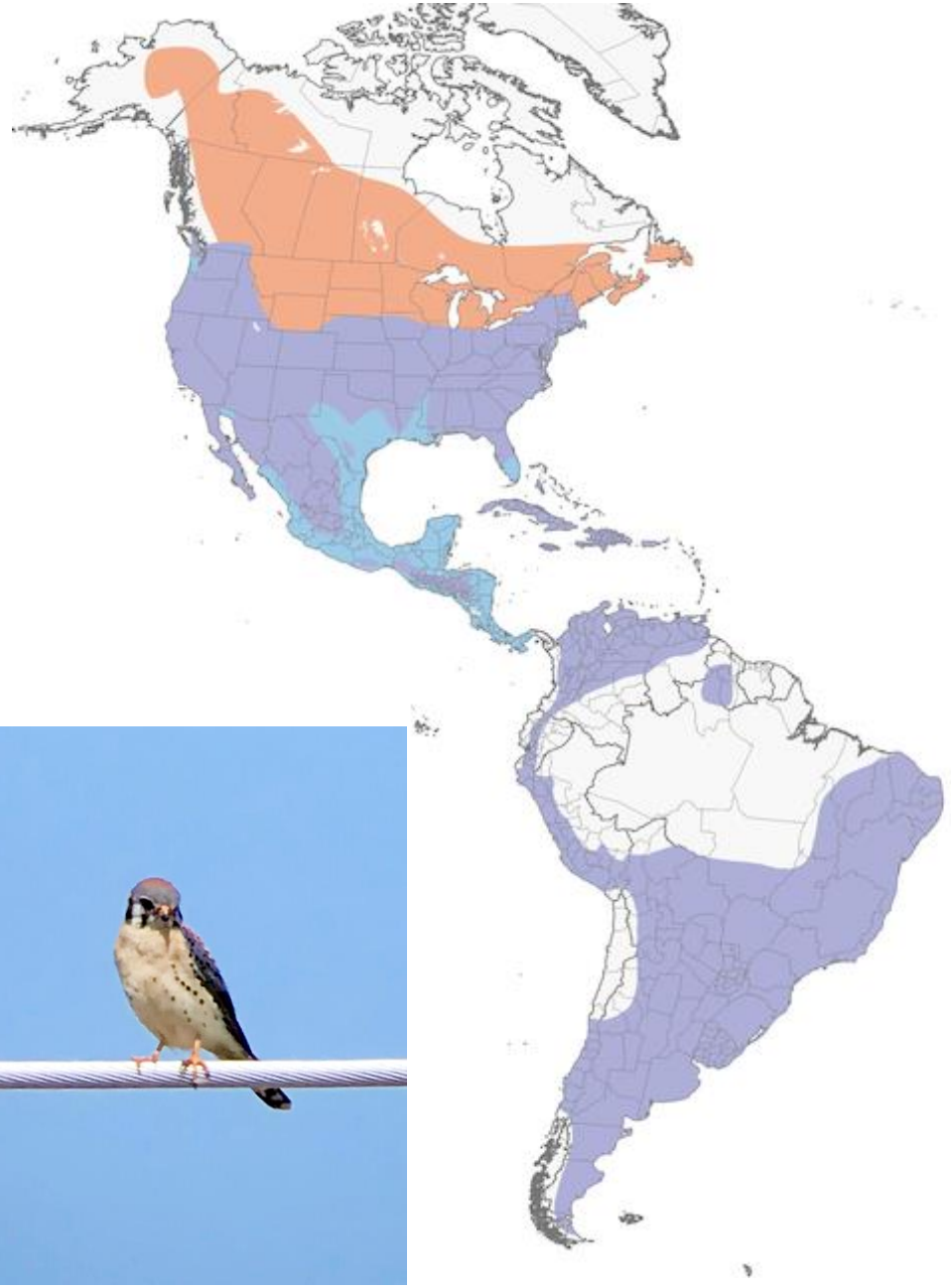
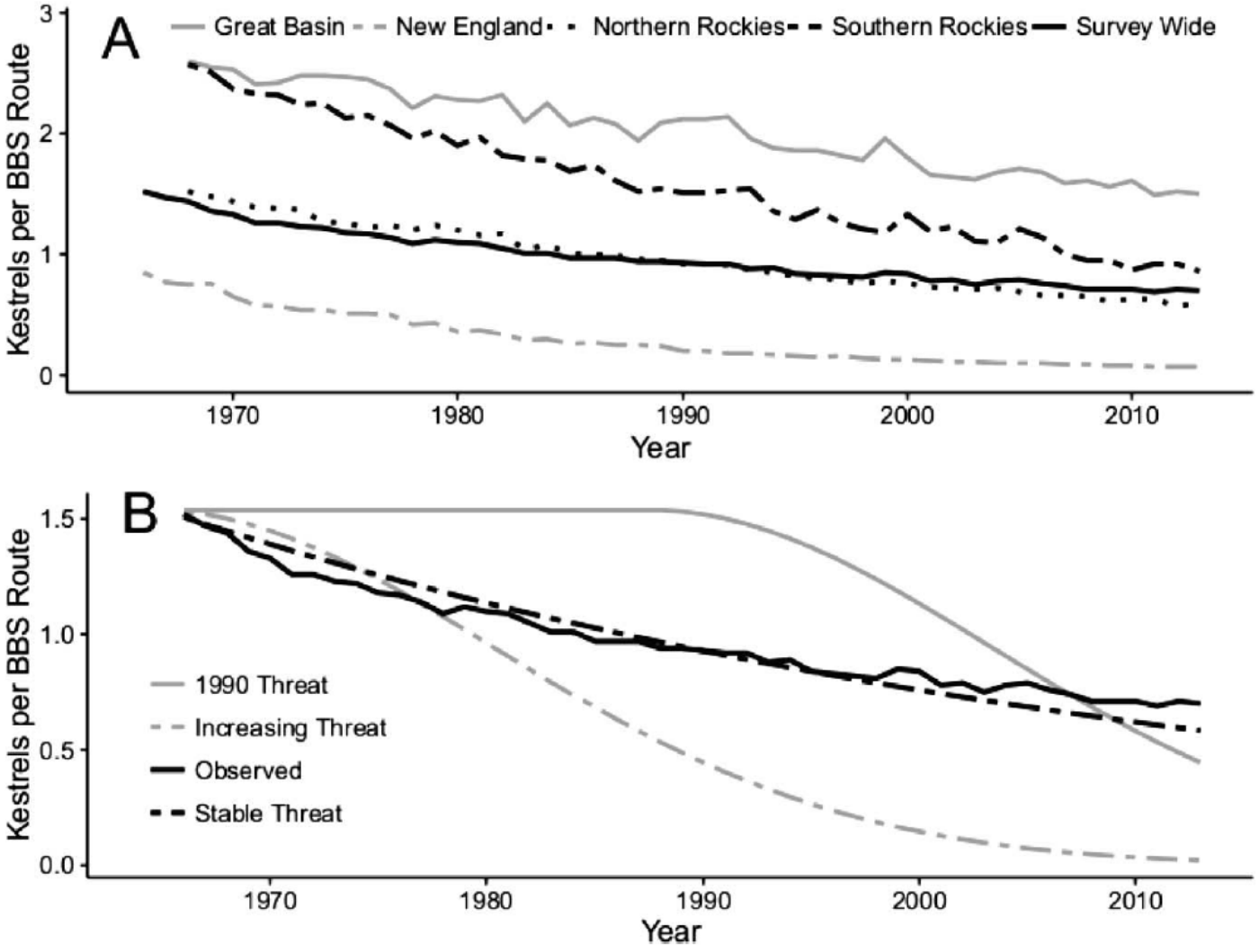
Intro to Research Problem

American Kestrels





North American Kestrel Decline

What We Know (Smallwood et al. 2009)

- All significant changes in kestrel populations surveyed during the BBS were negative
- More recent threats do not appear to be driving the decline
- Nesting success in kestrels is still high (84%)
- Resident and migratory kestrel populations are declining between breeding seasons, though both have high reproductive success

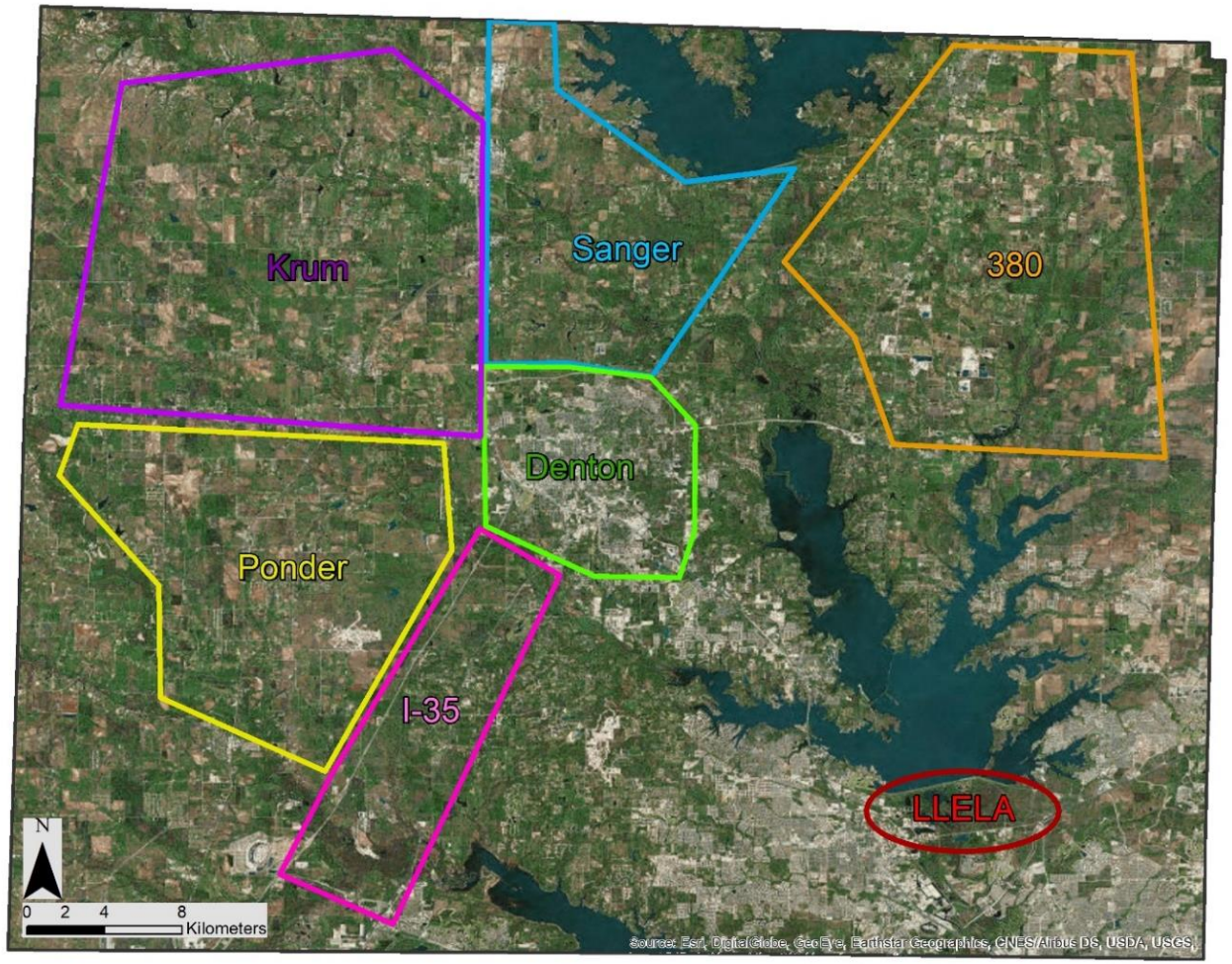
The principal cause of the decline likely lies on the wintering grounds or migratory routes.

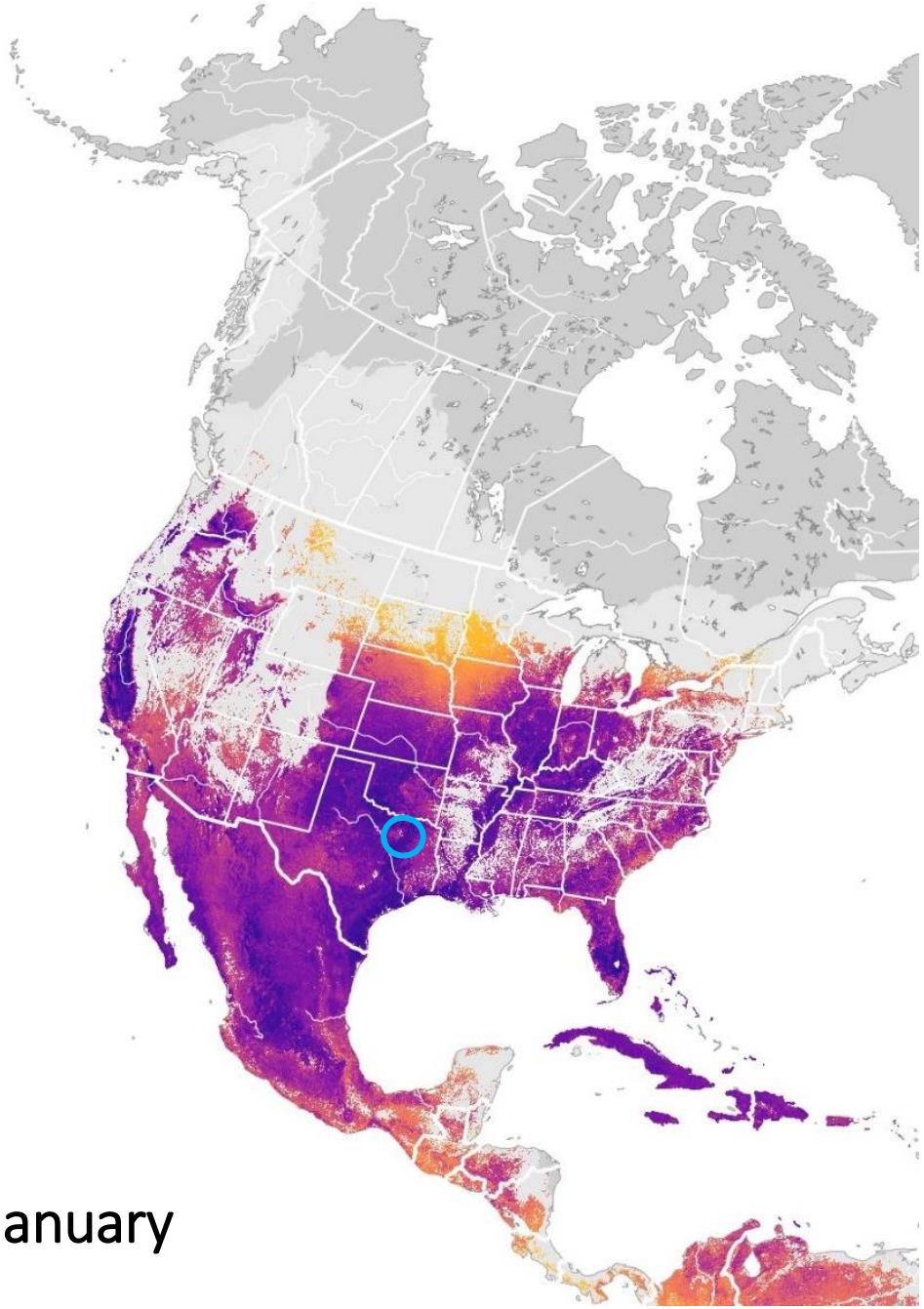
Kestrel Research Priorities (McClure et al. 2017)

1. Estimates of seasonal survival on the wintering grounds

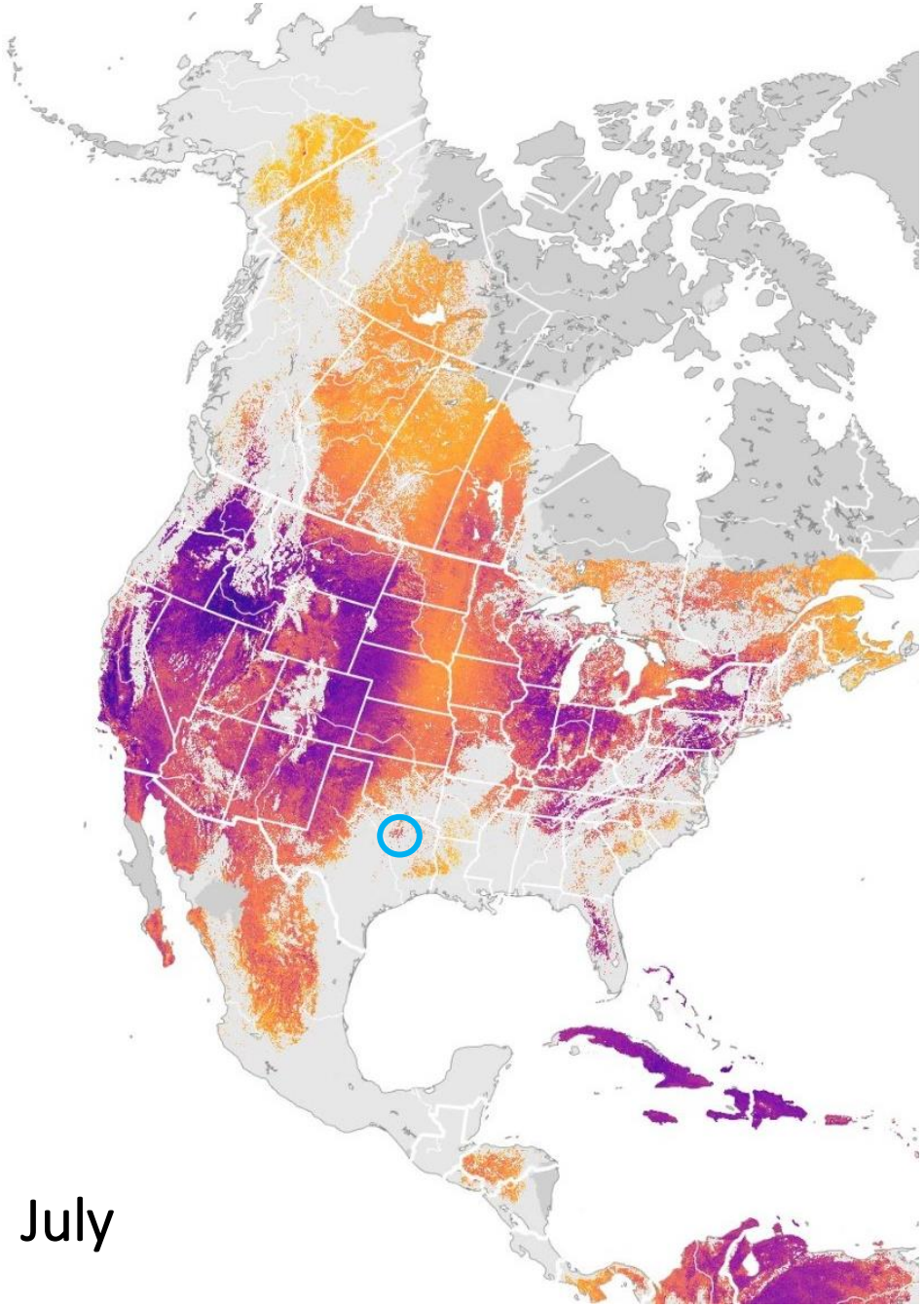
2. Determination of migratory connectivity and identification of migratory routes

Study Area: Denton County





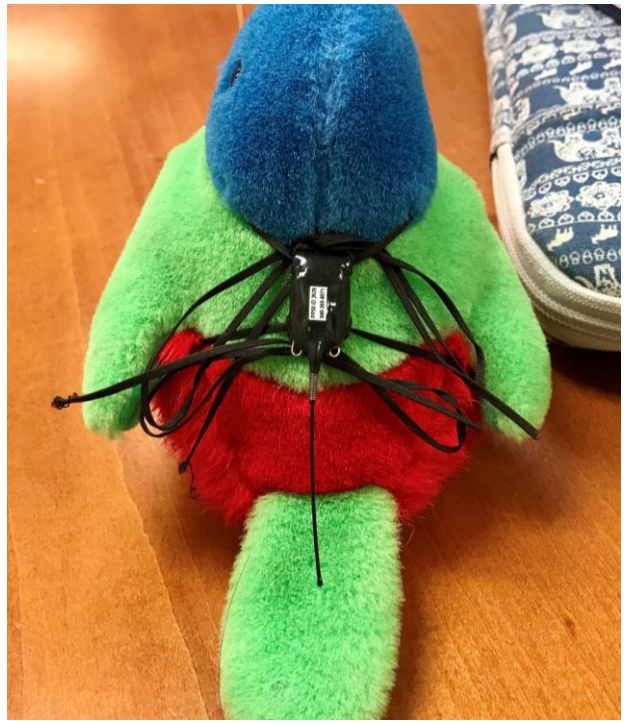
January

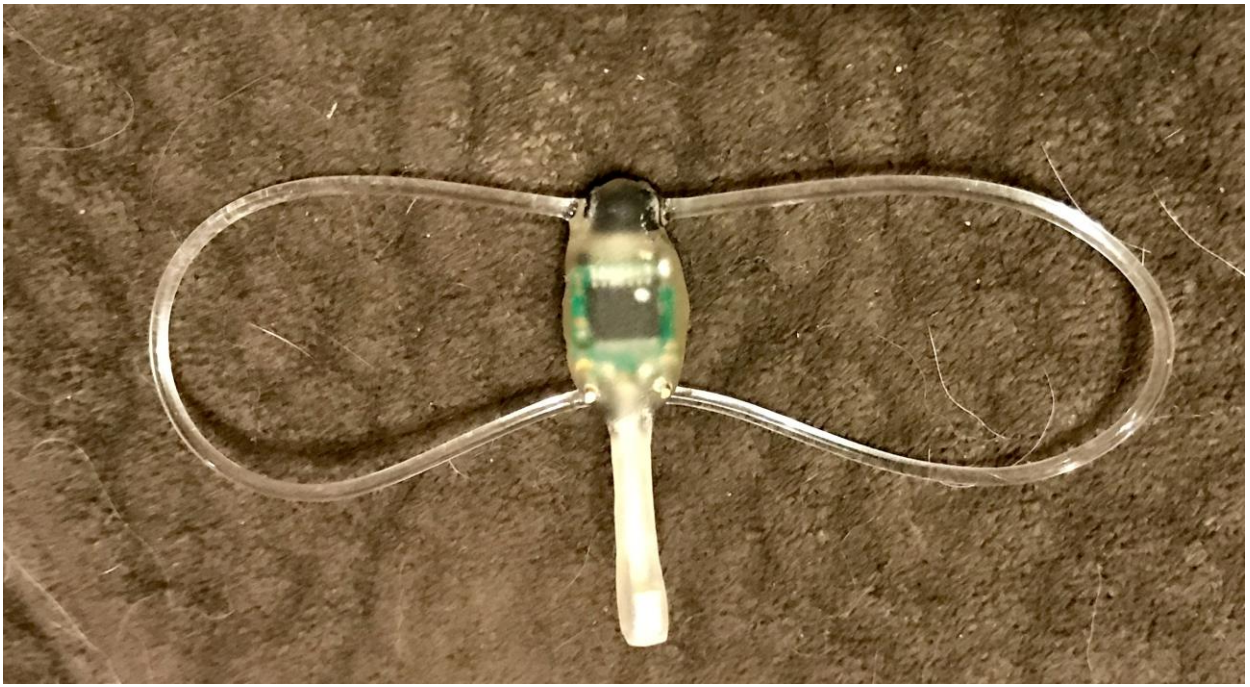


July

Wintering Ecology Gaps

- Very little research on wintering kestrels compared to the breeding season
  - *-Only one study on wintering kestrels in Texas to date*
- Demographic factors largely unknown
  - *-Survival throughout the winter*
  - *-Habitat usage*
  - *-Behavioral differences between sexes*
- Site fidelity and the key wintering areas not yet established





Migration Tracking

- Most direct way to track migration is to attach a device to the bird that records their geographic position

- The two most common methods for attaching trackers:
  - Backpack harnesses
  - Leg-loop harnesses

Kestrels and Trackers

- Kestrel morphology limits migration tracking methods
- Kestrels are too small for satellite trackers and transmitters often used on raptors
- Methods of attaching trackers based on the size of the bird
  - lighter, thinner materials like elastic used on passerines
  - thicker, sometimes metal materials used on raptors
- Biting capability enables them to shred through lighter harness materials.
- Kestrels are also too small to carry thicker materials

Discovery of Pairing Behavior

- Migratory raptors pairing during the winter is not well studied and rarely documented
    - adaptive significance of such behavior has not been established.

- Preliminary observations show wintering kestrels in N. Texas are exhibiting pairing behaviors
    - Behaviors occurring from October until spring migration

Research Questions

Question 1: What factors are related to kestrel survival within and between winter seasons and site fidelity in North Texas?

Question 2: Which of the two most common methods (leg-loop and backpack harnesses) is most effective for attaching migration tracking devices to American Kestrels?

Question 3: What are the potential benefits of pairing behavior exhibited by American Kestrels during the winter in North Texas?

Question 1

What factors are related to kestrel survival within and between winter seasons and site fidelity in North Texas?

Site Fidelity and Survival

Locality	Return Rate	n	Technique	Reference
Central Ohio	19.1%	21	Resightings of patagial tags	Mills 1975
South Texas	37.6%	65	Resightings of plastic color bands	Crouch et al. 2019
Southwestern Florida	3.4%	2,958	Recapture of banded kestrels	Hinnebusch et al. 2010
North Texas	**47.9%**	**123**	**Resightings of coded anodized bands**	**This study**

South Texas (Crouch et al. 2019):

- 50% return rate for females, 28% for males
- avg distance of territories between years at 221 m and 115 m
- Within season survival 67% for newly-banded birds and 84% for returning

SW Florida (Hinnebusch et al. 2010):

- 3.4% return, but 75% within 1 km of trapping location
- Est. annual adult survival 75%

Q1 Hypotheses

American Kestrels in better condition or achieving better foraging success will exhibit greater apparent survival.

Based on Crouch et al. (2019), I hypothesize that the return rates of kestrels in Denton County will be similarly high across the study period.

Q1 Rationale

- Determine what time of year the decline is occurring

- Annual adult survival in a couple studies, but only one for survival during the winter season specifically.

- Site fidelity can be beneficial as familiarity with a territory can lead to more successful foraging and threat avoidance.

- Site fidelity measured using territoriality and return frequencies

    - Previously studied with patagial tags or requiring recapture, likely leading to estimates lower than reality.

Q1 Methods: Banding

Q1 Methods: Point Surveys

- Systematically survey sub-study areas for marked and unmarked kestrels
    - Search within 1 km radius of last known location for marked individuals
- At least 5 full surveys per winter of each point
    -November through March
- Supplemented by incidental sightings during trapping outings

Q1 Analysis: Apparent Survival

- Estimate adult survival between years and within a winter season

- Will use MARK with a mark-resight model called (Z)NPE

- (Z)NPE requires individual identity, allows sampling with or without replacement, and individuals may be sighted more than once during a given sampling period

- Total number of marked individuals present within a population does not have to be known during a given sampling period (most robust to use over extended periods of time)

(Z)NPE Model Assumptions

1) Demographic and geographic closure

2) No marks are lost

3) No errors are made distinguishing between marked and unmarked individuals

4) Marked and unmarked individuals are equally likely to be sighted

Q1 Analysis: Return Rates and Site Fidelity

Return rates will be recorded using point survey data

-Can use a GLM model to evaluate effect of predictor variables return rates, including:

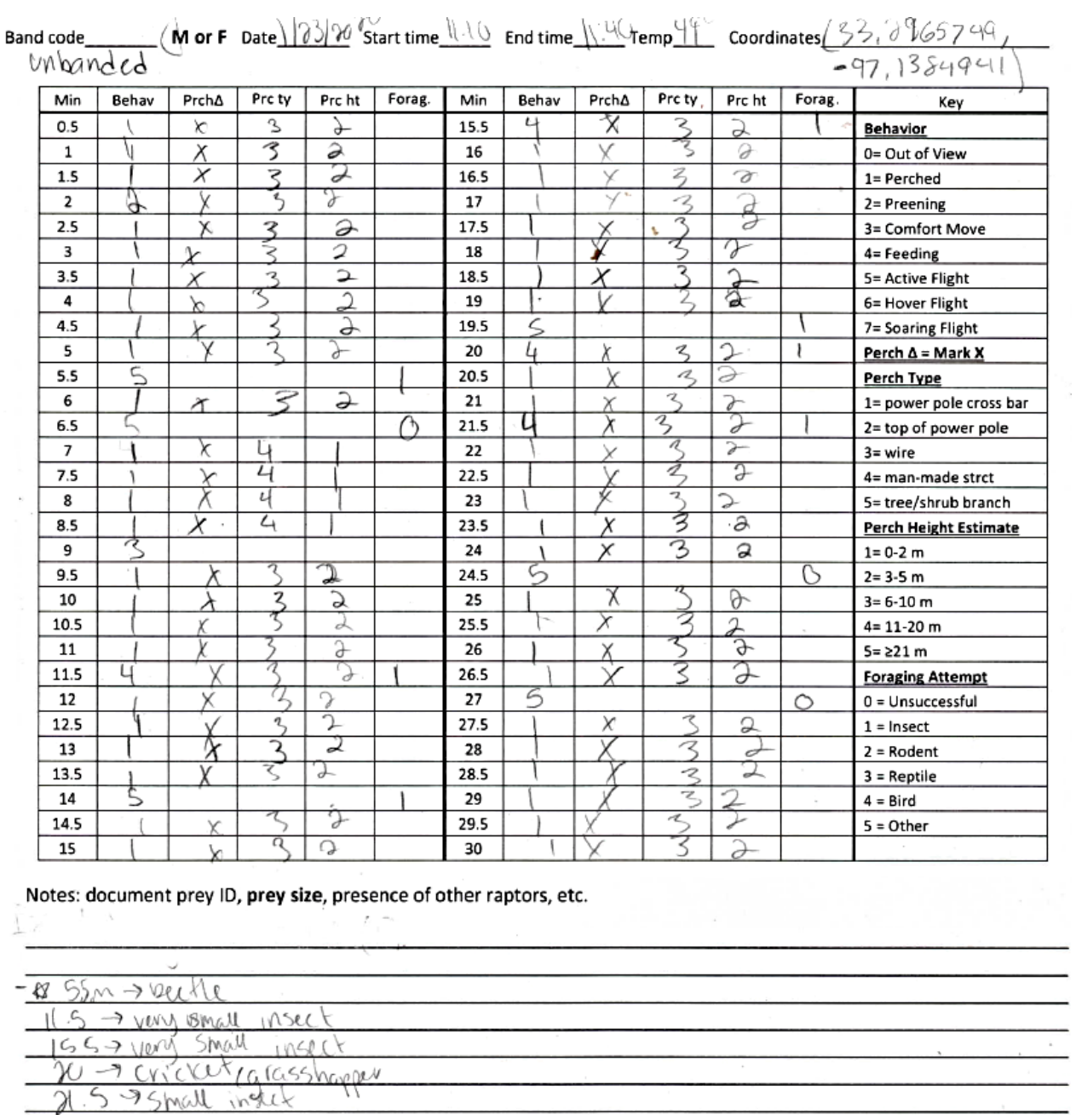
age, sex, mass, body condition, habitat classification, energetic health, pairing status, tracker status, and calendar year

Proxy territories will be calculated for kestrels with 3+ sightings and the mean site fidelity will be the distance from capture location to the center of this area

Site fidelity will be calculated as the distance between capture location and first resighting for kestrels with 1-2 sightings

Q1 Methods: Behavioral Observations

- Data will be taken every 30 seconds for half an hour
  - Will include information on their current behavior such as foraging, preening, eating, perched, comfort movements, and flight type
- Estimate the size of the prey (relative to kestrel's head size) and determine prey type (arthropod, mammal, bird) for successful foraging attempts



Band code _____ (M or F) Date 7/23/20 Start time 11:10 End time 11:40 Temp 99° Coordinates (33.2965749, -97.1384941)
unbanded

Min	Behav	PrchΔ	Prc ty	Prc ht	Forag.	Min	Behav	PrchΔ	Prc ty	Prc ht	Forag.	Key
0.5	1	X	3	2		15.5	4	X	3	2	1	**Behavior**
1	1	X	3	2		16	1	X	3	2		0= Out of View
1.5	1	X	3	2		16.5	1	X	3	2		1= Perched
2	1	X	3	2		17	1	X	3	2		2= Preening
2.5	1	X	3	2		17.5	1	X	3	2		3= Comfort Move
3	1	X	3	2		18	1	X	3	2		4= Feeding
3.5	1	X	3	2		18.5	1	X	3	2		5= Active Flight
4	1	X	3	2		19	1	X	3	2		6= Hover Flight
4.5	1	X	3	2		19.5	5				1	7= Soaring Flight
5	1	X	3	2		20	4	X	3	2	1	**Perch Δ = Mark X**
5.5	5				1	20.5	1	X	3	2		**Perch Type**
6	1	X	3	2		21	1	X	3	2		1= power pole cross bar
6.5	5				0	21.5	4	X	3	2	1	2= top of power pole
7	1	X	4	1		22	1	X	3	2		3= wire
7.5	1	X	4	1		22.5	1	X	3	2		4= man-made strct
8	1	X	4	1		23	1	X	3	2		5= tree/shrub branch
8.5	1	X	4	1		23.5	1	X	3	2		**Perch Height Estimate**
9	3					24	1	X	3	2		1= 0-2 m
9.5	1	X	3	2		24.5	5				0	2= 3-5 m
10	1	X	3	2		25	1	X	3	2		3= 6-10 m
10.5	1	X	3	2		25.5	1	X	3	2		4= 11-20 m
11	1	X	3	2		26	1	X	3	2		5= ≥21 m
11.5	4	X	3	2	1	26.5	1	X	3	2		**Foraging Attempt**
12	1	X	3	2		27	5				0	0 = Unsuccessful
12.5	1	X	3	2		27.5	1	X	3	2		1 = Insect
13	1	X	3	2		28	1	X	3	2		2 = Rodent
13.5	1	X	3	2		28.5	1	X	3	2		3 = Reptile
14	5				1	29	1	X	3	2		4 = Bird
14.5	1	X	3	2		29.5	1	X	3	2		5 = Other
15	1	X	3	2		30	1	X	3	2		

Notes: document prey ID, **prey size**, presence of other raptors, etc.

- 8 5.5m → beetle
11.5 → very small insect
15.5 → very small insect
20 → cricket/grasshopper
21.5 → small insect

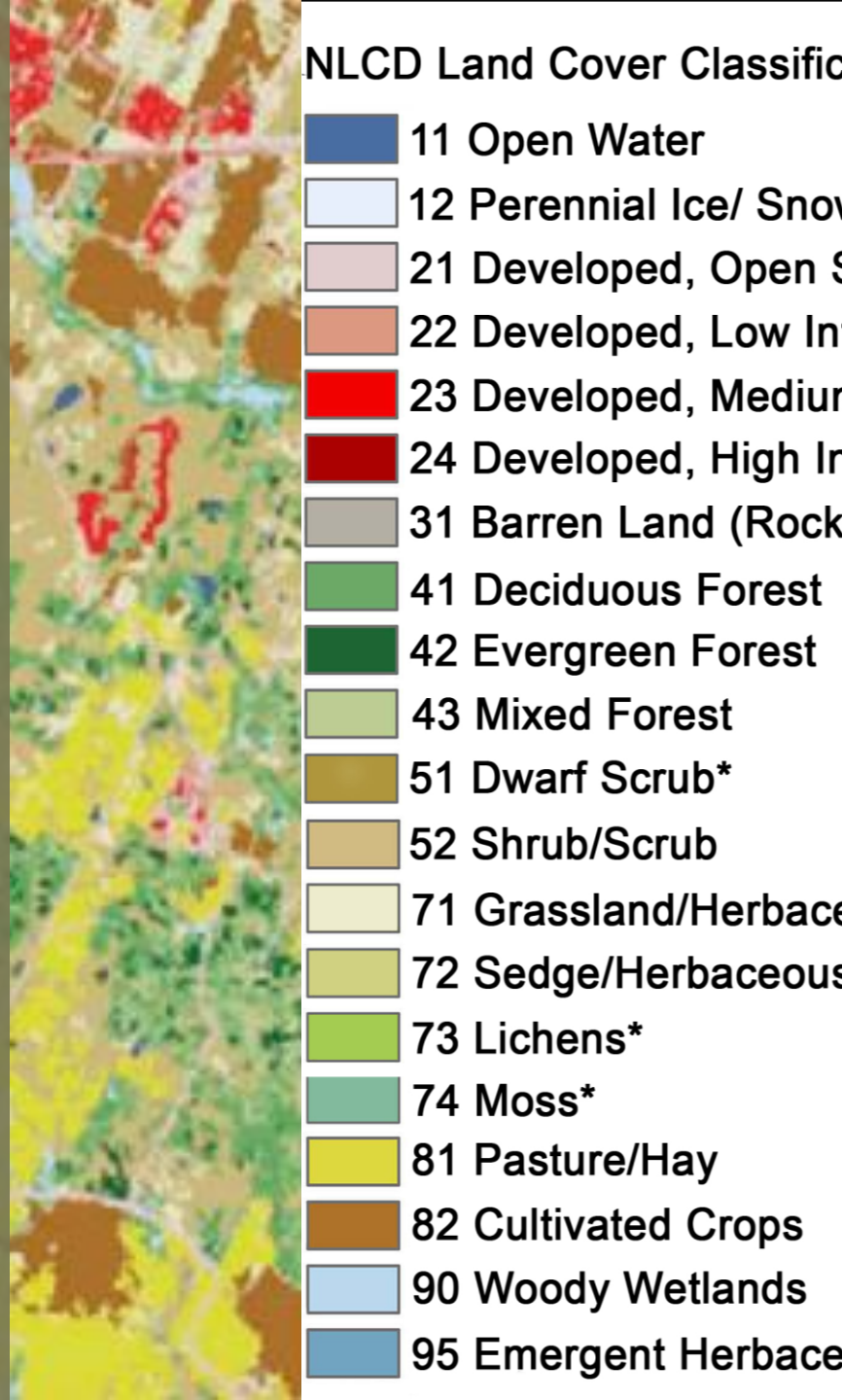
Q1 Analysis: Classifying Habitat and Body Condition

- Habitat classified into general categories
  - open grassland, ag field, obstructed grassland, mixed woodland, woodland

- Classifications will be determined based on National Landcover Database and covering a 1-ha plot as a proxy territory calculated in ArcMap.

-Will also divided into rural and urban, as classified by the U.S. Census Bureau

- Body condition will be calculated using a PCA of morphometric data collected for each kestrel divided by the mass.



Q1 Analysis: Estimate Energetic Health

Estimate individual's intake of energy versus their daily energy expenditure (DEE)

Kestrels spend a significant portion of their day hunting

- Hover hunting is particularly energetically expensive

Quantify foraging successes using field observations to estimate energy intake

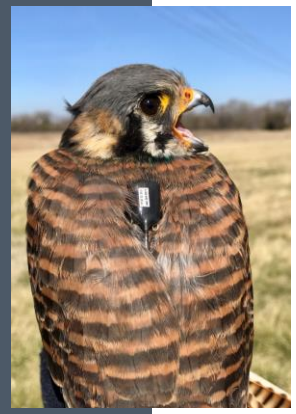
DEE calculated based on environmental factors and prior studies on the species' metabolic rates

Caloric intake = DEE, prey availability likely not adversely affecting winter survival

Question 2

Which of the two most common methods (leg-loop or backpack harnesses) is most effective for attaching migration tracking devices to American Kestrels?

Two Tracker Attachment Methods



Backpack with Teflon:

-most common way to attach tracking devices to raptors

-only study published to date attaching trackers to American Kestrels used Teflon in a backpack configuration (Crandall and Craighead 2019)

-sit on upper back

-cut resistant and relatively light, but must be fit with the bird in hand

Leg-loop with Silicon:

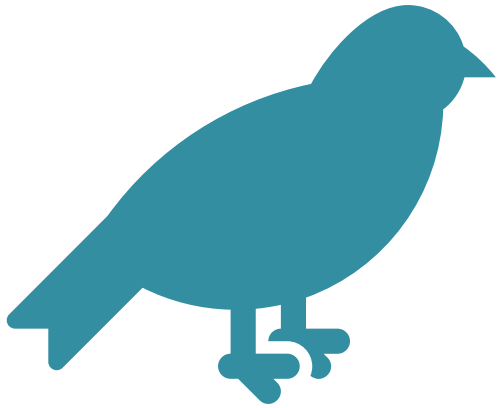
-common on smaller birds, but deployed on raptors as well

- can be attached quickly by being prefabricated

- require a material with stretch

-sit on lower back

Q2 Hypothesis



Because of the differences in materials, I propose that the leg-loop harnesses with silicone will be easier for the kestrels to remove and the backpack harnesses using Teflon will be more likely to stay attached.

American Kestrels with trackers attached via a backpack harness will be more likely to return with their tracker intact the following winter.

Q2 Rationale

Tracker attachment methods untested on many small falcons

This will be the first study comparing backpack and leg loop harnesses as methods of tracking devices on small raptors.

Geolocators are cheap and light weight, but imprecise (186 ± 114 km)

Archival GPS units are precise (± 10 m) but costly and heavier

I will compare 1) geolocator attachment (leg-loop vs backpack)

2) trackers that differ by weight (geolocator vs GPS) but are both attached as a backpack

This will allow me to test whether return rates differ for the two attachment methods with the same tracker type and if they differ based on tracker weight using the same attachment method (backpack).

Q2 Methods: Deploy Trackers

Year 1 (2018-19): Deployed 25 trackers

-15 geos, 10 GPS

-geolocators incorporated due to funds and need for increased sample size

- 10 geo leg-loops, 5 geo backpacks, 10 GPS backpacks

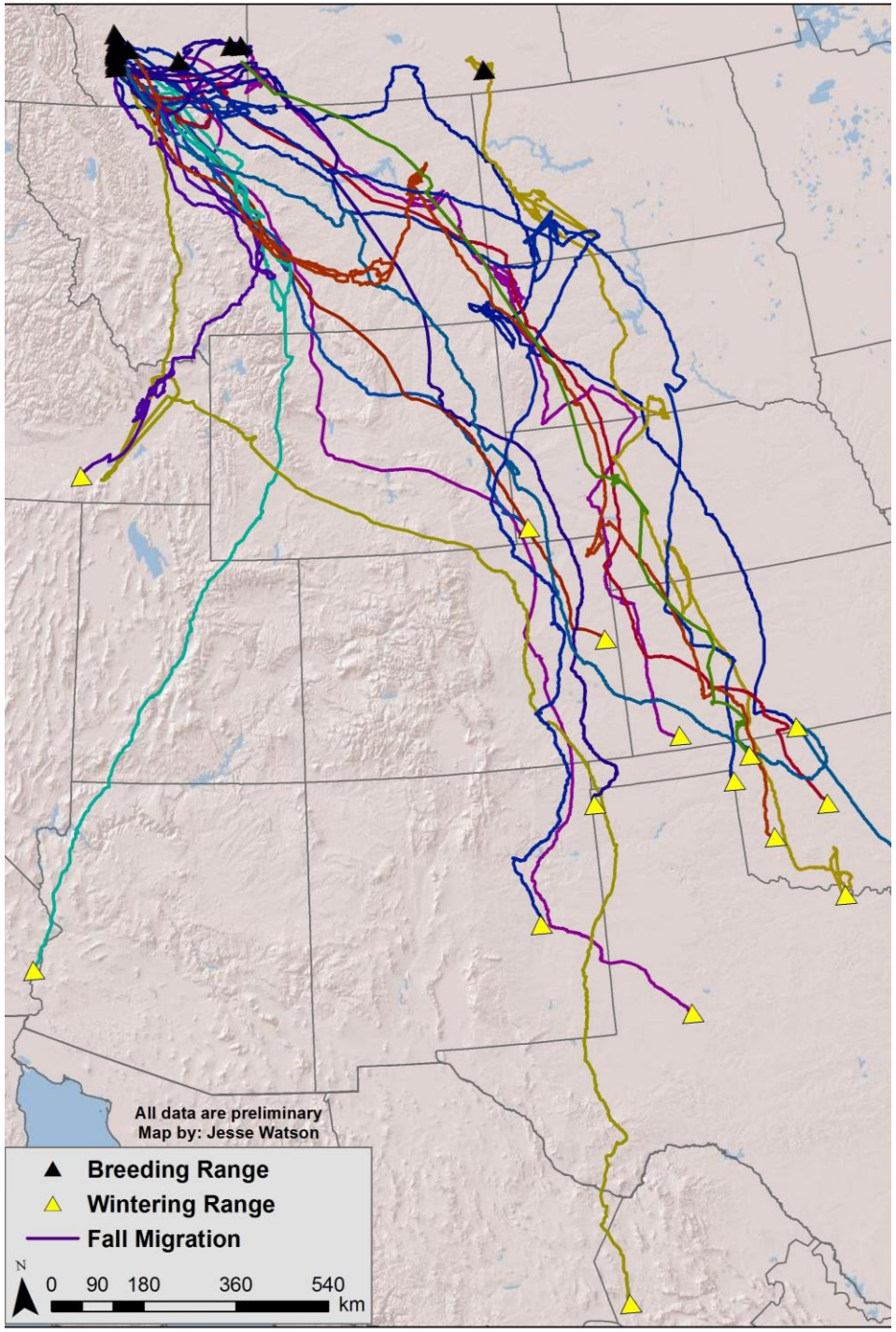
Year 2 (2019-20): Deploy 40 GPS trackers

- 20 in North Texas, 20 in Central Texas
- All harnessed as backpacks
- Test leap-frog migration hypothesis

Attachment methods of trackers fit on kestrels in Year 1 that returned in Year 2.

	GPS Backpack (n=10)	Geo Backpack (n=5)	Geo Leg-loop (n=10)
Attached	7	1	1
Not Attached	1	1	0
Unknown	1	0	1
Total	9	2	2

Q2 Methods: Recover Trackers



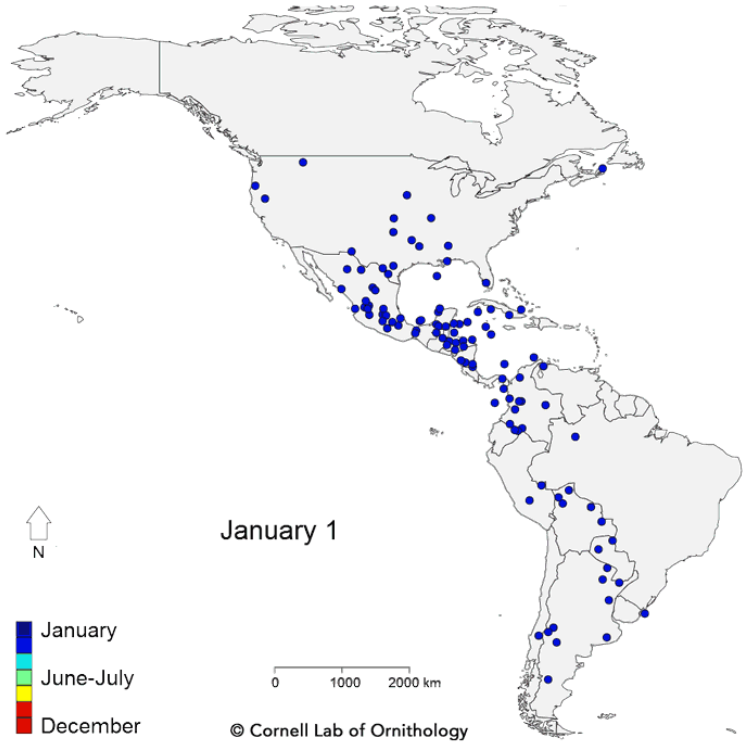
Q2 Analysis: Comparisons

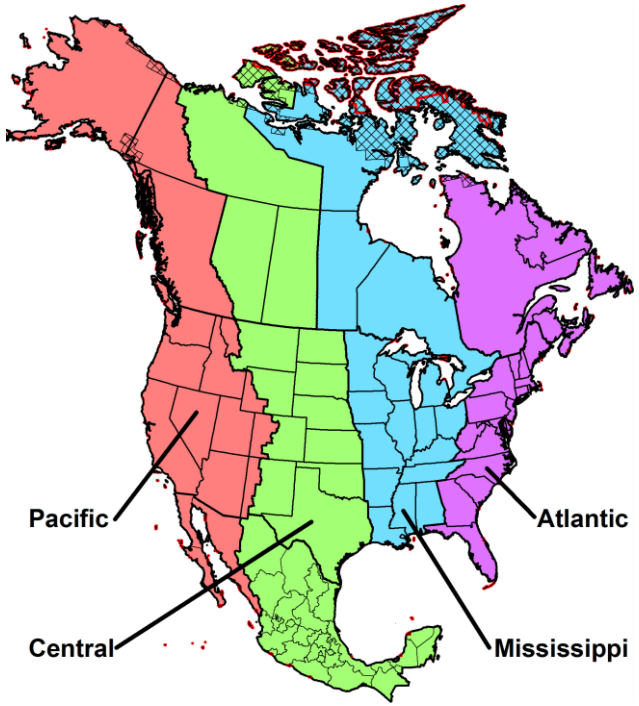
- Test whether there is a difference in return rates between tracker types and attachment methods

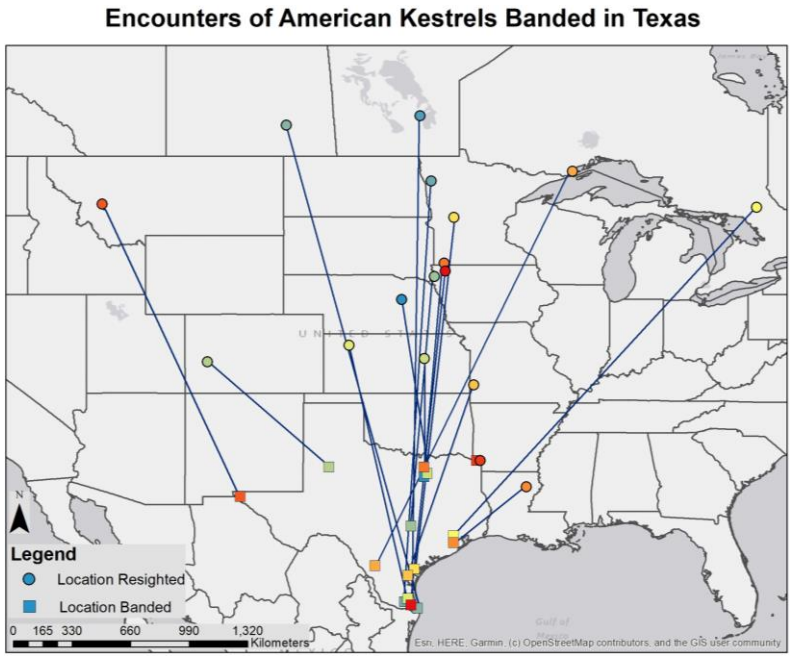
- If any geolocators are recovered, data will be converted to coordinates using R packages GeoLight and FlightR

- Analyses could include individuals' migratory pathways between wintering and breeding territories, timing of arrival or departure during both migratory directions, and differences by sex.

- If a enough trackers are retrieved from both study areas (north and central Texas), could analyze data for evidence of a leap-frog migration pattern.







Q2 Analysis: Visualization

Question 3

What are potential benefits of the pairing behavior exhibited by American Kestrels during the winter in North Texas?

Winter Pairing in Migratory Raptors

Only documented twice in populations of migrating raptors

- Red-tailed Hawks: study in OK found 18 pairs in the winter, but only 1 pair on the same routes in the summer
  - migrating breeding partners potentially meet back up on their wintering grounds
  - winter romances

- American Kestrels: study in CA focused on resident paired kestrels during the winter, mentioned migratory birds in passing but made no comments on any pairing behavior observed in the migrant population
  - assumption that all pairs were breeding residents
  - may suggest that all the birds pairing in Denton County over the winter are local year-long residents that breed together

Winter Pairing in Other Groups

Winter pairing pervasive in Anatidae

- **Pairs typically dominate unpaired individuals**
- Have increased access to premium food sources and sites
- Female waterfowl benefit disproportionately more

Documented in Black-capped Chickadees

- Females had better access to foraging sites and protection
- Lead to an increase in female survival over unpaired females

American Kestrel females occupy higher quality habitat, so dynamic could be swapped

- Males could benefit from access to better habitat
- Females may benefit by receiving courtship feedings
- Pairs may dominate single birds of either sex

Q3 Hypotheses

Overwintering paired kestrels are breeding partners that remain paired year-round, as either resident birds that do not migrate from the study area or as a breeding pair that reunites on their wintering grounds.

If pairing occurs during the winter in migratory birds, this behavior likely provides an advantage to either or both sexes.

Q3 Rationale

Raptors are considered highly territorial and generally thought to migrate independent of their breeding partners

~35% of the kestrels in Denton County exhibited pairing behaviors during the winter of 2018-19

Identifying the advantage of such behavior can have important implications for winter survival, migratory behavior, or the conduct of resident birds throughout the non-breeding season

-If the pairs are breeding partners, winter pairing could mean increased bond and reproductive success (Social Bond Hypothesis).

-If the pairs are not breeding partners, pairing could increase winter survival

Q3 Methods: Behavioral Observations of Pairs

Pairs will be targeted for behavioral observations throughout the winter

Observations will inform if specific pairing behaviors occur, such as:

- Courtship feedings
- Allopreening
- Copulations and attempts

Also document hunting behaviors and foraging successes, which may impact survival.

Q3 Analysis: Energetic and Habitat Usage

Analyze differences between the paired and individual kestrels of both sexes in:

- Energetic health
- Apparent winter survival
- Return rates
- Foraging efficiency
- Habitat quality (using foraging success as a proxy)

If a difference is observed within any of these factors, pairing may have significant benefits.

*Because I cannot currently determine where our wintering kestrels breed, I cannot assess reproductive success, which may also influence on pairing behavior.

Resident Kestrels

Kestrels are present in Denton County year-round, though much lower density during the breeding season

- The kestrels that breed here are likely residents
- Residents interact with wintering population October – March

Residents may have different behaviors and survival rates than the wintering population

Residents may exhibit higher site fidelity than migratory birds in the same population

Migration costly and prep increases foraging activity

Q3 Methods: Identification of Residents

Presence-absence point surveys similar to those in Q1

If a banded kestrel is observed in May - August, it will be classified as a resident

- Behaviors (such as pairing and foraging) and survival will be analyzed separate from the migratory wintering birds

When possible, I will trap and band unmarked kestrels during the breeding season

Birds banded during the summer will then be searched for the next winter to confirm their resident status

Q3 Analysis: Demographics of N. Texas Breeding Kestrels

During summer surveys for residents, behavioral observations will also be conducted

These will contribute to territory polygons, energetic analyses, and our overall understanding of resident kestrels breeding at the edge of their range.

Though limited, observations could be particularly important to document, as North Texas appears to be an island of breeding American Kestrels.

Timetable

	2020												2021											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Question 1																								
Banding	X	X	X									X	X	X	X									
Presence/Absence Observations	X	X	X		X	X	X	X		X	X	X	X	X	X									
Behavioral Observations	X	X	X								X	X	X	X	X									
Data Analysis and Visualization				X	X	X			X	X						X	X	X	X	X	X	X		
Question 2																								
Deploy Trackers	X	X	X																					
Recover Trackers	X	X	X								X	X	X	X	X									
Analysis and Visualization				X	X	X	X	X	X							X	X	X	X	X	X	X		
Question 3																								
Banding				X	X	X																		
Behavioral Observations	X	X	X								X	X	X	X	X									
ID of Summer Residents				X	X	X	X	X								X	X	X	X	X				
Analysis and Visualization				X	X	X	X	X	X							X	X	X	X	X	X	X		
Defend Dissertation																								X




Questions?