Spring migration of Indiana bats (*Myotis sodalis*) and what it means for the wind industry

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Wind Wildlife Research Meeting XI

Broomfield, Colorado

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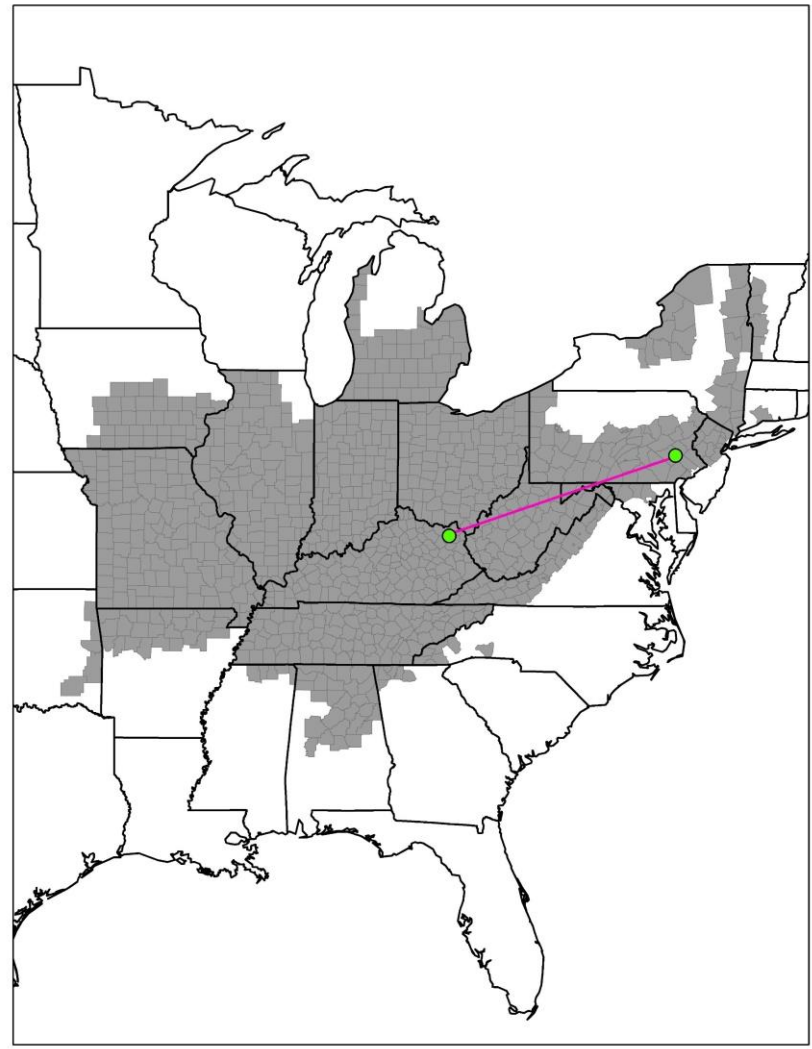
Study Species

- Indiana bat (*Myotis sodalis*) federally endangered
- Small: 5 – 8 g, 35 – 41 mm forearm
- Hibernates in winter, roosts in trees in summer
- Regional migrant (< 500 km), however…
- 672.7 km, however…
- Banded in 2013, recovered in 2015



Introduction

- Most migration information known from band recoveries
- Unanswered questions:
  - How long does it take?
  - Do they fly throughout the whole night?
  - Do they forage along the way?
  - Do they fly in a straight line between habitats?
  - How does weather affect them?
  - How fast do they fly?

Introduction

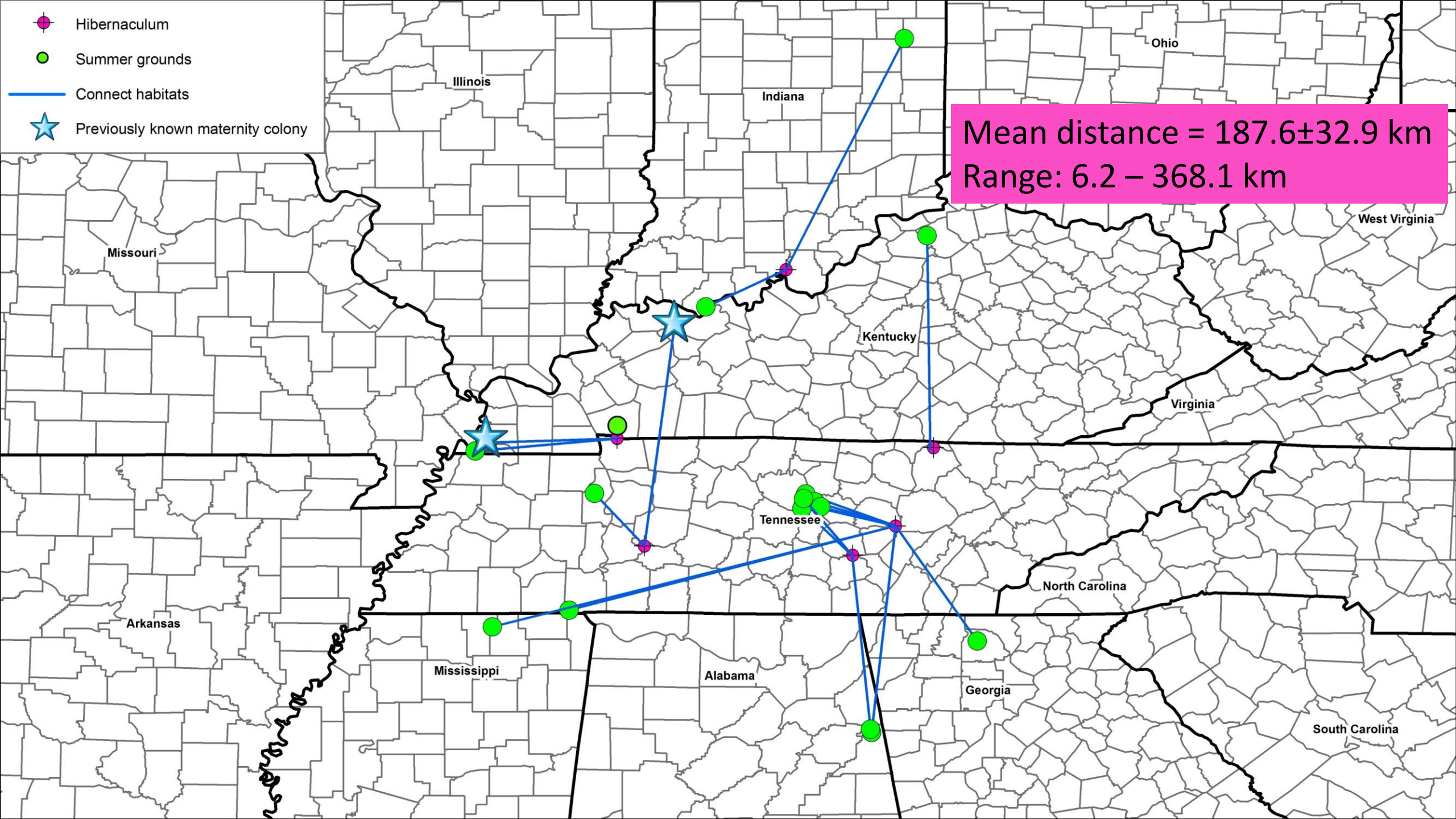
- Hypotheses:
  - Bats will migrate north
  - Bats will stop during the night to forage
  - Bat behavior will be altered by inclement weather

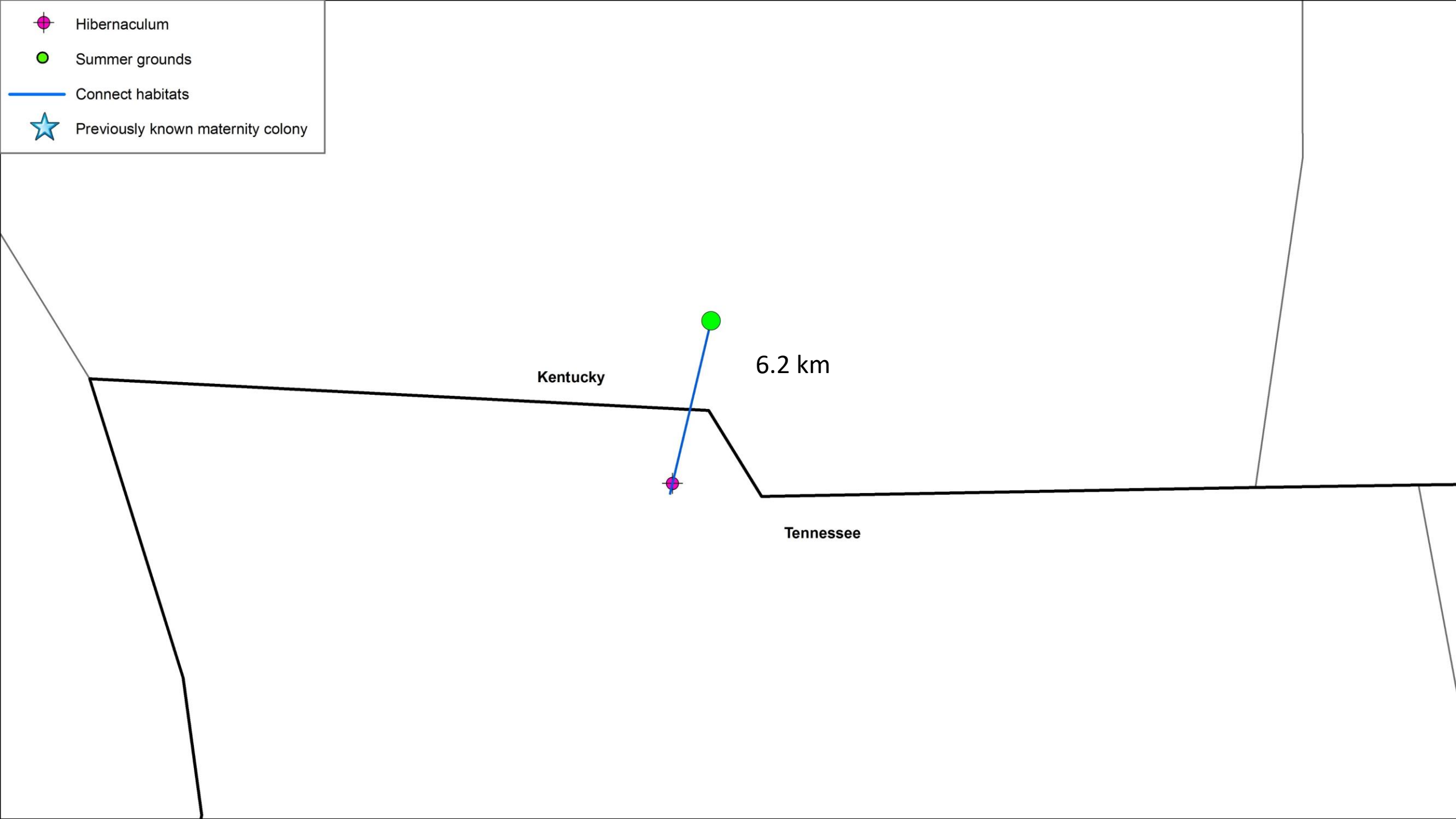
Methods

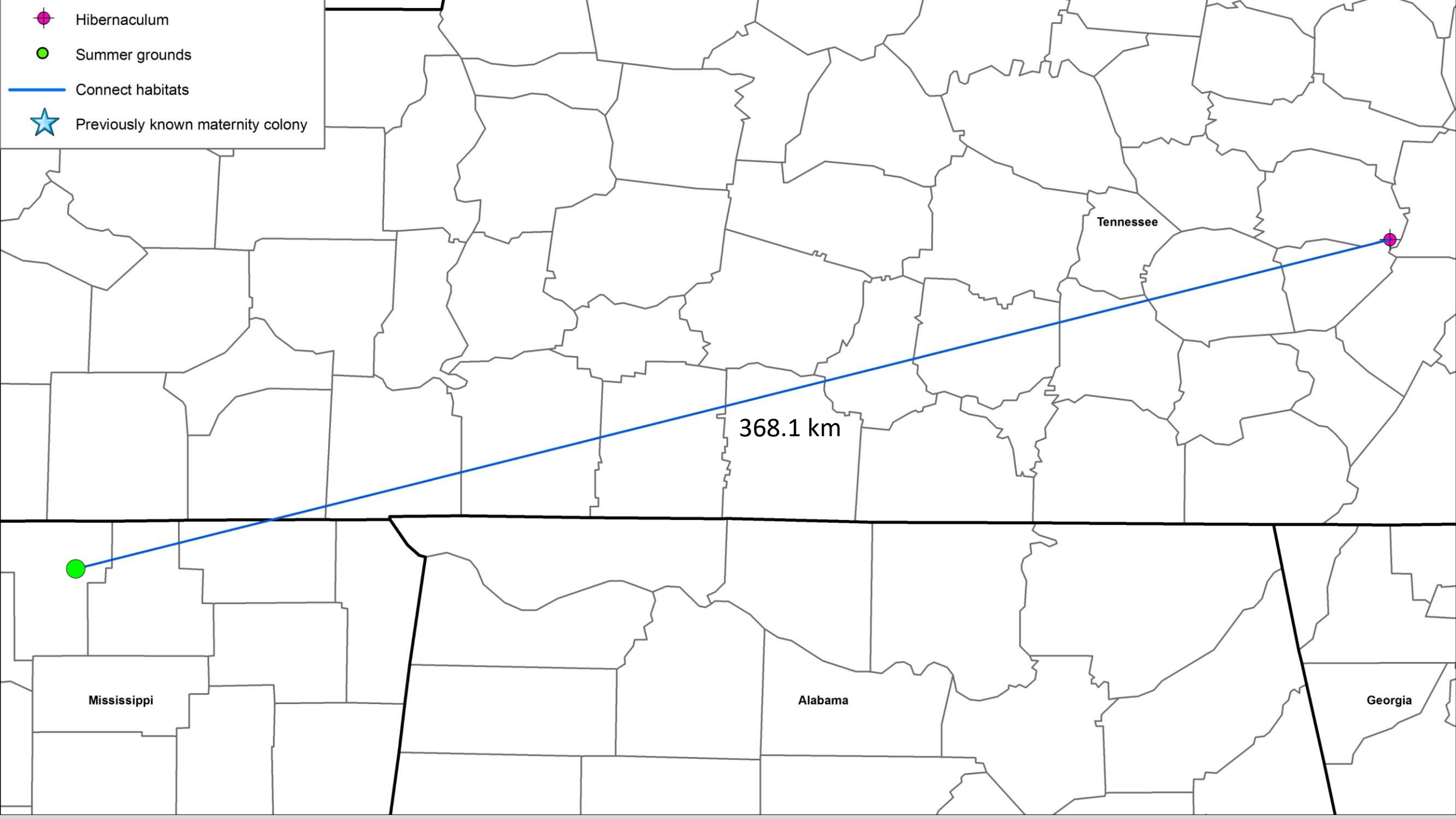
- Collect female Indiana bats from hibernacula in early April 2009 - 2016
- Radio-tag bats with temperature sensitive transmitters
  - Record temperature of bat with data logger
  - Record ambient temperature with iButton®
- Collect location points from airplane
- Ground support – track when needed
- Locate diurnal roosts
- Identify maternity grounds

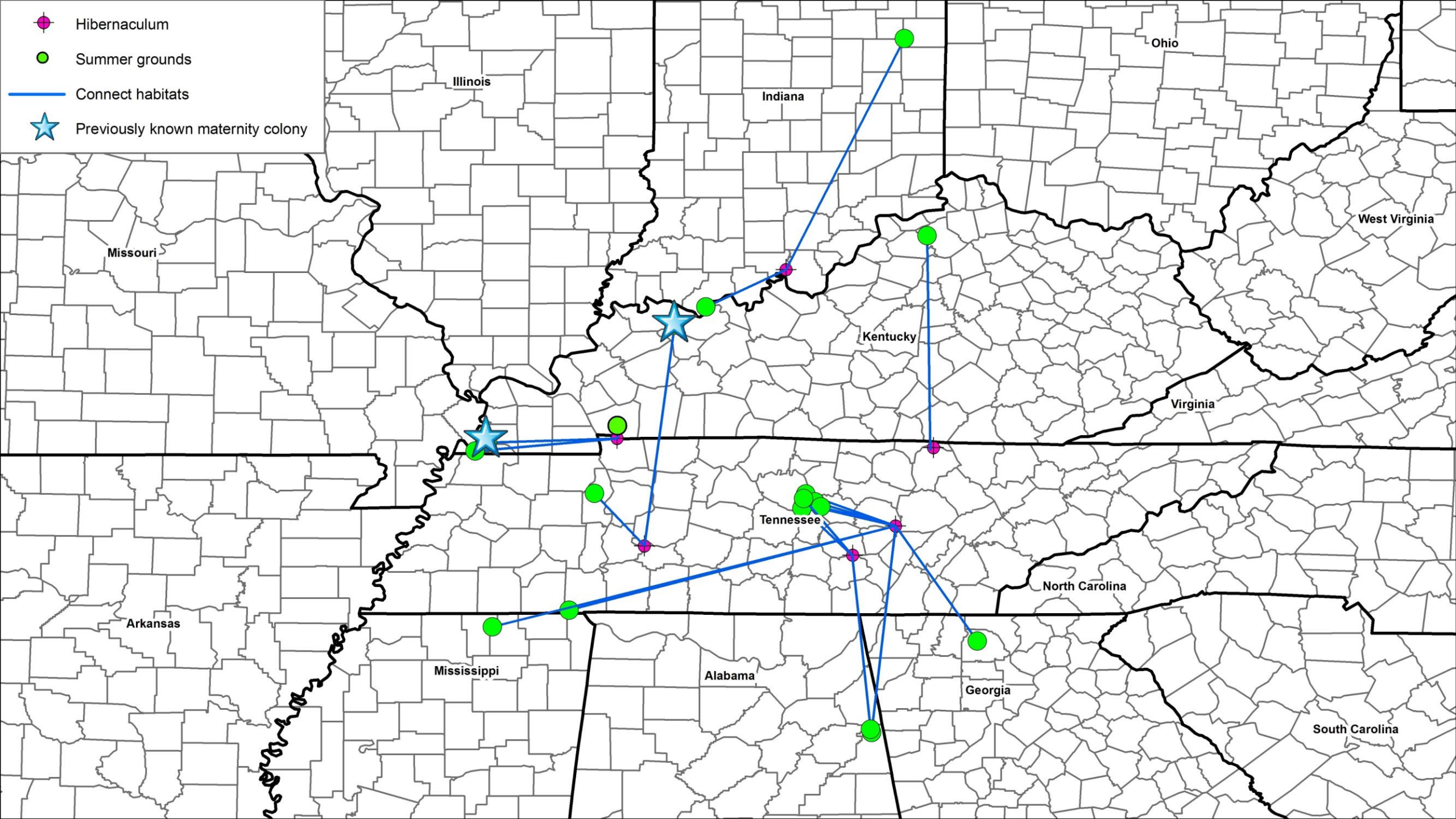
Results

- 348 Indiana bat captures, 236 transmitters. 40 bats caught more than once.
  - ($\overline{X}$ = 68%, range: 33 - 100% per visit, n = 15 visits)
- Tracked 11 individual bats
- 3,392 location points ($\overline{X}$ = 308.4±67.9 points/bat, range: 44 – 804 points/bat)
- 16 connections from winter to summer
  - 14 previously unknown
- 6 states
- New state records for GA, AL, MS
- Southernmost colony known in range


Hibernaculum
Summer grounds
Connect habitats
Previously known maternity colony
Mean distance = 187.6±32.9 km
Range: 6.2 – 368.1 km
Illinois
Indiana
Ohio
Missouri
Kentucky
West Virginia
Virginia
Tennessee
North Carolina
Arkansas
Mississippi
Alabama
Georgia
South Carolina

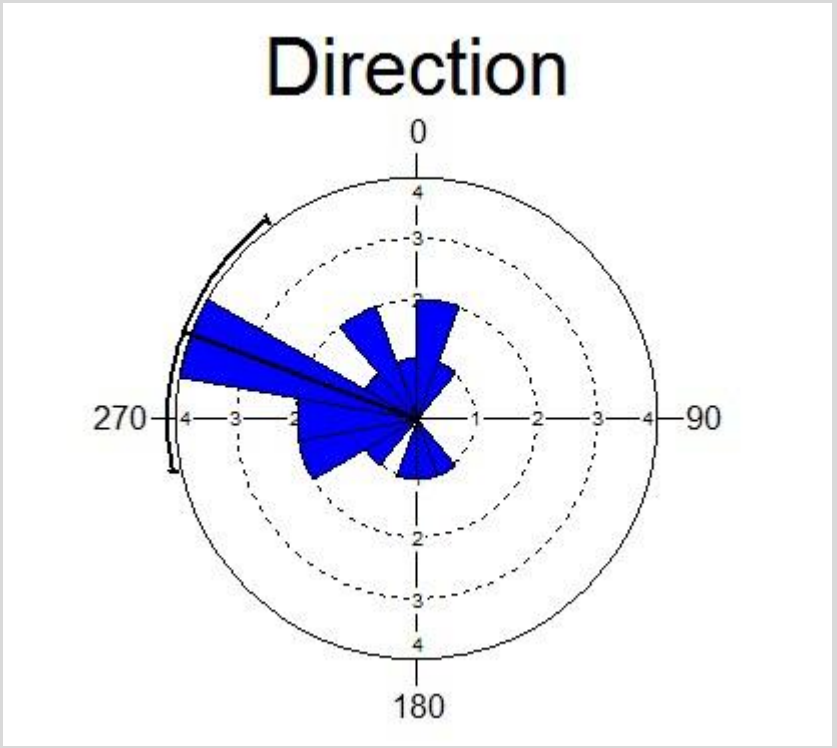

Hibernaculum
Summer grounds
Connect habitats
Previously known maternity colony
6.2 km
Kentucky
Tennessee


Hibernaculum
Summer grounds
Connect habitats
Previously known maternity colony
Tennessee
368.1 km
Mississippi
Alabama
Georgia


Hibernaculum
Summer grounds
Connect habitats
Previously known maternity colony
Illinois
Indiana
Ohio
West Virginia
Missouri
Kentucky
Virginia
Tennessee
North Carolina
Arkansas
Mississippi
Alabama
Georgia
South Carolina

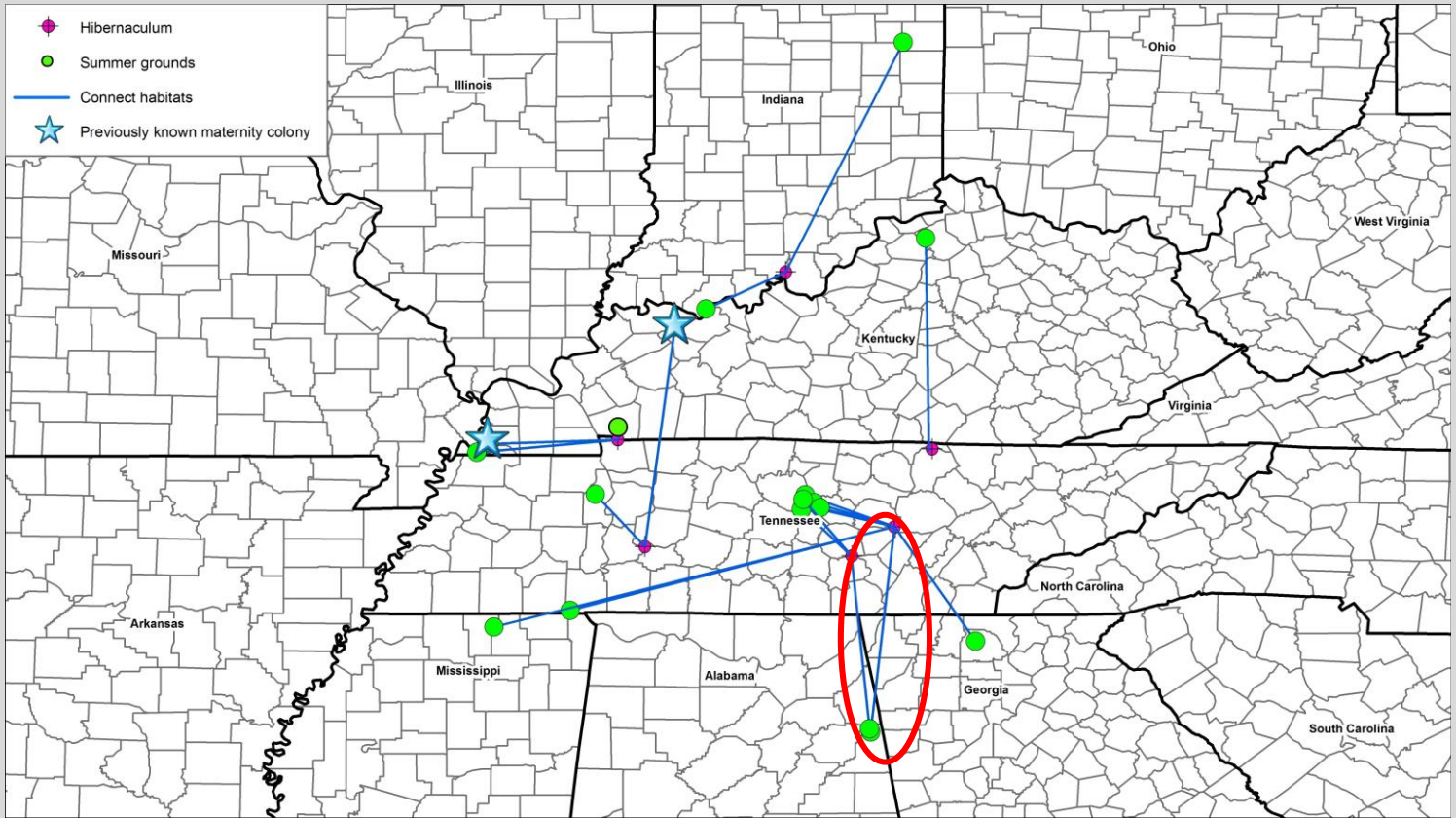
Results

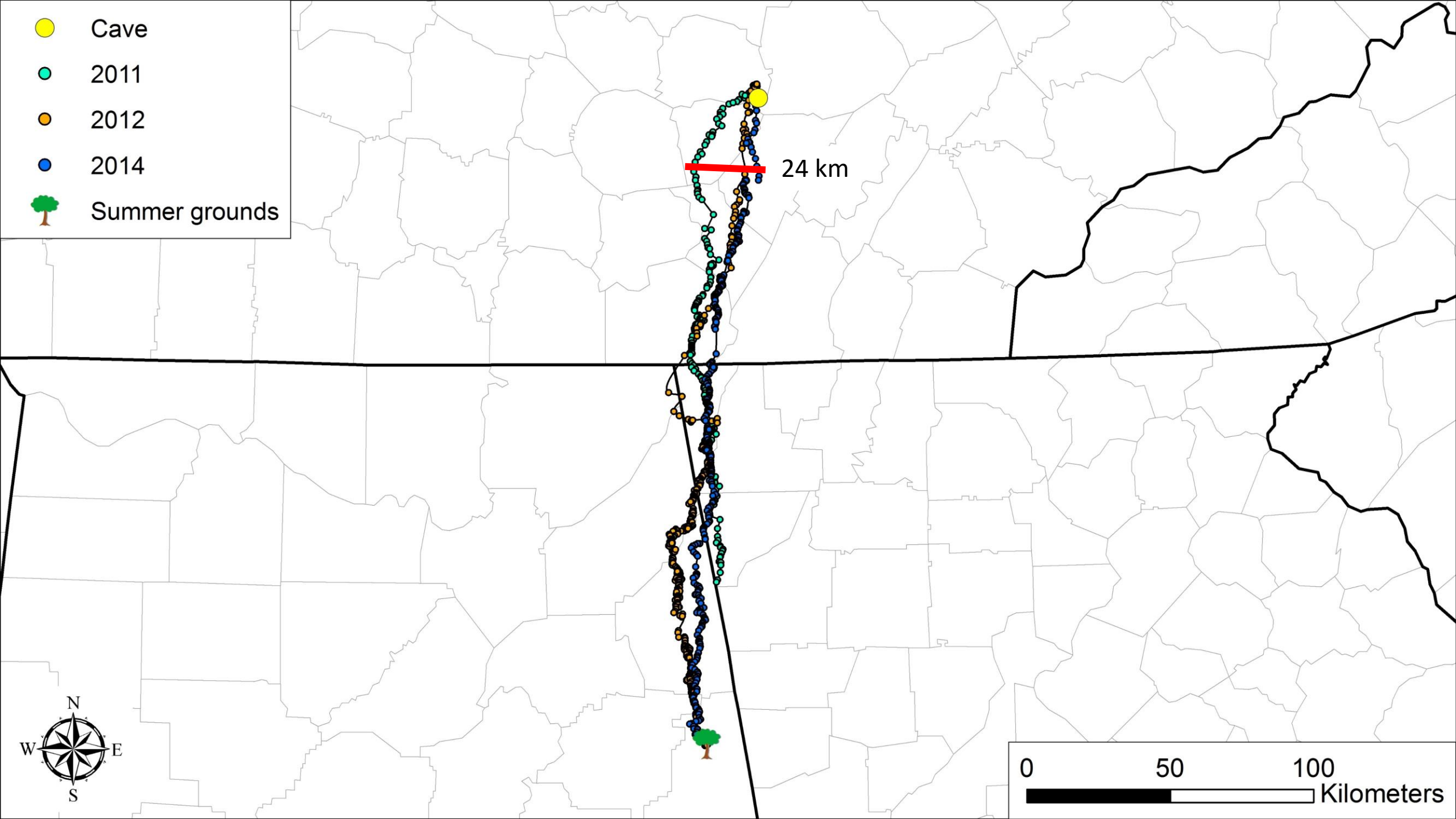
- A few bats migrated north, but most traveled west
  - Oriana v4.02
  - Mean direction = 290.6±16.6°
  - Rao's Spacing Test U = 172.6
  - P < 0.05



Results – Migration Corridors

- Most connections – 1 bat tracked



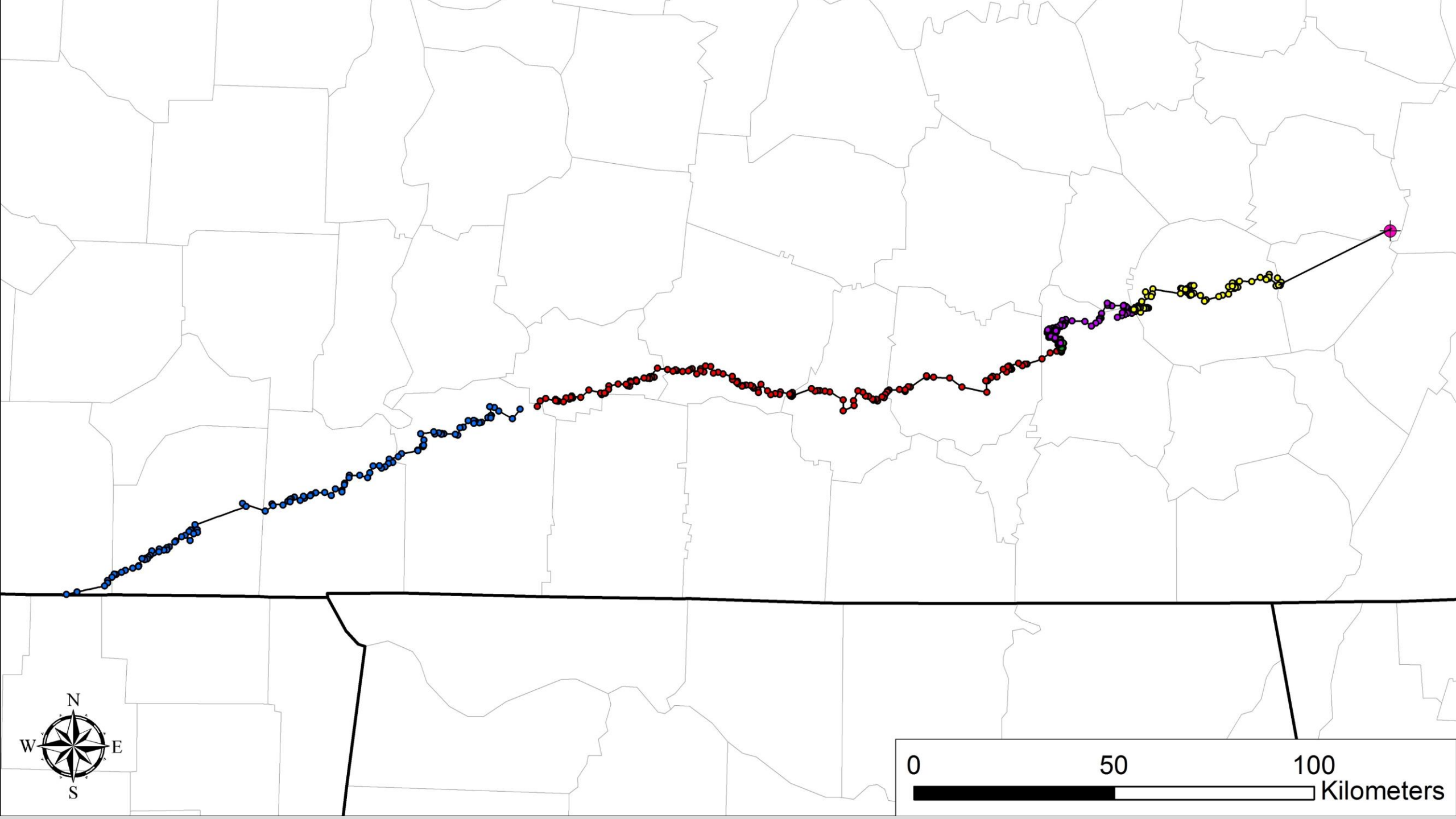

Cave
2011
2012
2014
Summer grounds
24 km
N
W
E
S
0
50
100
Kilometers

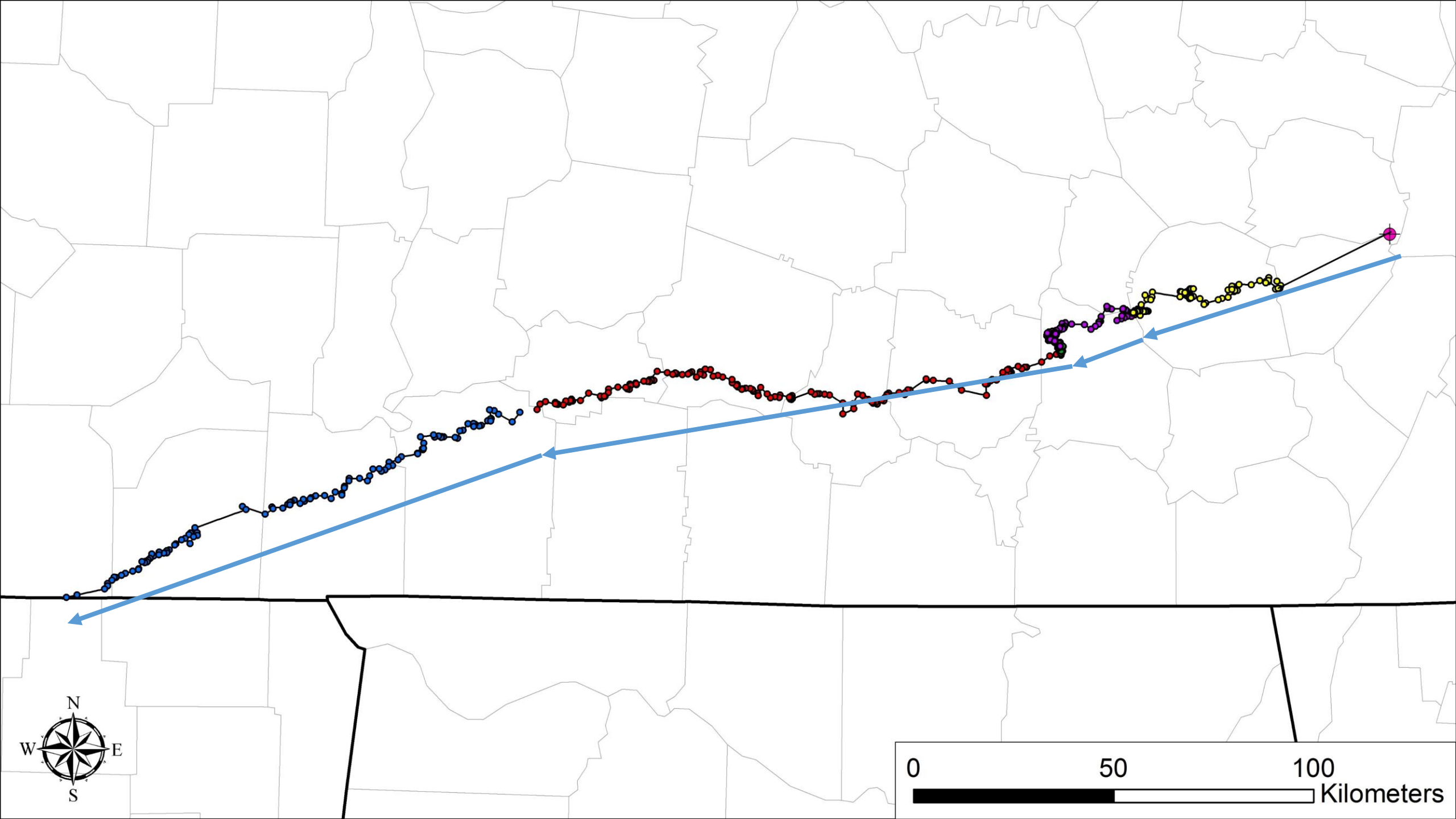
Results - Movement

- Mean duration of active migration movement
  - 2.7±0.4 nights (range: 1 – 5 nights)
- Mean duration of total migration journey
  - 5.3±1.3 nights (range: 1 – 16 nights)
- Reasons for difference
  - Distance ($\bar{x}$ = 187.6±32.9 km, range: 6.2 – 368.1 km)
  - Nightly speed ($\bar{x}$ = 9.4±0.8 km/hr, range: 0.7 – 19.0 km/hr)

Results - Movement

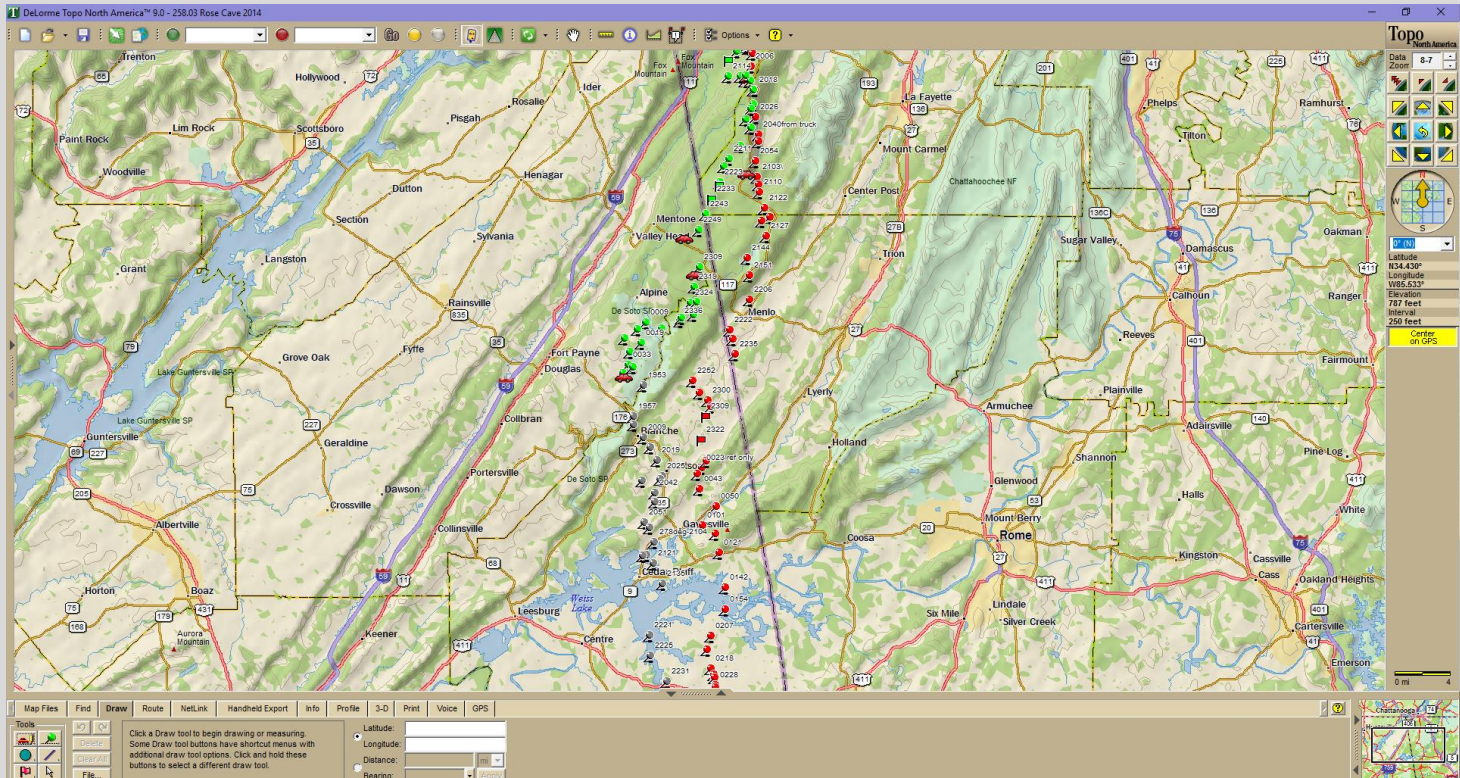
- Wide range in nightly speed
  - Distance

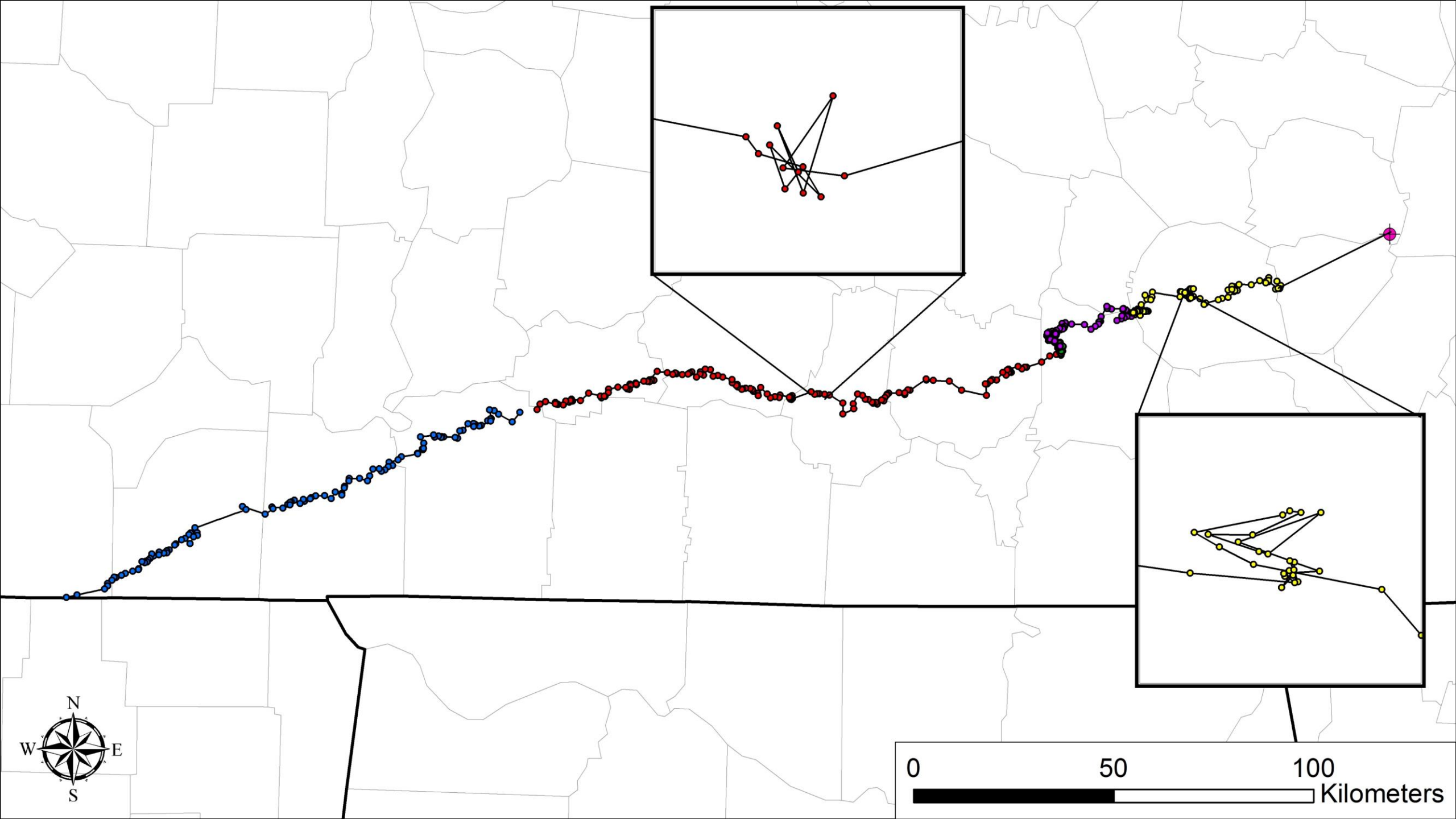

N
W
E
S
0
50
100
Kilometers


N
W
E
S
0
50
100
Kilometers

Results - Movement

- Wide range in nightly speed
  - Distance
  - Foraging

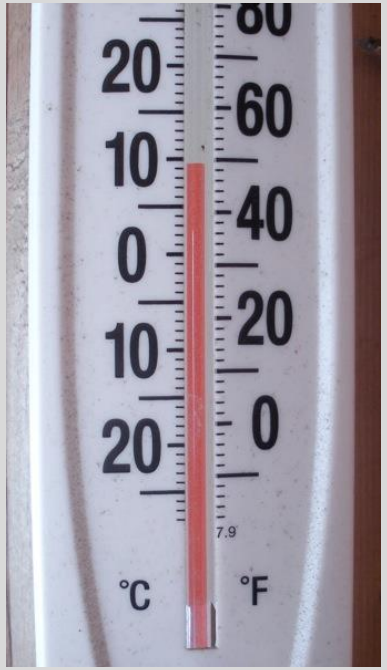


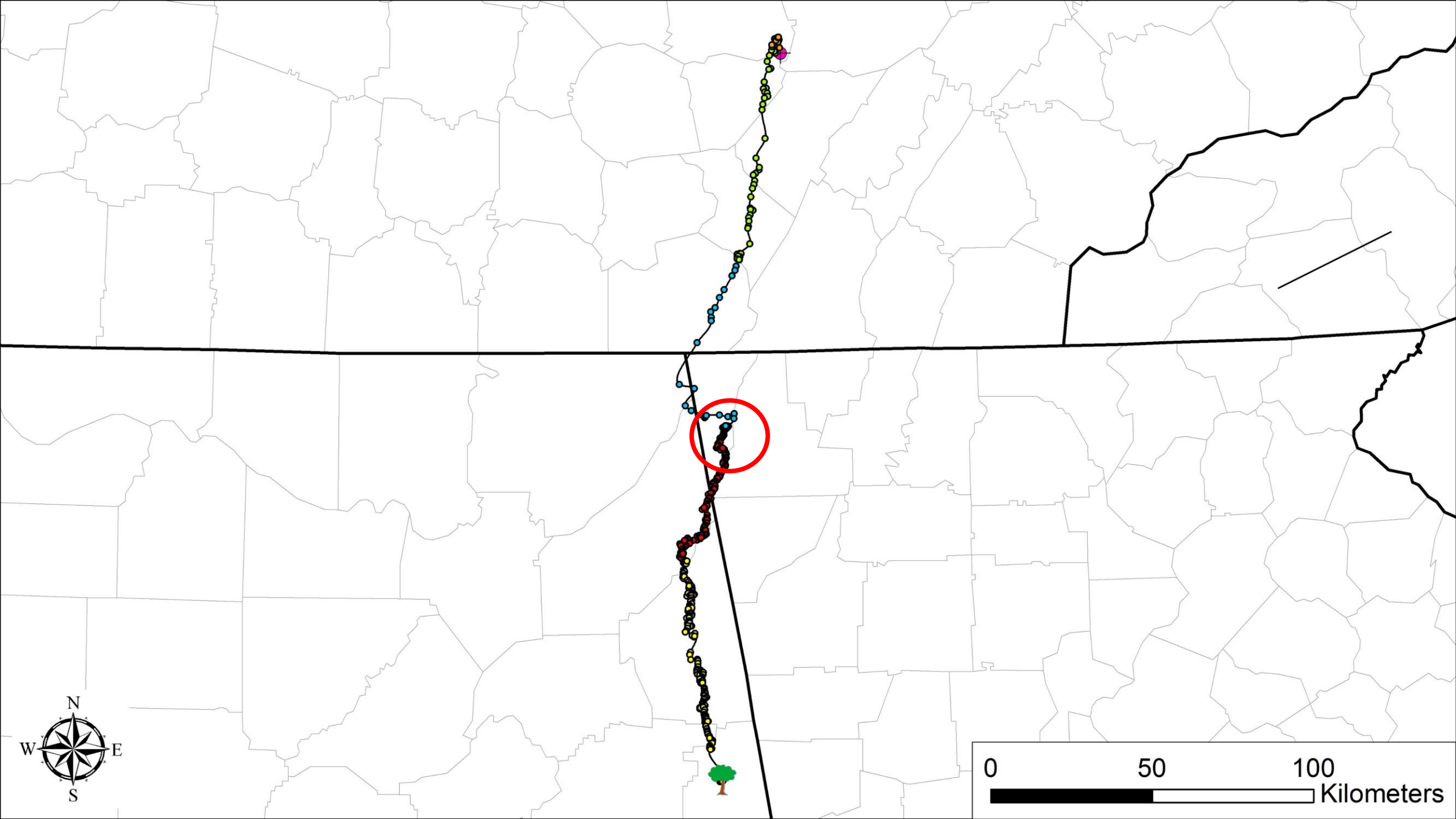

N
W
E
S
0
50
100
Kilometers

Results - Movement

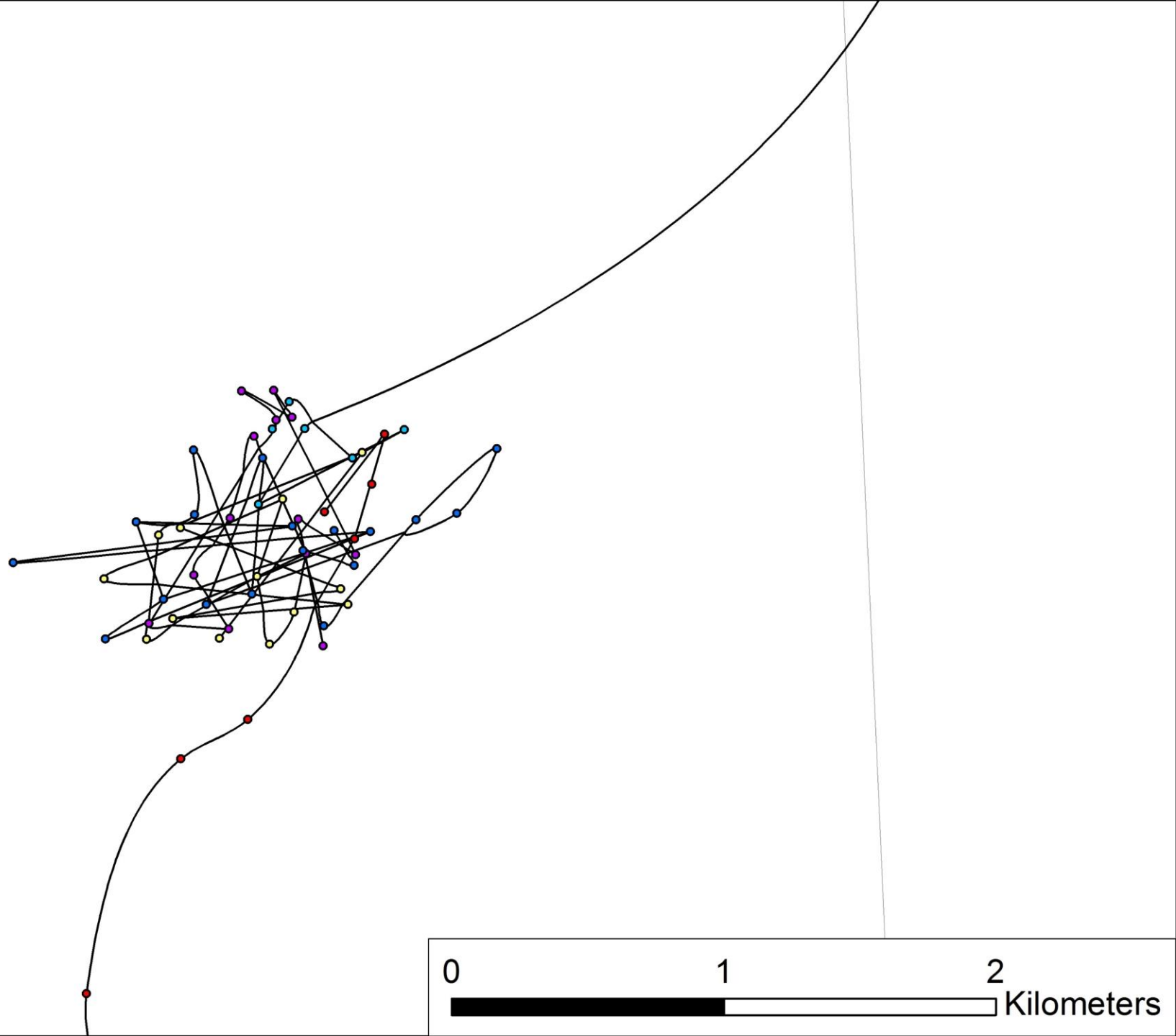
- Mean duration of active migration movement
  - 2.7±0.4 nights (range: 1 – 5 nights)
- Mean duration of total migration
  - 5.3±1.3 nights (range: 1 – 16 nights)
- Reasons for difference
  - Distance ($\bar{x}$ = 162.5±24.1 km, range: 5.8 – 368.1 km)
  - Nightly speed ($\bar{x}$ = 9.4±0.8 km/hr, range: 0.7 – 19.0 km/hr)

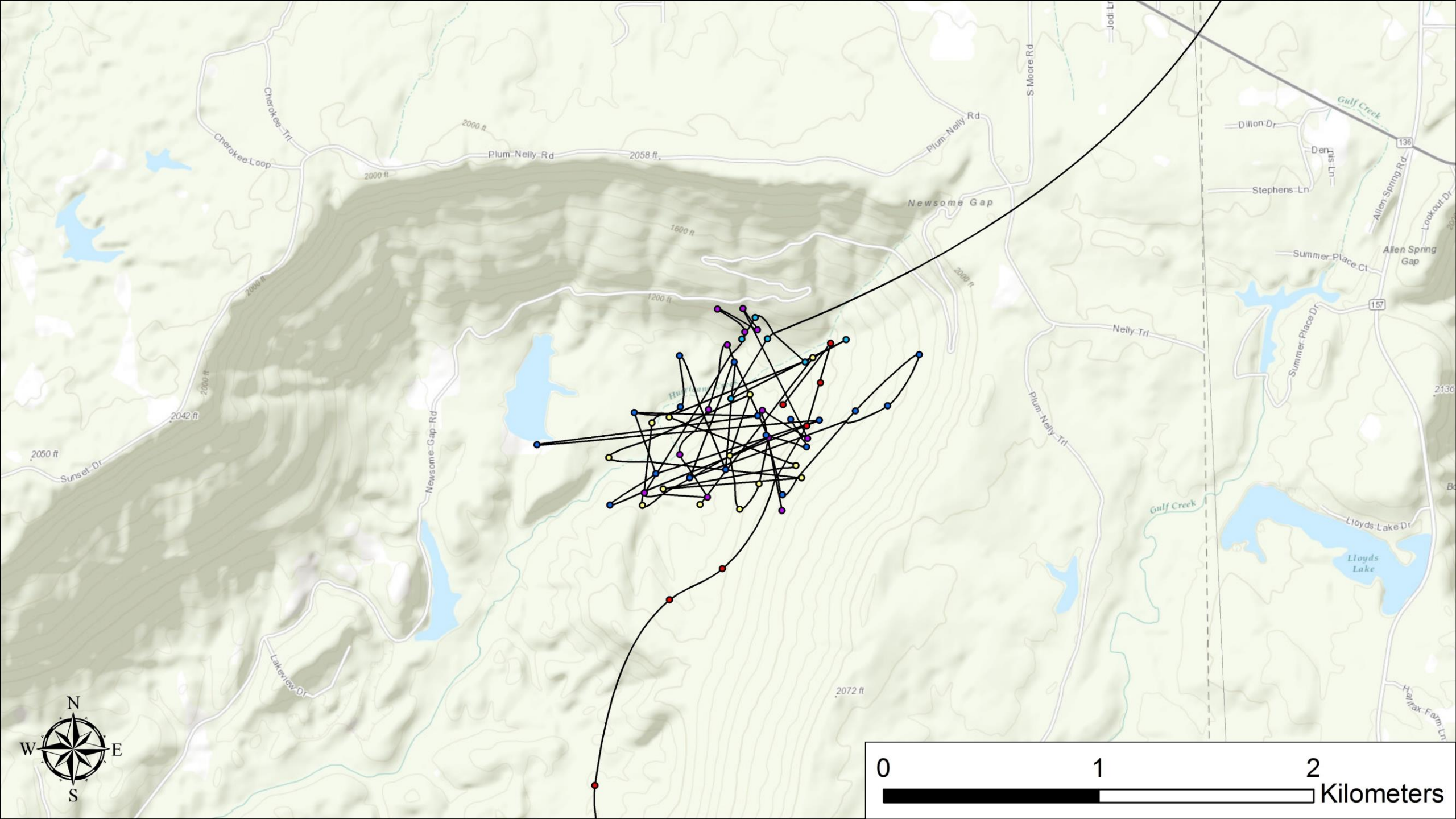
WEATHER




N
W
E
S
0
50
100
Kilometers

4 days



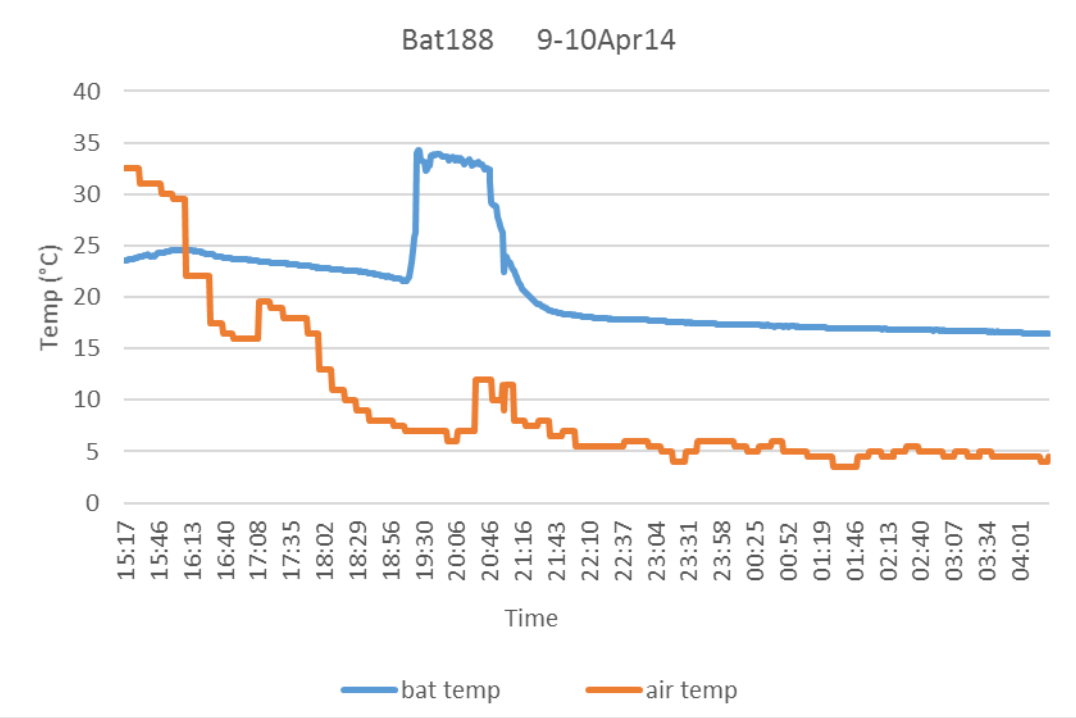

Cherokee Trl
Cherokee Loop
Plum Nelly Rd
2000 ft
2058 ft
Newsome Gap
1600 ft
1200 ft
2000 ft
S Moore Rd
Gulf Creek
Dillon Dr
Dennis Ln
Stephens Ln
Allen Spring Rd
Lookout Dr
Allen Spring Gap
Summer Place Ct
Summer Place Dr
136
157
Nelly Trl
Plum Nelly Trl
Newsome Gap Rd
2042 ft
2050 ft
Sunset Dr
Lakeview Dr
Lloyds Lake Dr
Lloyds Lake
2072 ft
Halfrax Farm Ln
N
W
E
S
0
1
2
Kilometers

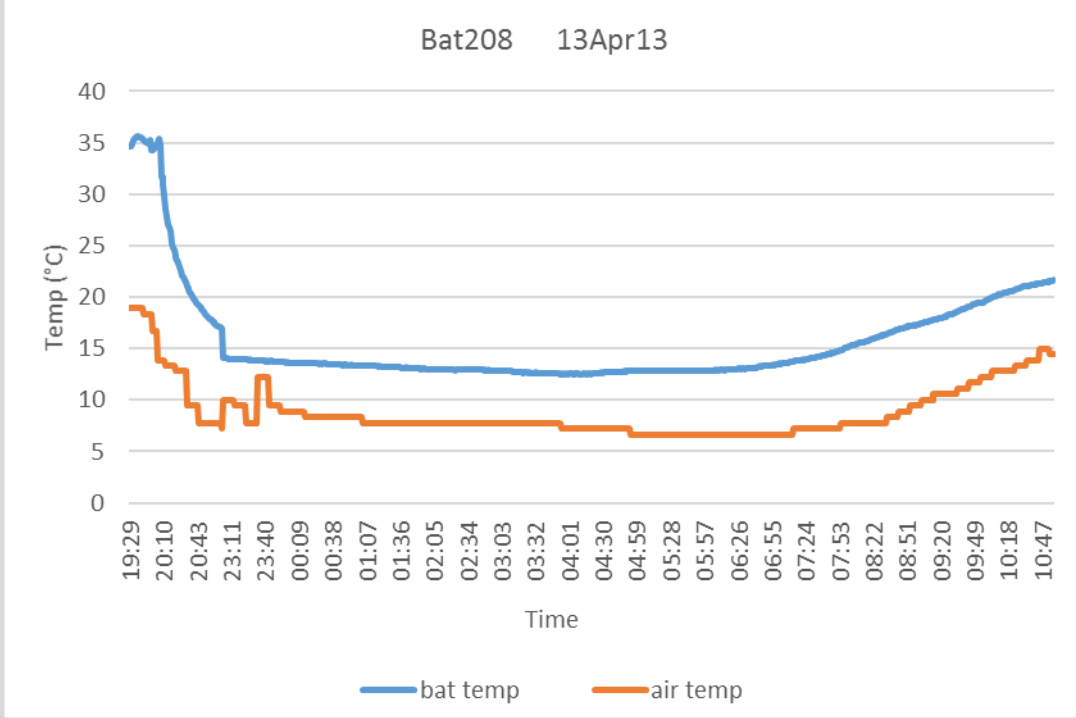
Results – Temperature, day and night

- Mean temp of awake bats = 34.1±0.0°C (range: 25.5 – 38.3°C)
- Mean of air temp = 15.7±0.1°C (range: 4.5 – 38.0°C)

- Mean temp of asleep bats = 19.8±0.1°C (range: 11.9 – 34.4°C)
- Mean of air temp = 14.4±0.1°C (range: 3.5 – 40.0°C)

Results – Temperature, day and night





Results – Temperature, day and night

- Take home message –

  Spring migrating bats are not active when ambient temperature is < 10°C

  0.5% of active bat temps occurred when ambient < 10°C

  (9 ambient temperature data points out of 1,641)

  - If active, not for long.
    - May be searching for a roost
    - May be in a roost and observers couldn't tell for sure

Discussion

- Hypothesis 1 – Bats migrate north
- Hypothesis 2 - Bats will stop along their migration path to forage
- Hypothesis 3 - Bat behavior will be altered by inclement weather

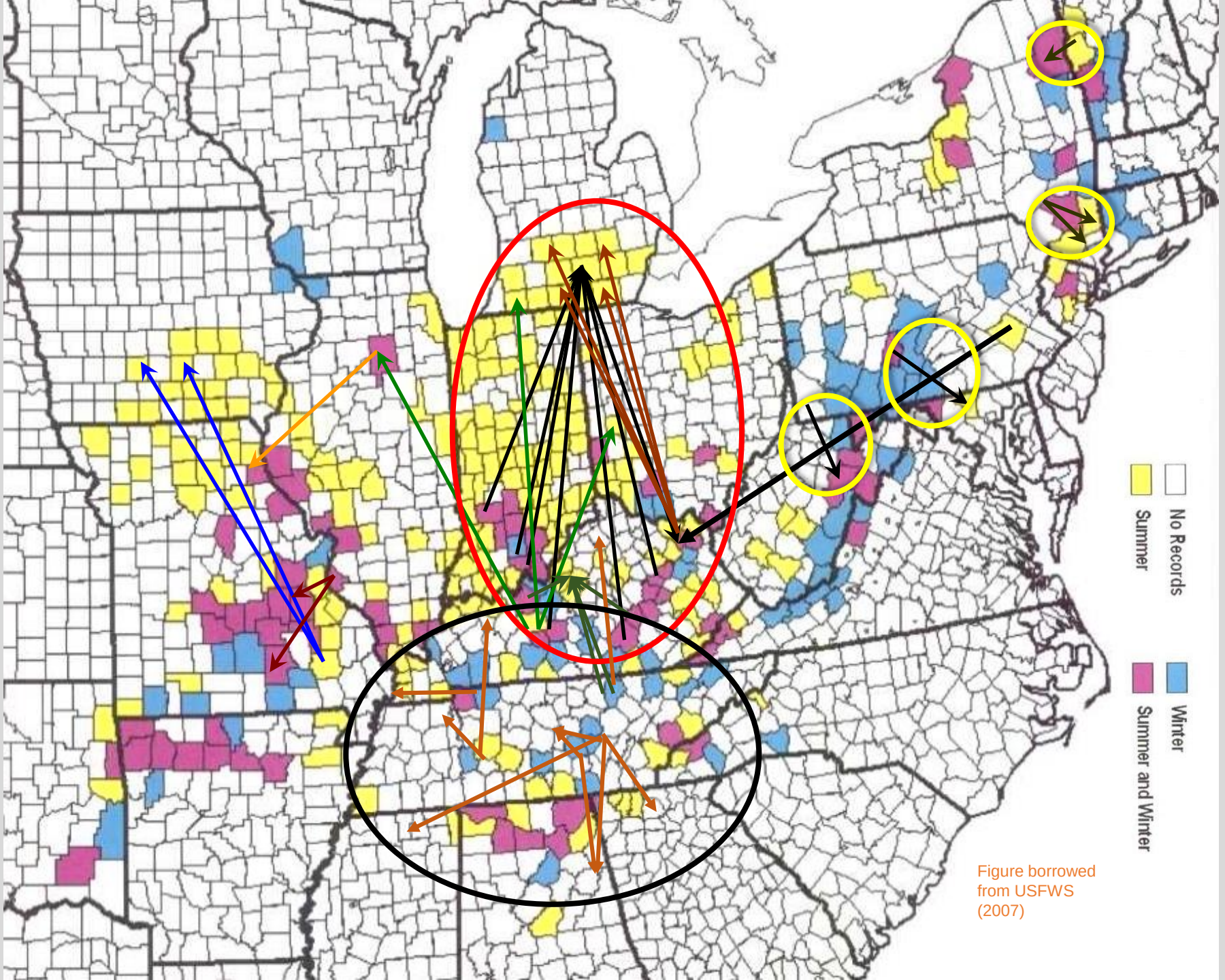


Figure borrowed from USFWS (2007)

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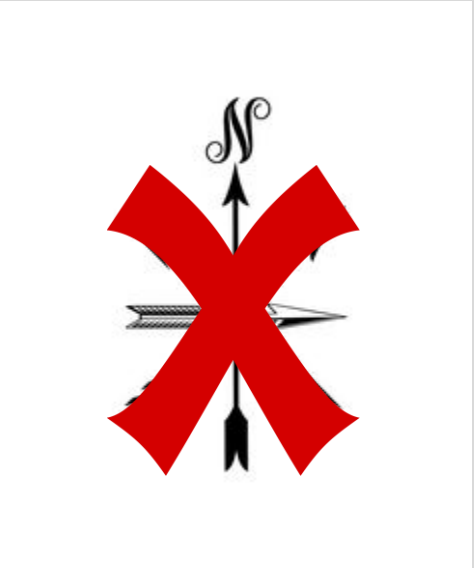

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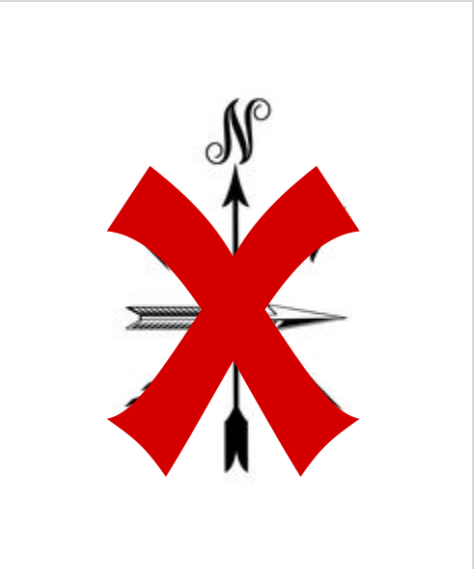

Conclusion – Wind Industry

- Bats fly relatively straight paths from hibernacula to summer grounds
  - Know the connections (banding, tracking) before you site your turbines

- Migrating bats stop migrating when it gets cold
  - Program turbines to operate when temps drop below 10°C (???)

Future plans

- Landscape analysis
  - Anecdotally: utilized forested areas, but travelled quickly across open fields (IN)
- Determine altitude
  - Anecdotally: flying at treetop or below
- Compare to autumn migrating bats – highest time for turbine mortality
- Spring and autumn migration in other regions
- Migration studies with other bat species

Acknowledgements

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TVA
Tennessee Valley Authority

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DEPT. OF NATURAL RESOURCES
WILDLIFE RESOURCES
LAW ENFORCEMENT
GEORGIA

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TENNESSEE
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