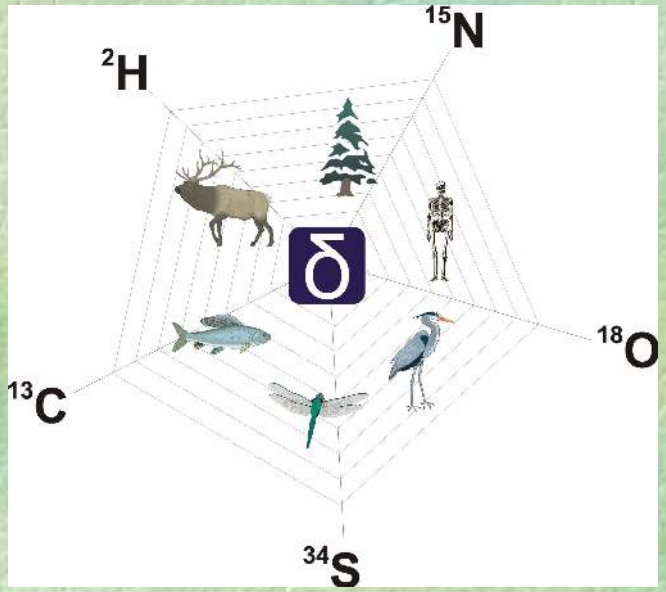
Tracking bird movements using stable-hydrogen isotopes

Keith A. Hobson



Principles of isotopic tracking

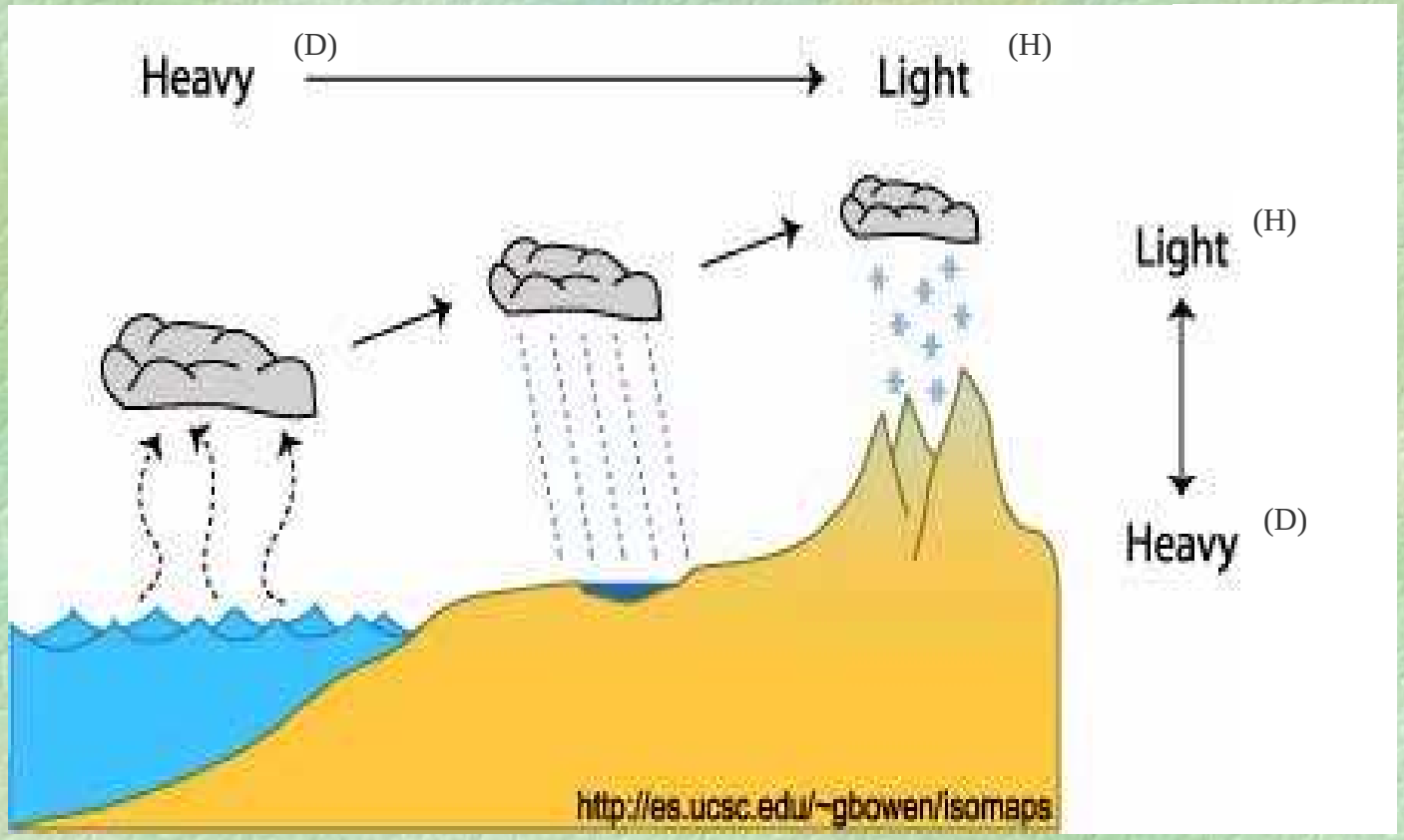
- Animals move between unambiguous isotopically distinct “landscapes” and their tissues retain this information.
- Information “time window” depends on tissue chosen.
- Feathers are inert following formation and so lock in the isotope signal at the site of feather growth

N.A. avian band recoveries (1955-2000)

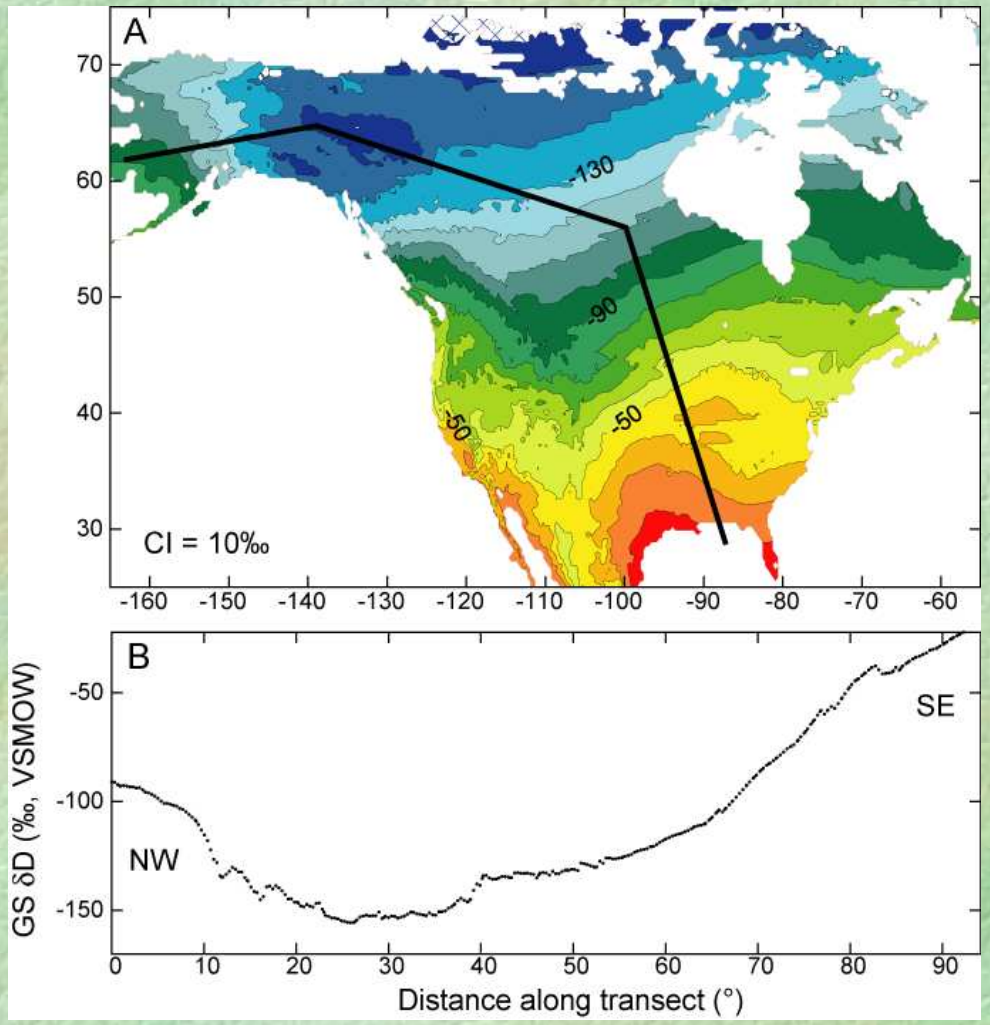
Species	Banded	recap	%
Canada Goose	2,991,538	594,114	19.9
Mallard	5,935,960	878,704	14.8
N. Pintail	1,286,499	142,449	11.1
Merlin	26,308	674	2.6
Logg.shrike	22,897	196	0.86
Sp. sandpiper	13.673	79	0.58
R-t. hummingbird	54,218	53	0.10
Am. redstart	275,222	256	0.09
Myrtle warbler	824,013	704	0.09
W. flycatcher	28,194	20	0.07
Sw. thrush	371,313	251	0.07

So, there are good reasons to band birds but creating connectivity maps using band recoveries is not really one of them ……

The BIG breakthrough: Using deuterium …..

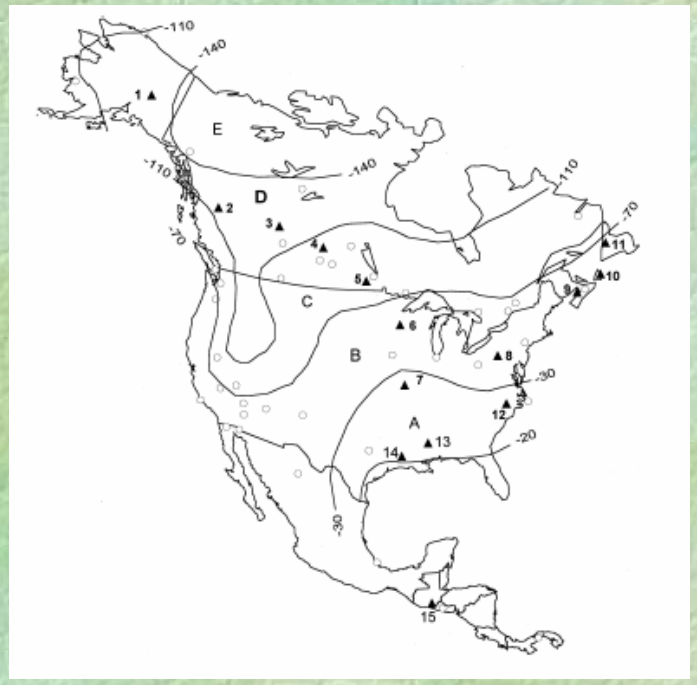


The mean annual precipitation δD pattern:

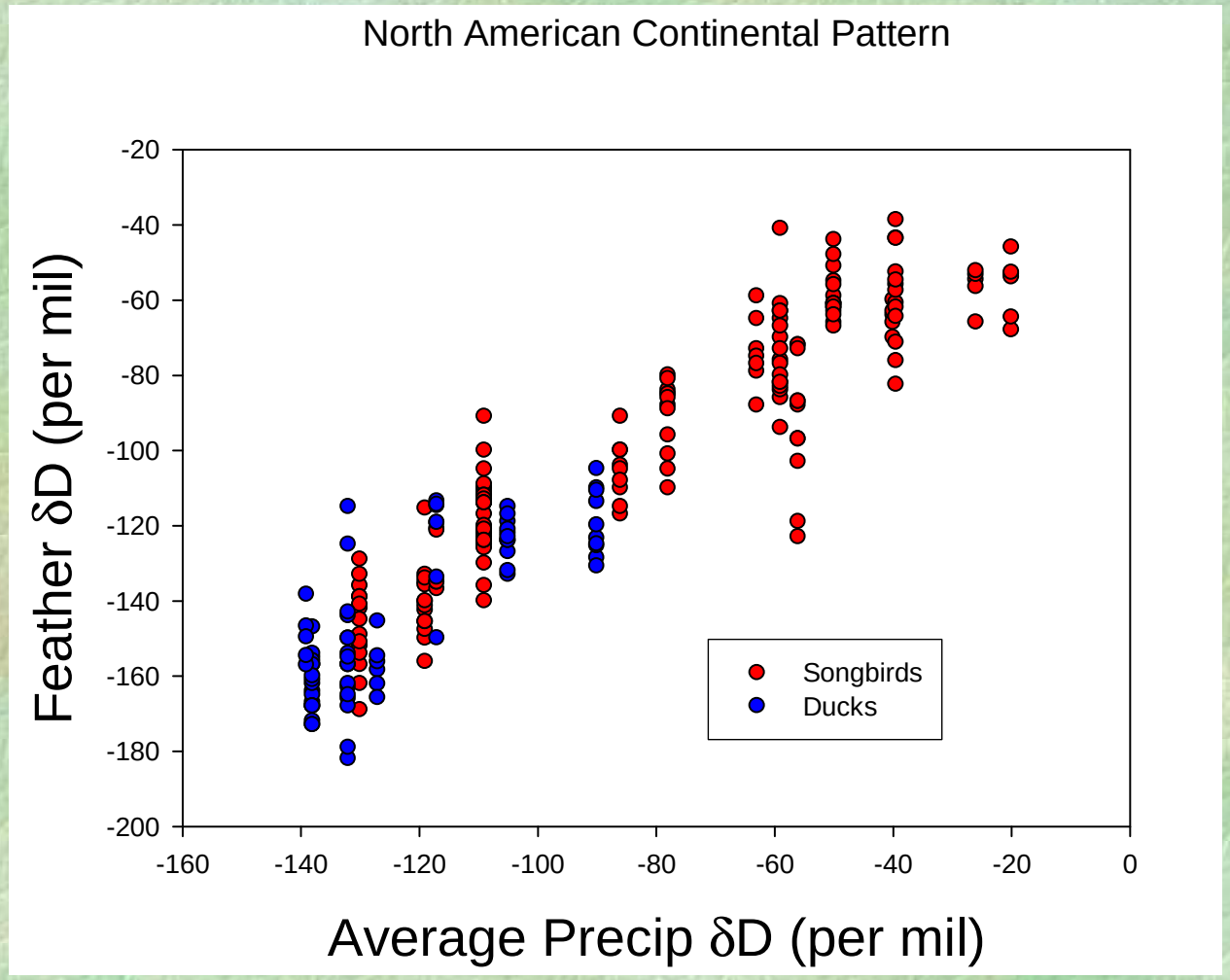


Bowen et al. 2005

How does this pattern translate into bird feathers?



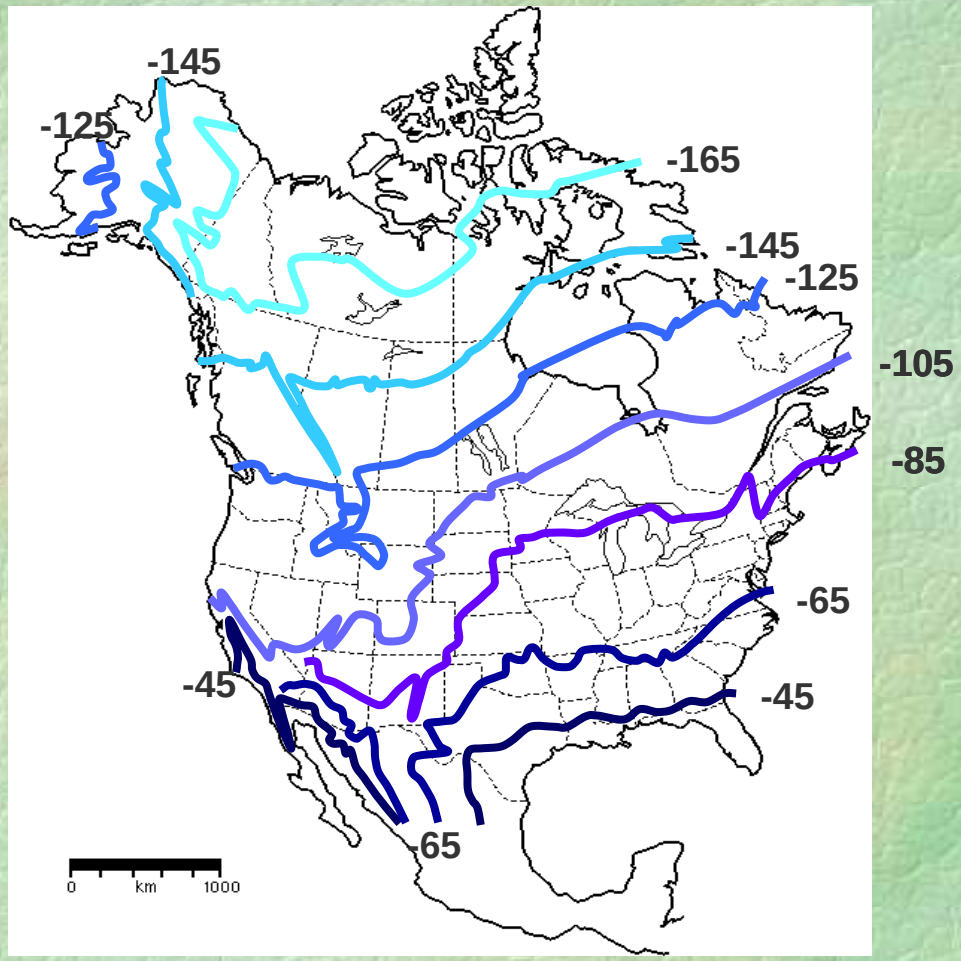
Hobson and Wassenaar *Oecologia* 109:142-148


North American Continental Pattern
Feather δD (per mil)
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-160
-140
-120
-100
-80
-60
-40
-20
0
Songbirds
Ducks
Average Precip δD (per mil)

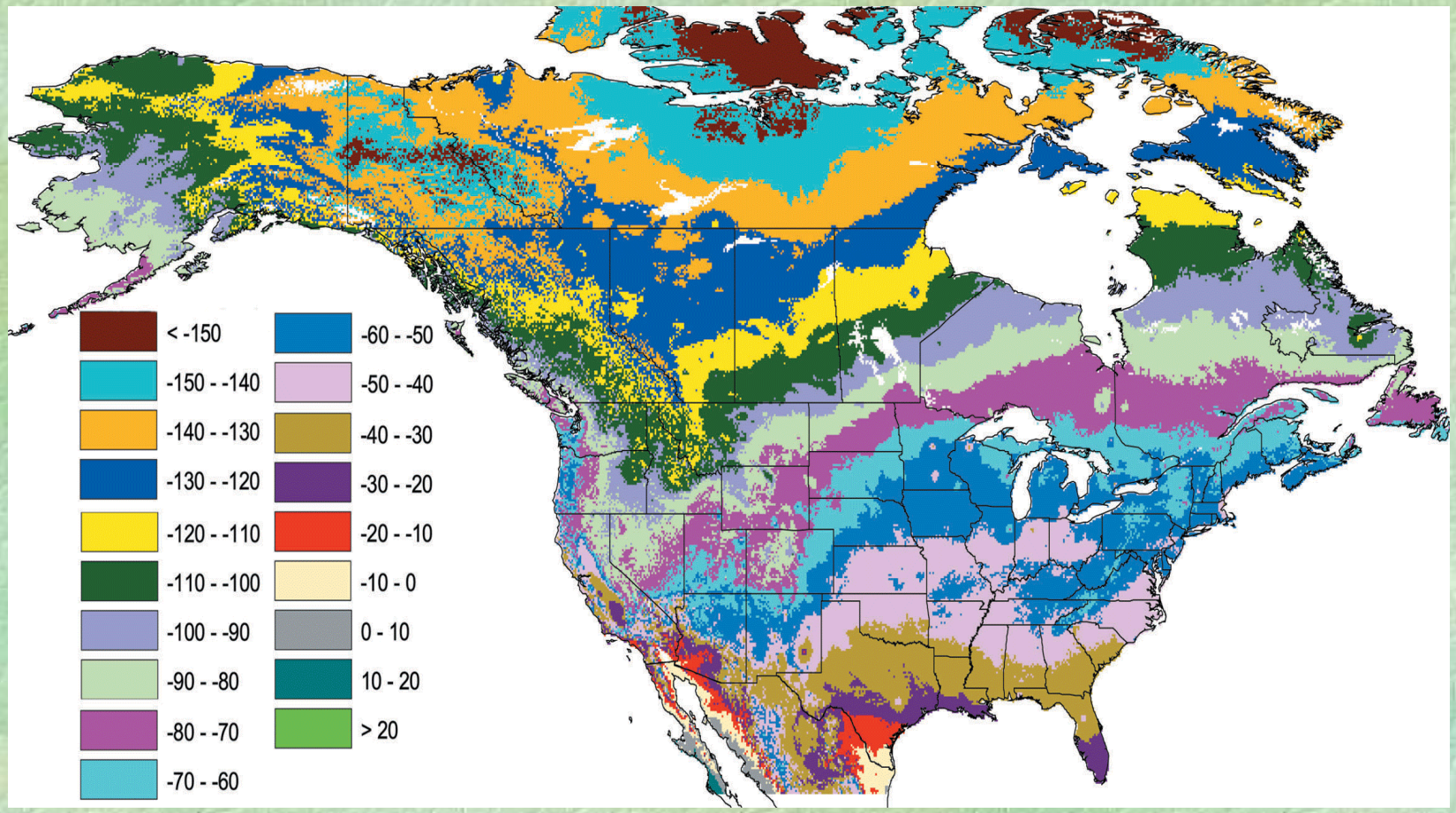
- Based on a 40+ year IAEA dataset
- Can be portrayed as the “growing-season average” pattern (e.g. Meehan et al. 2004) OR as an annual average (Bowen et al.) or monthly.
- Involves patterns corrected for elevation or not in the interpolation.
- Lacks an analysis of spatial/temporal variance.
- Some areas of the continent are poorly represented

- However, we are typically interested in the pattern of deuterium in organisms and not in precipitation per se.
- This requires knowledge of the isotopic discrimination between precipitation and the organism of interest.
- For songbirds, ducks and cranes, we use a value of -25 per mil, but other groups differ.

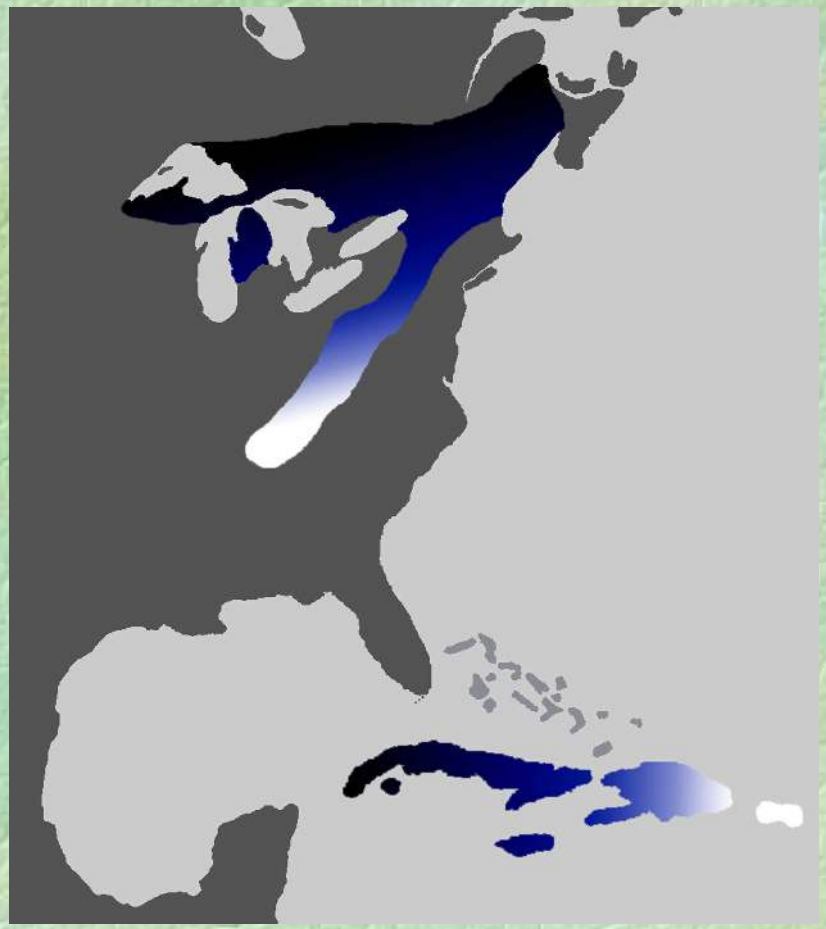
For most birds, their feathers should follow this map…



For raptors, a bit different…



Some examples of how the deuterium approach have been used

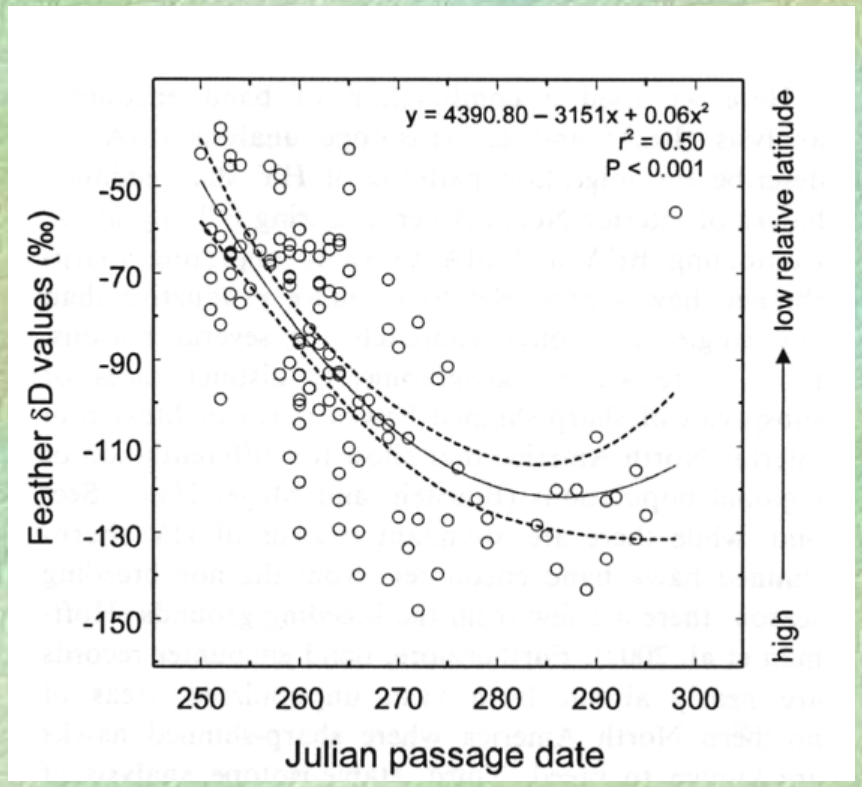


Rubenstein et al. (Science 2002)

“Leapfrog” migration revealed ..

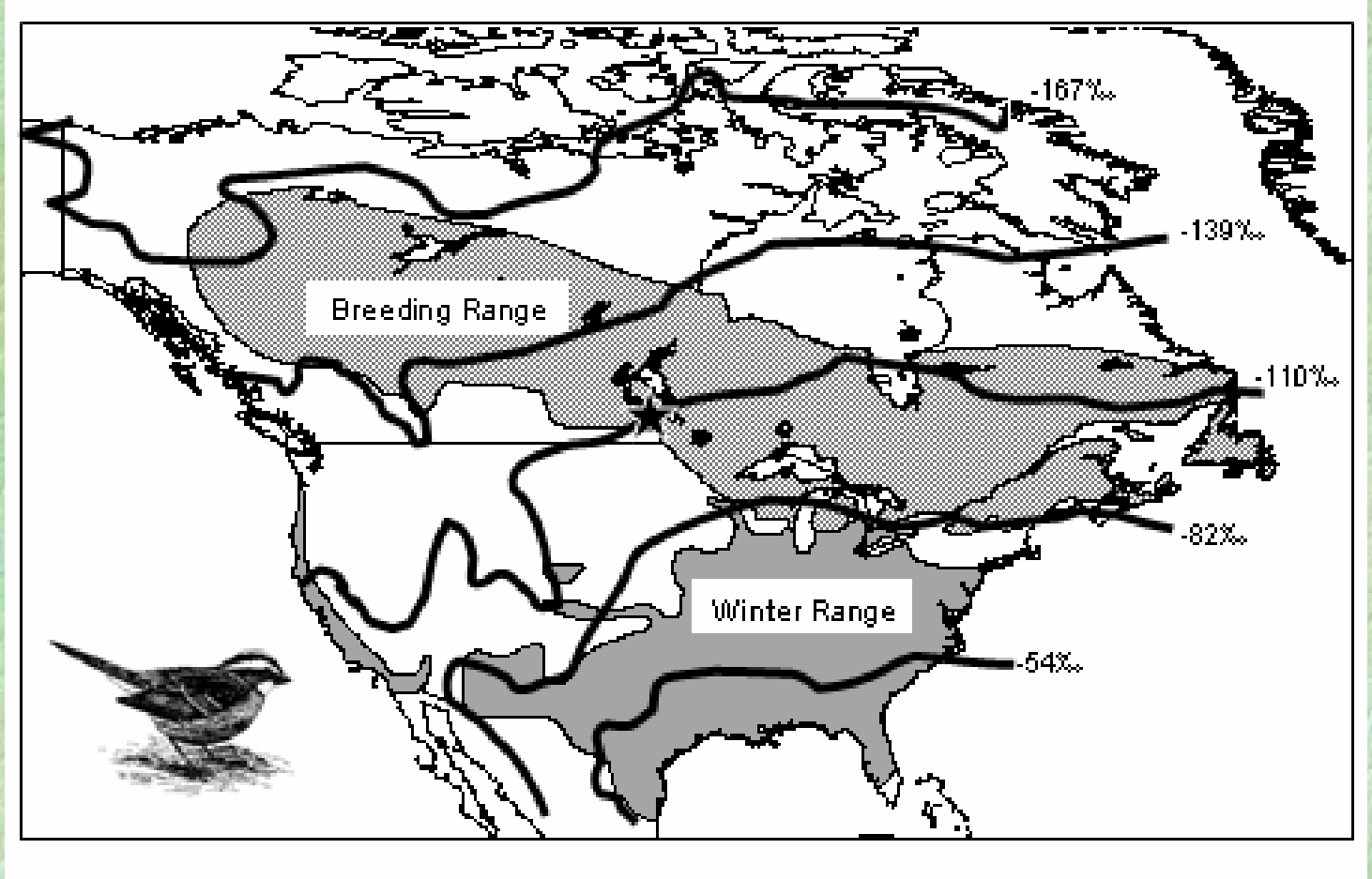
Kelly et al. (Oecologia 2002)

Passage times and origins of migrating hawks ….more northern birds arrive later …

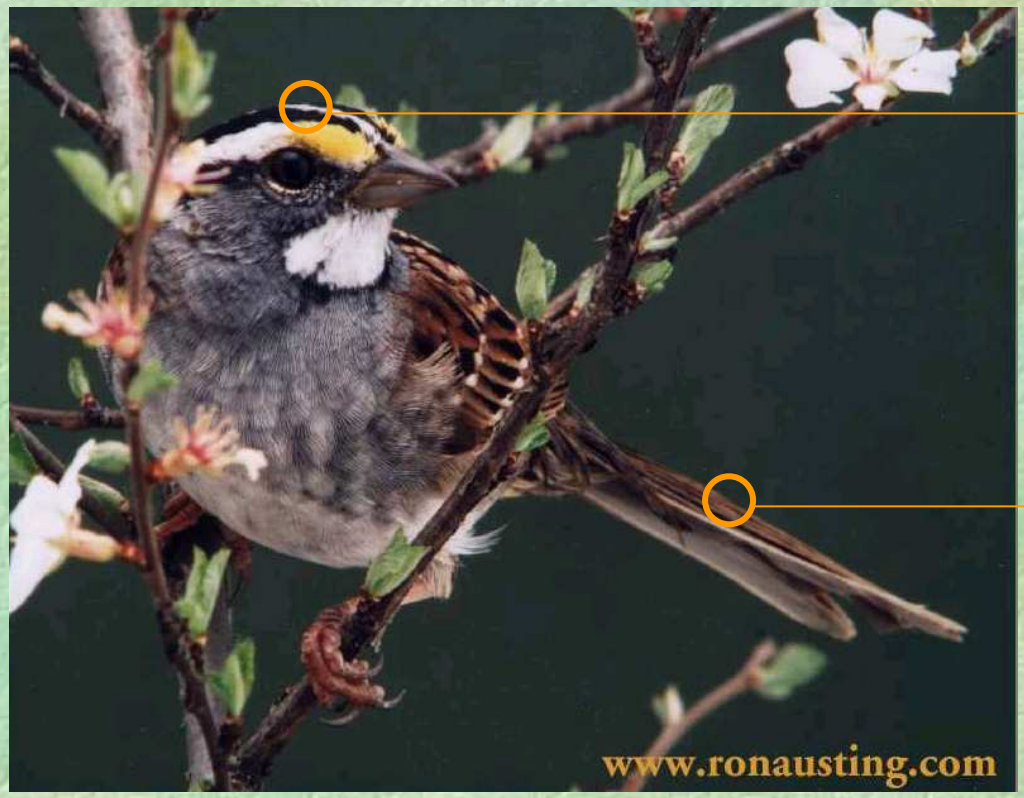


Smith et al. *J.A.B.* 34:387-392

More information from migration monitoring stations …..



Breeding- and Wintering-Ground Tracers

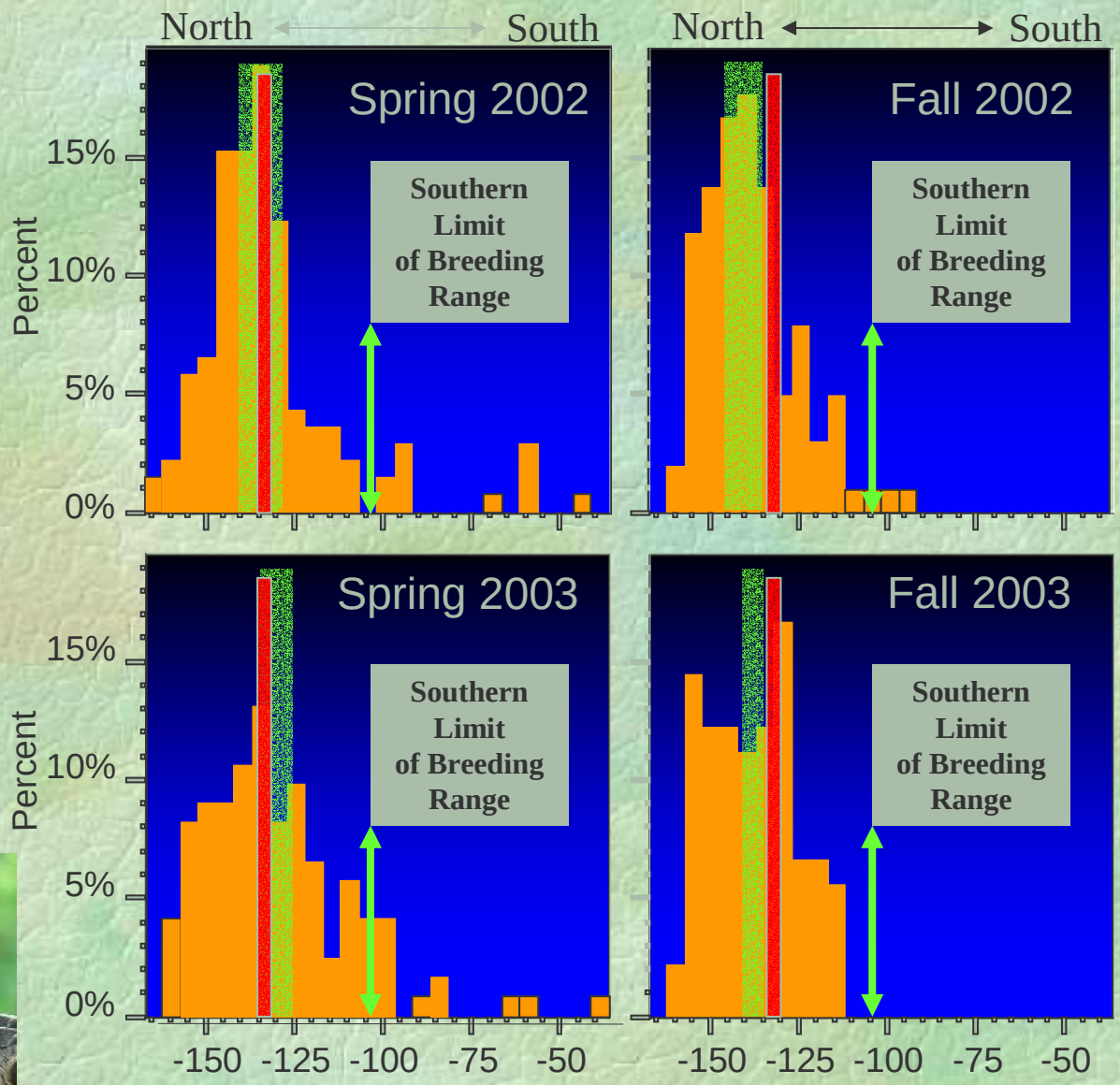


δD Head Feathers
(wintering ground)

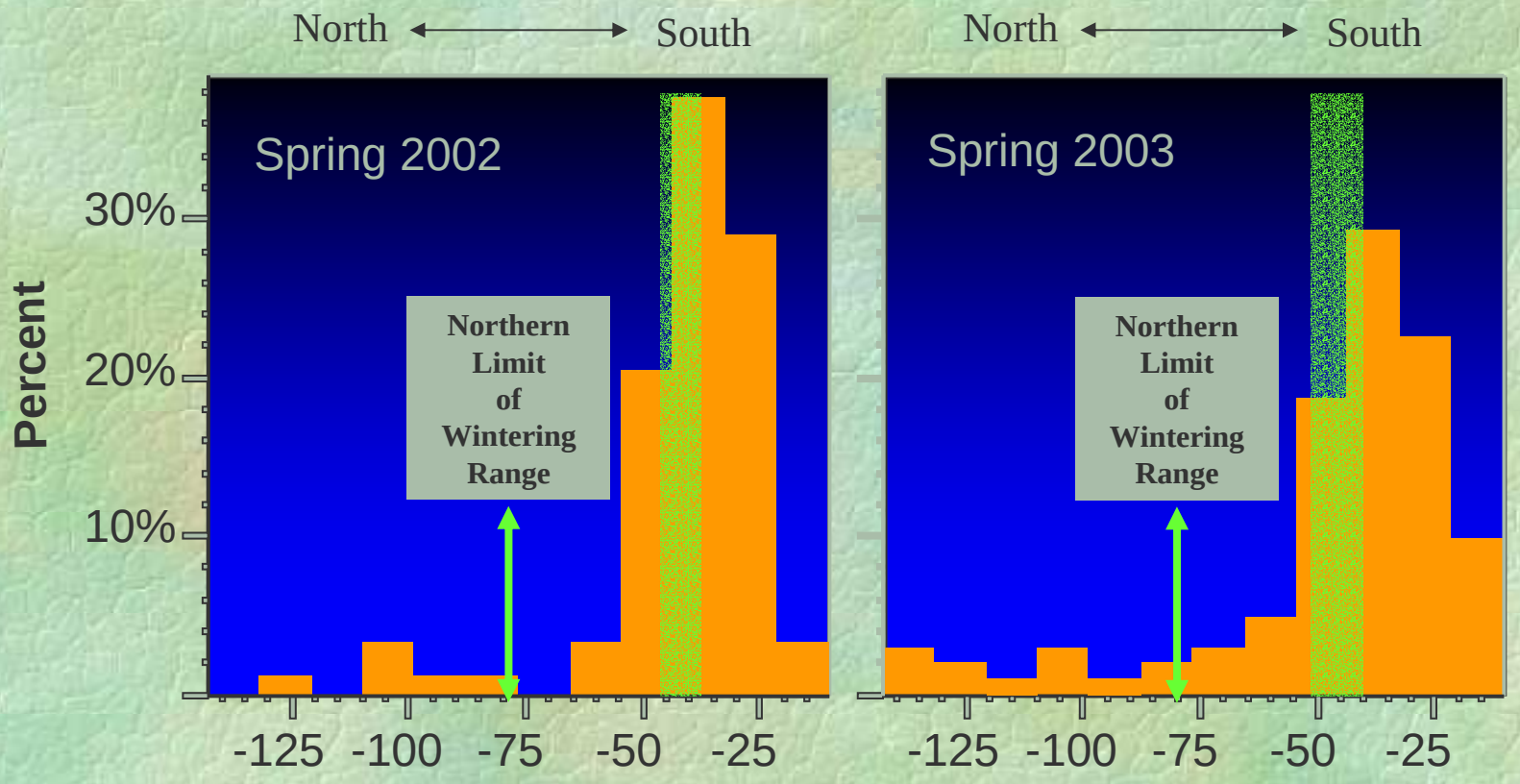
δD Tail Feathers
(breeding ground)

Mazerolle and Hobson *Condor 107:280-288*

Breeding-Ground Tracer

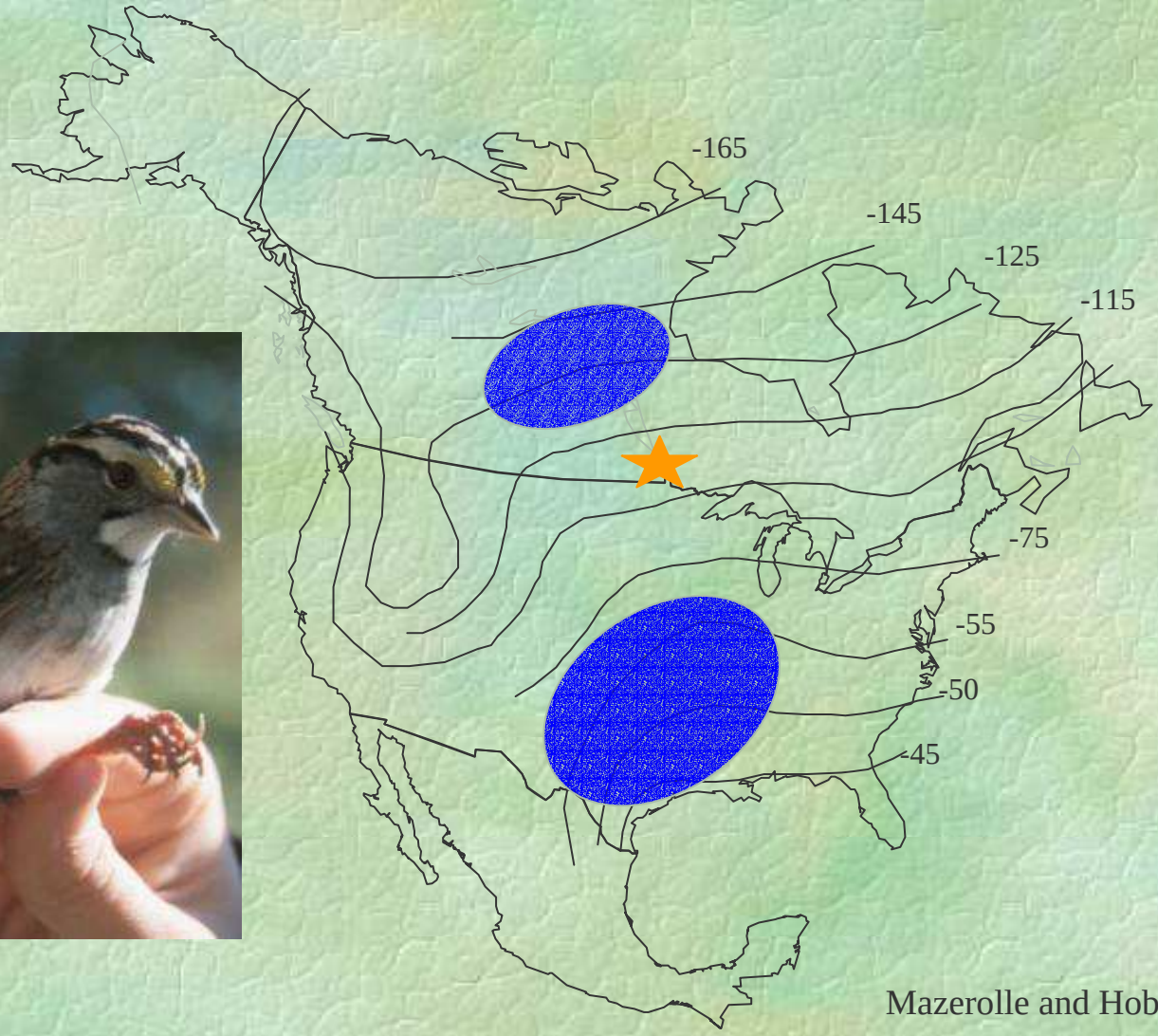


Wintering-Ground Tracer



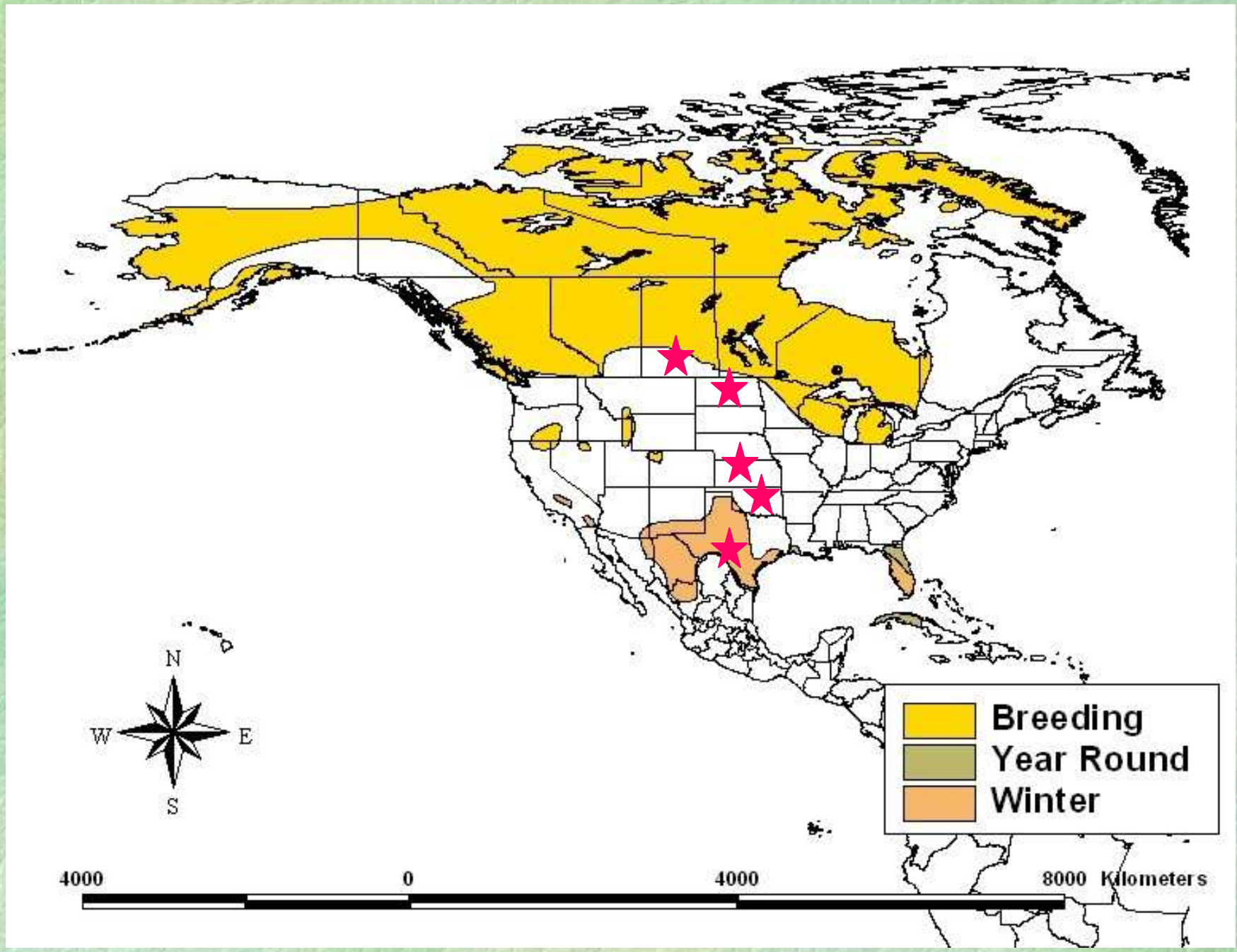
δD Head Feathers (‰)

Catchment area of White-throated Sparrows banded at the Delta Marsh Bird Observatory

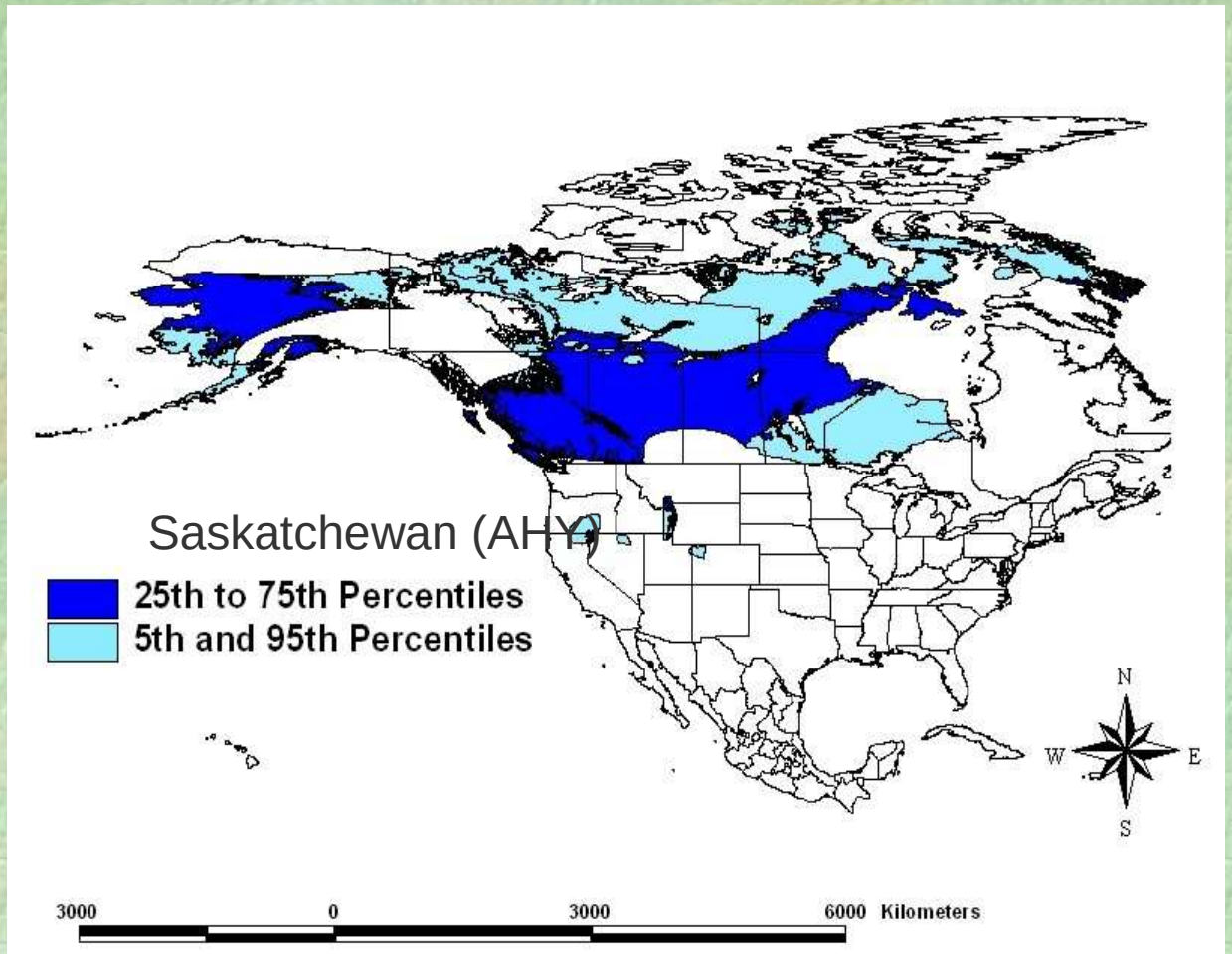


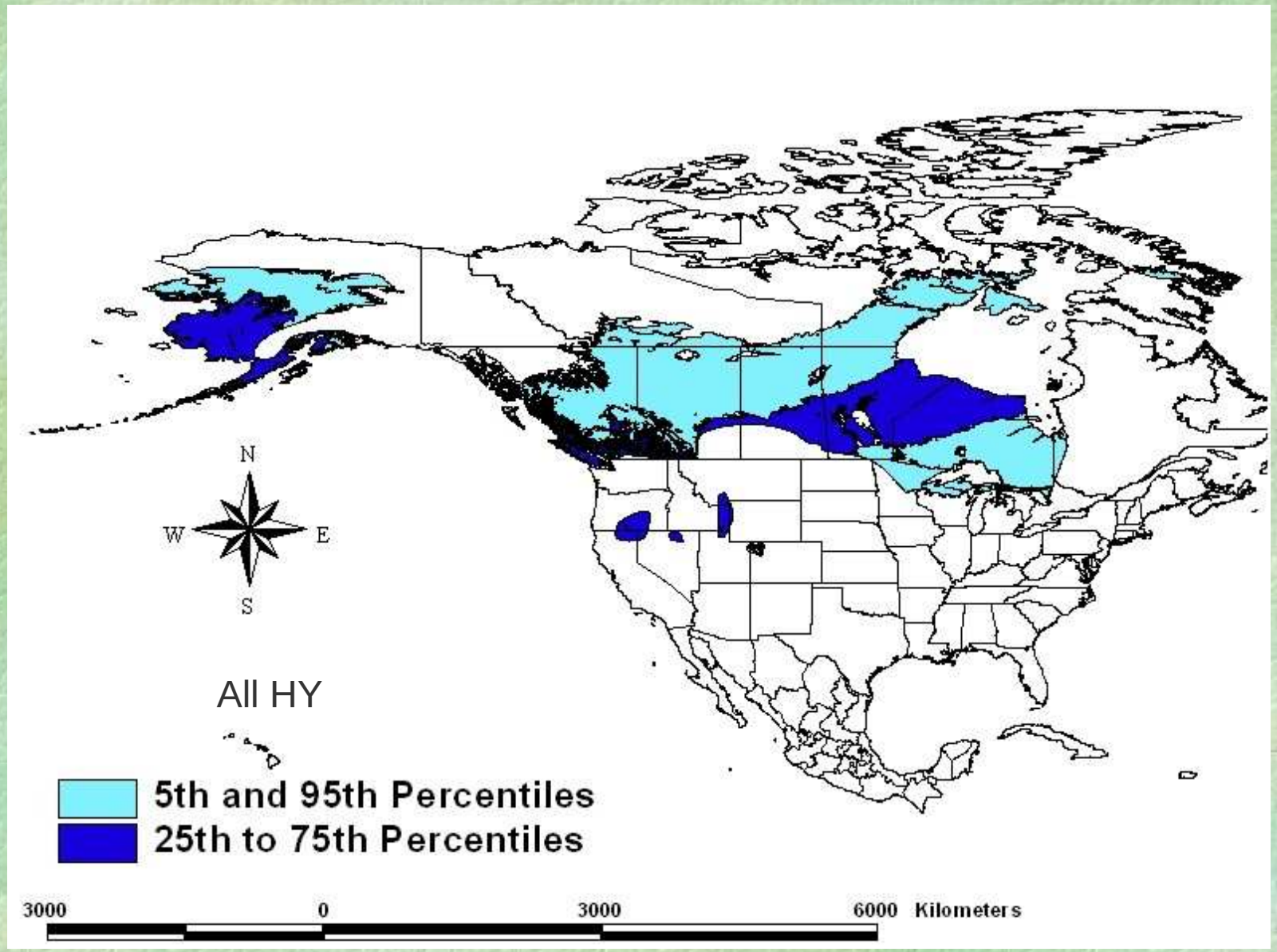
Mazerolle and Hobson

Origins of hunter-killed Sandhill Cranes?

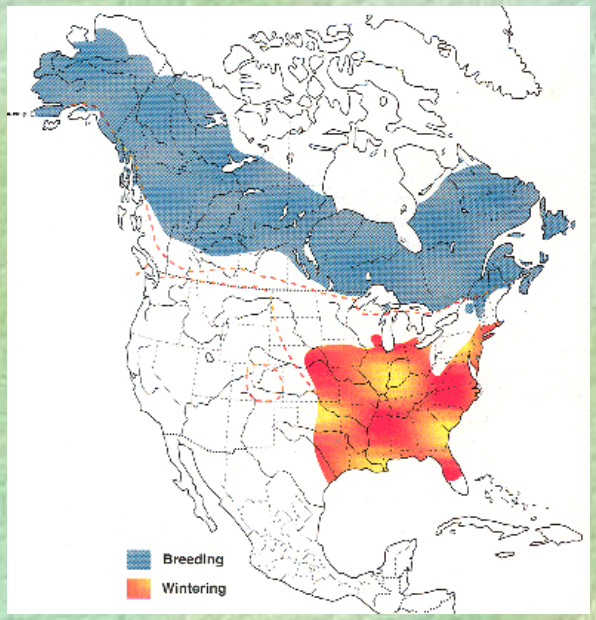

N
W
E
S
Breeding
Year Round
Winter
4000
0
4000
8000 Kilometers

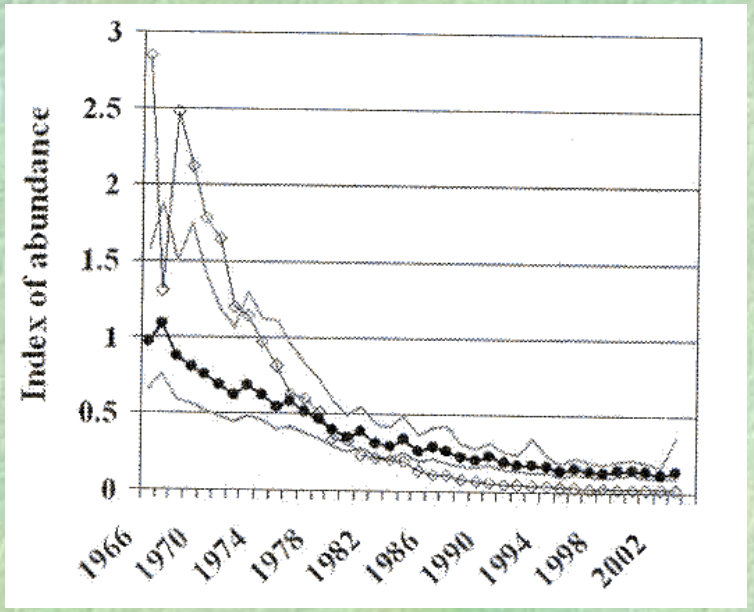
Combining isotope results with the isotope basemap GIS layer ….



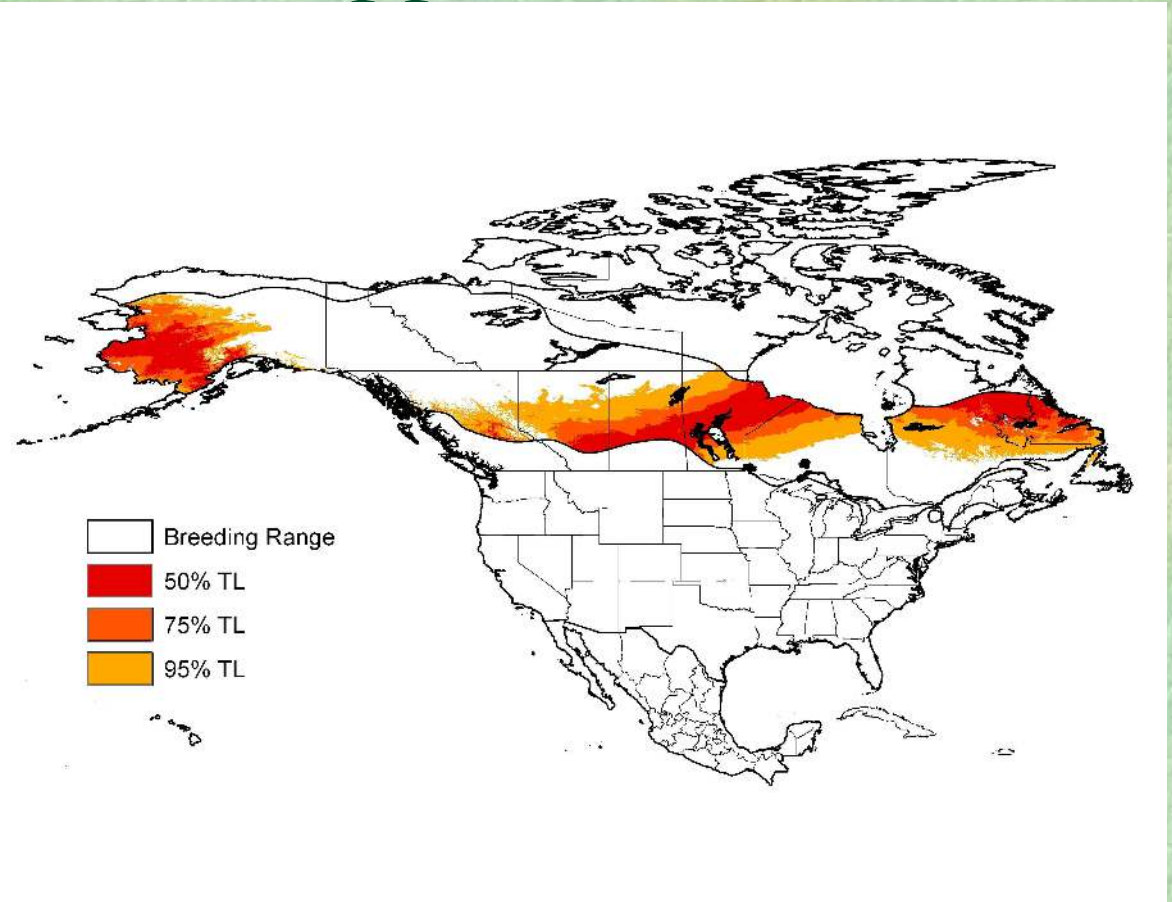

N
W
E
S
All HY
5th and 95th Percentiles
25th to 75th Percentiles
3000
0
3000
6000 Kilometers

Rusty Blackbird

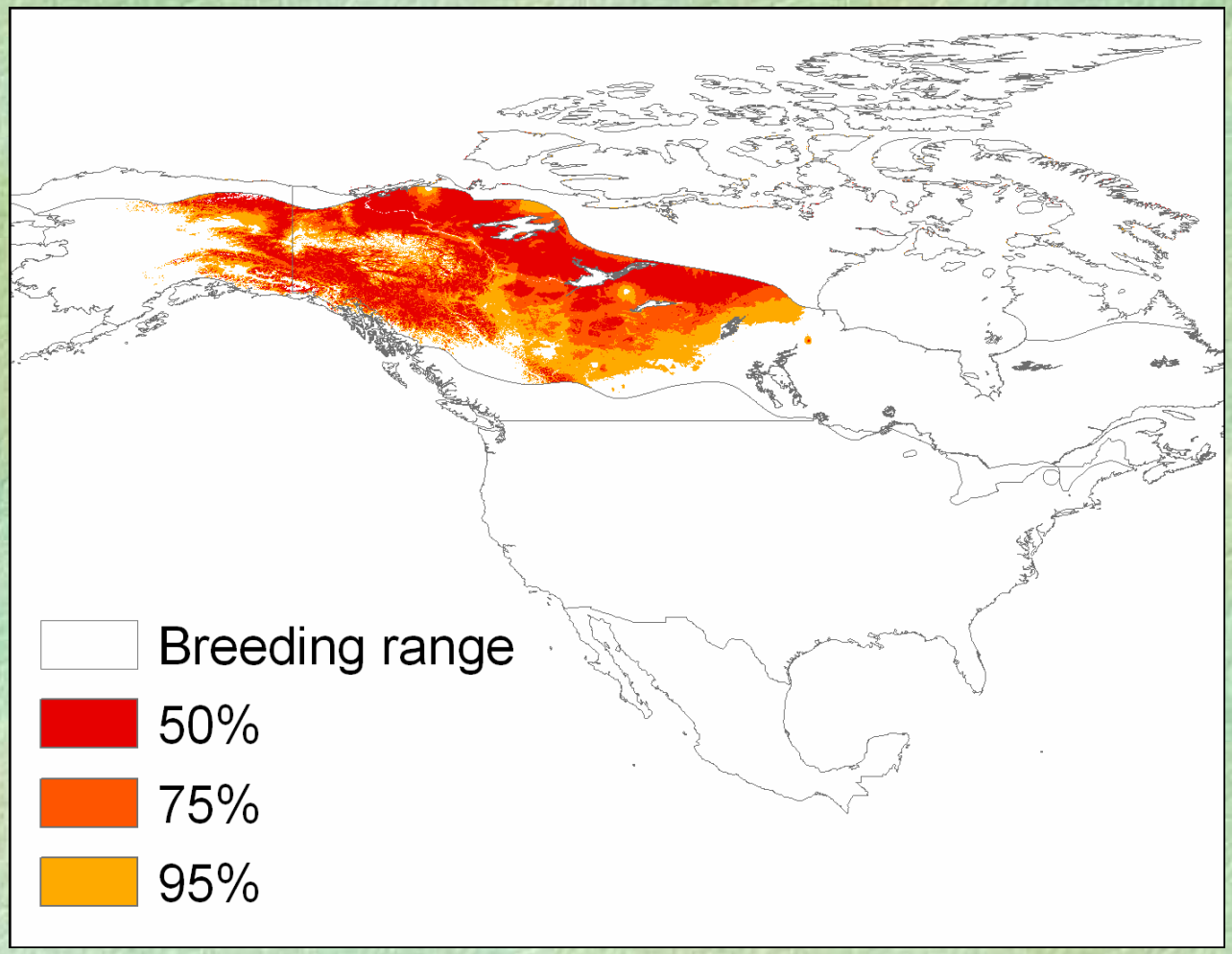




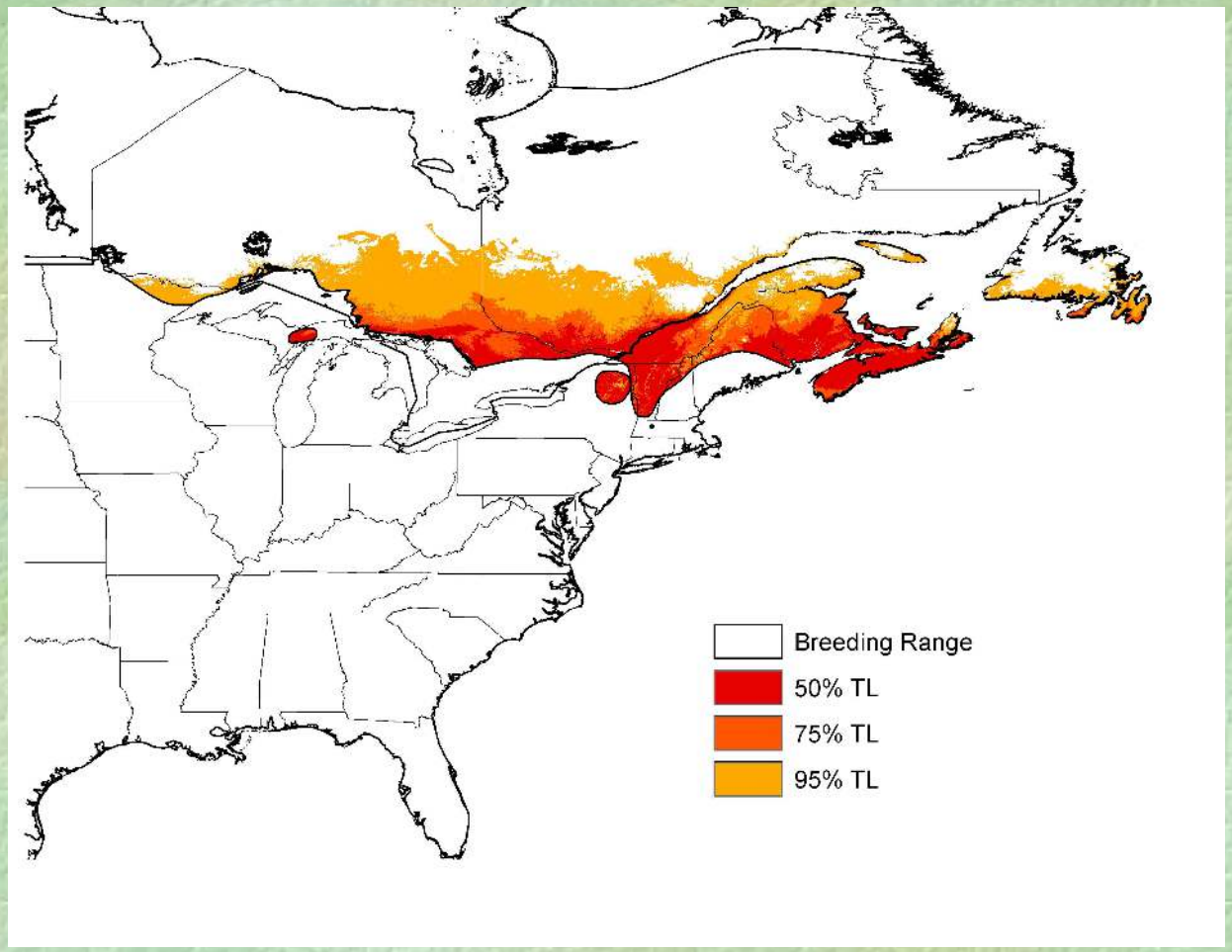
Historical distribution from museum skins (n=199) for birds wintering west of the Appalachians.



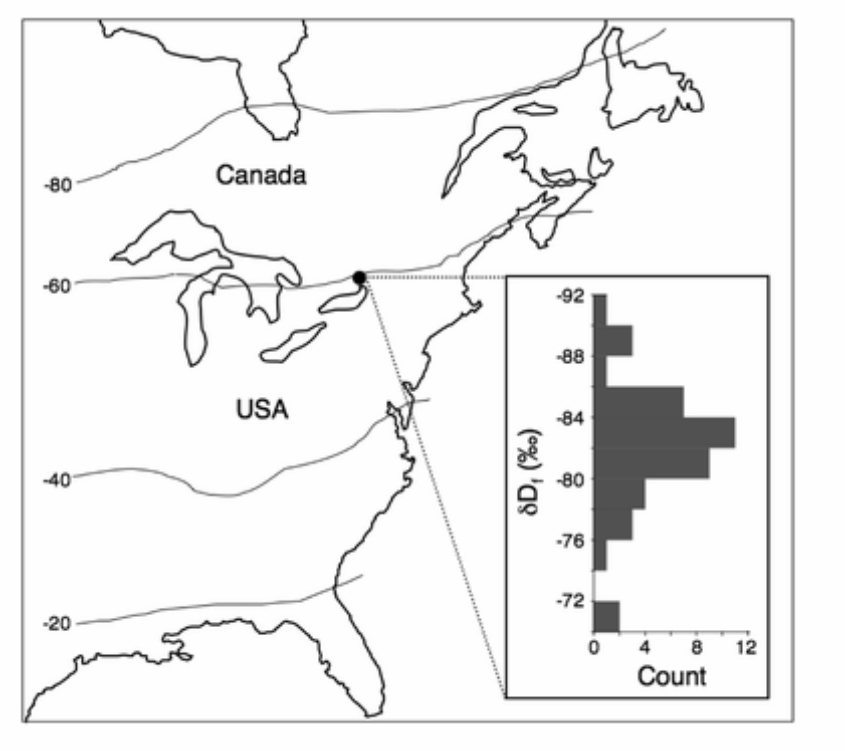
Current origins from birds wintering west of the Appalachians (n=140)….



Origins of birds wintering east of the appalachians (n=67) …



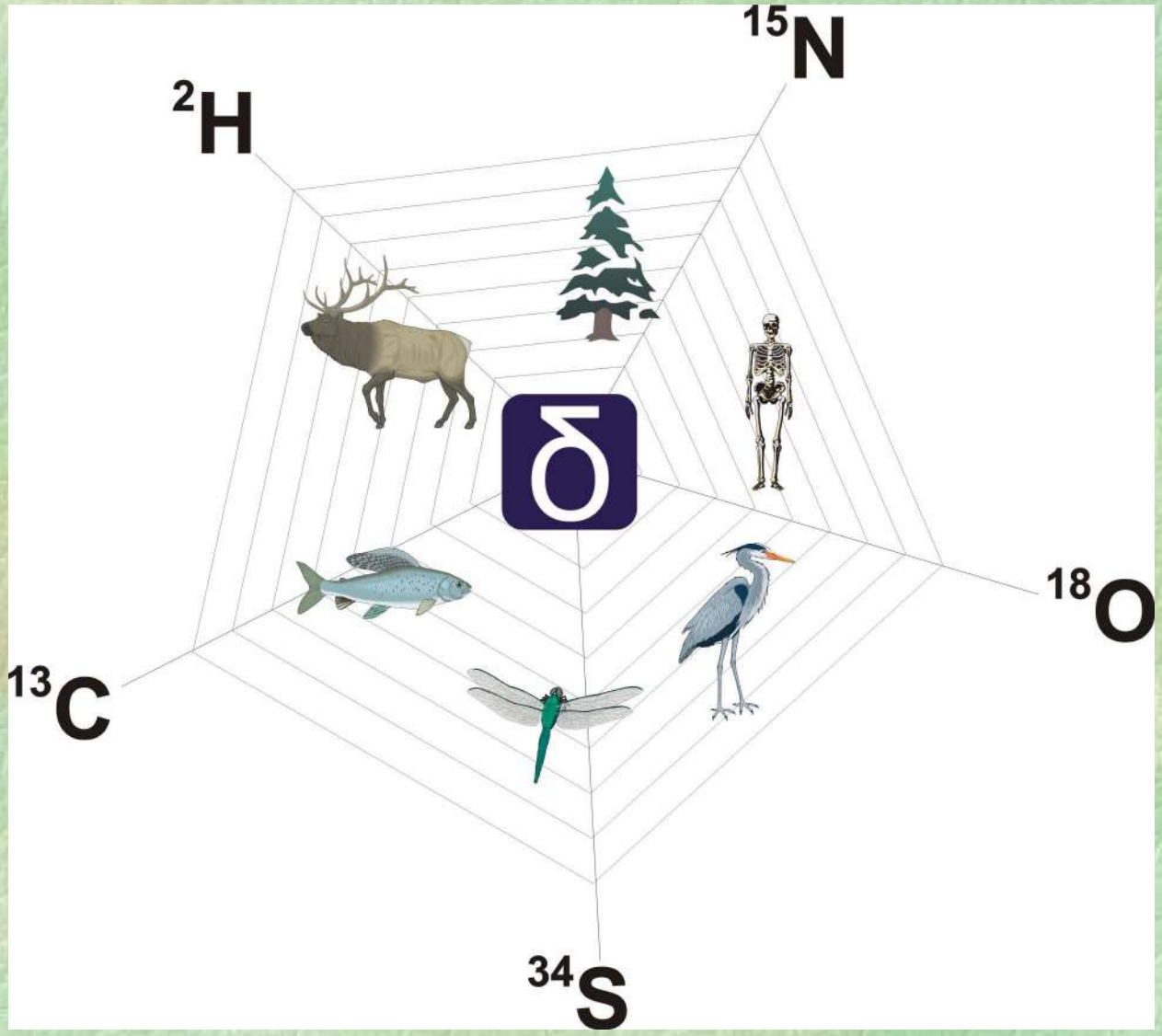
Variance in assignment. This recent study from Queen's confirms our use of the -25 per mil factor AND shows small (±4 per mil) over a 5-year period for this site ….



Langin et al. 2007 Oecologia

So, an optimistic scenario is that the error we can expect corresponds to about 2 degrees of latitude …. BUT more work is needed on this.

For CMMN, we have a robust tool that is suitable for delineating approximate catchment areas of spring and fall migrants ….


^{15}N
^{2}H
^{18}O
^{13}C
^{34}S