strontium and trace elements

1. building on stable-hydrogen isotopes: strontium isotopes

2. using a shot-gun approach: trace elements

strontium and trace elements

1. building on stable-hydrogen isotopes: strontium isotopes

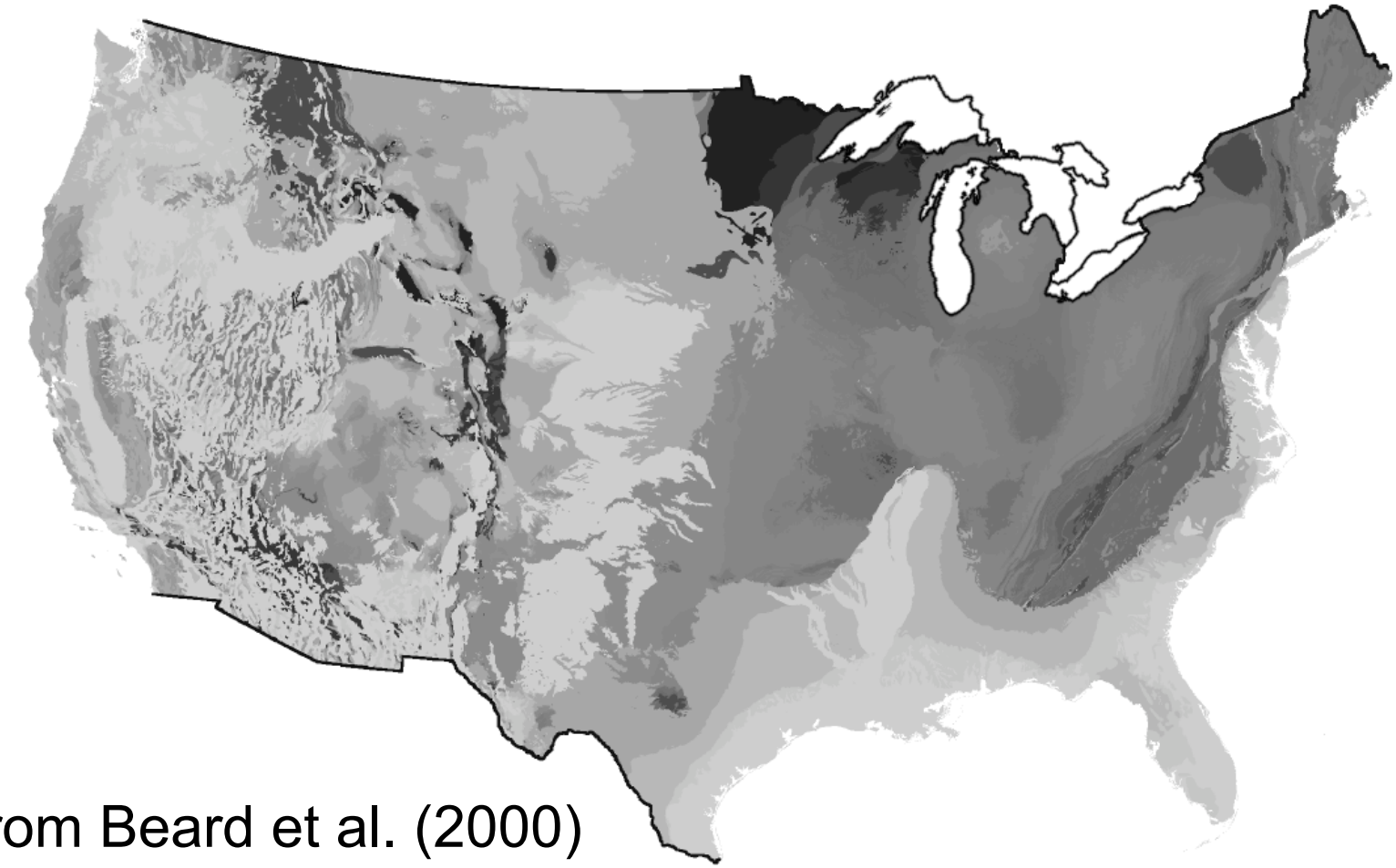
- problem: δD does not always provide sufficient resolution to answer many types of questions
- potential solution: multiple, complimentary markers
- strontium isotopes: hypothesized to provide (a) predictable and (b) complimentary information

strontium and trace elements

- strontium: non-nutrient, alkaline earth metal
- $^{87}Sr/^{86}Sr$ changes with time due to decay of ^{87}Rb to ^{87}Sr
- highest $^{87}Sr/^{86}Sr$ values are found in older bedrock
- salmonids (Kennedy *et al.* 1997),
- African elephants (Vogel *et al.* 1990)
- black-throated blue warblers (Chamberlain *et al.* 1997)

strontium and trace elements

- predicted $^{87}Sr/^{86}Sr$ values based on age of bedrock

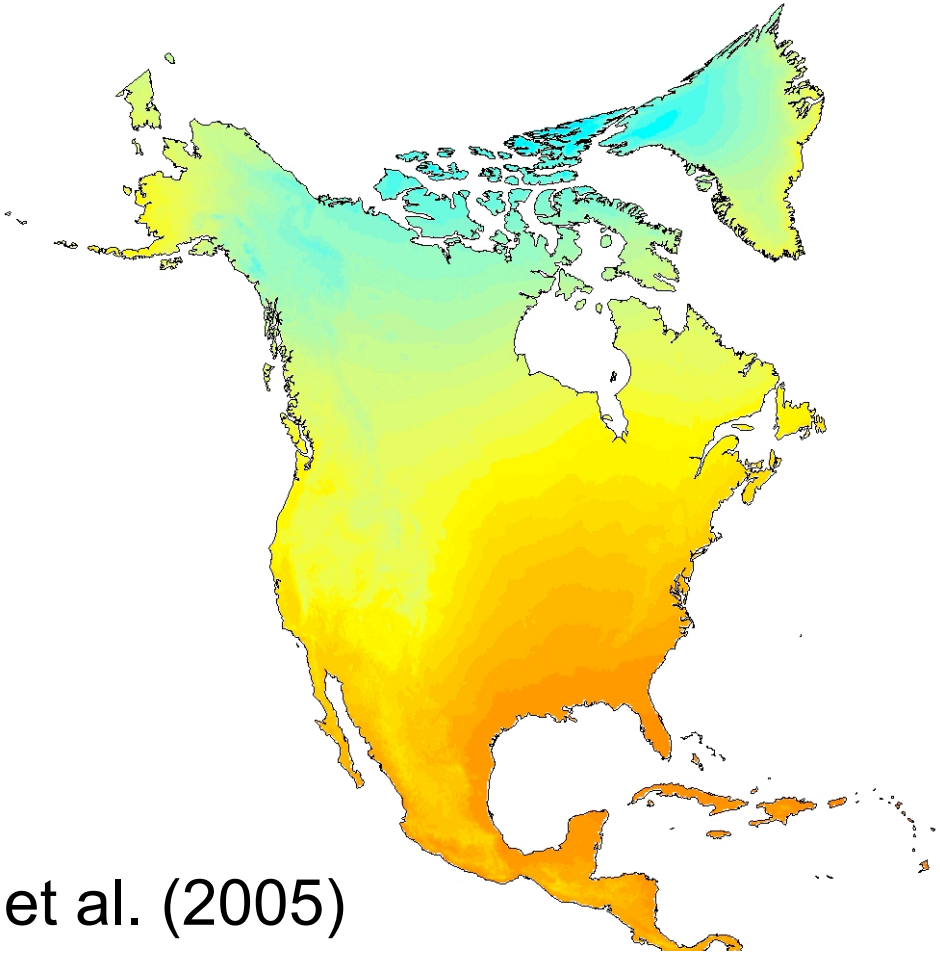


from Beard et al. (2000)

strontium and trace elements

…combine with stable-hydrogen isotopes (δD)

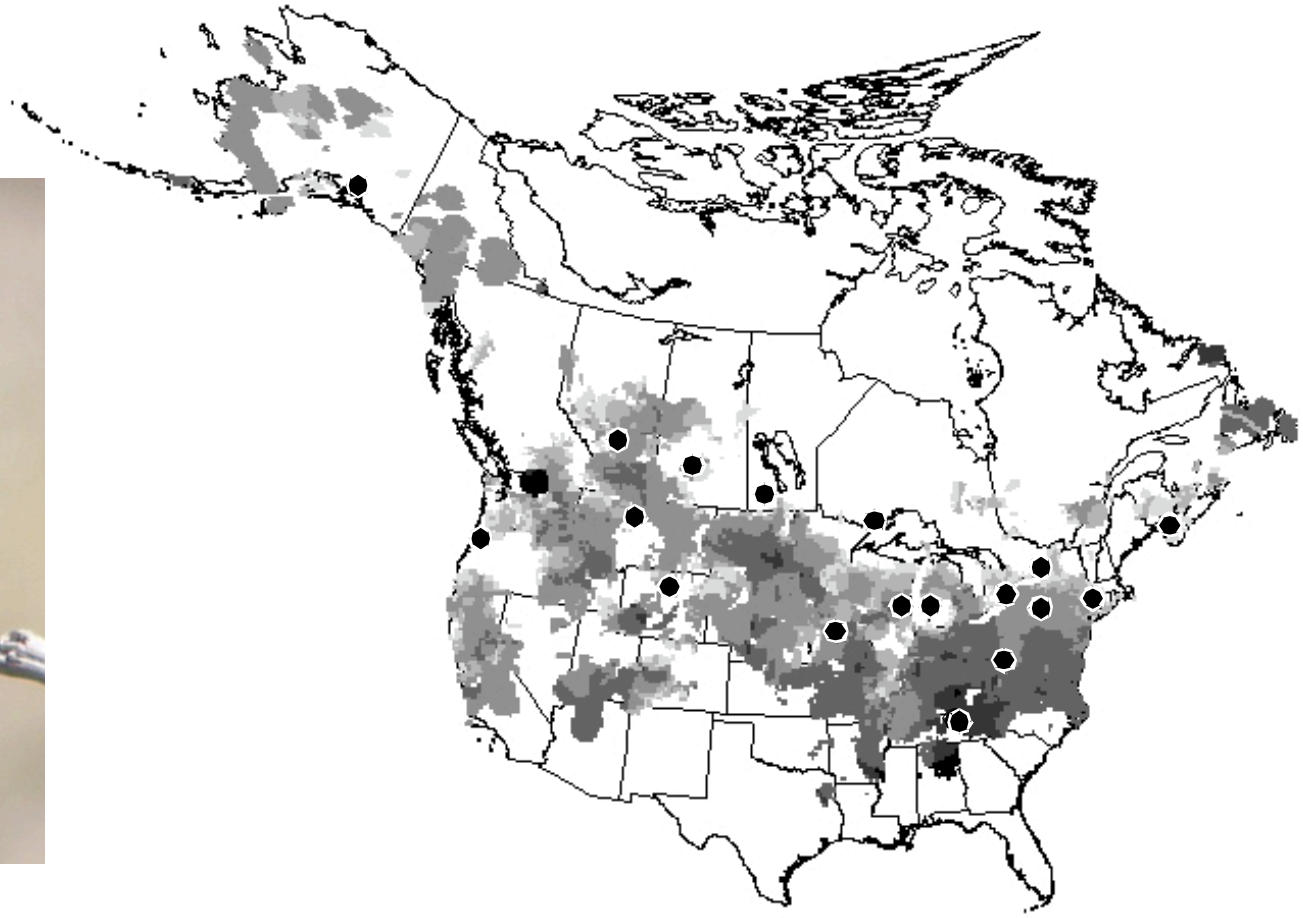
- predicted values based on growing-season precipitation



from Bowen et al. (2005)

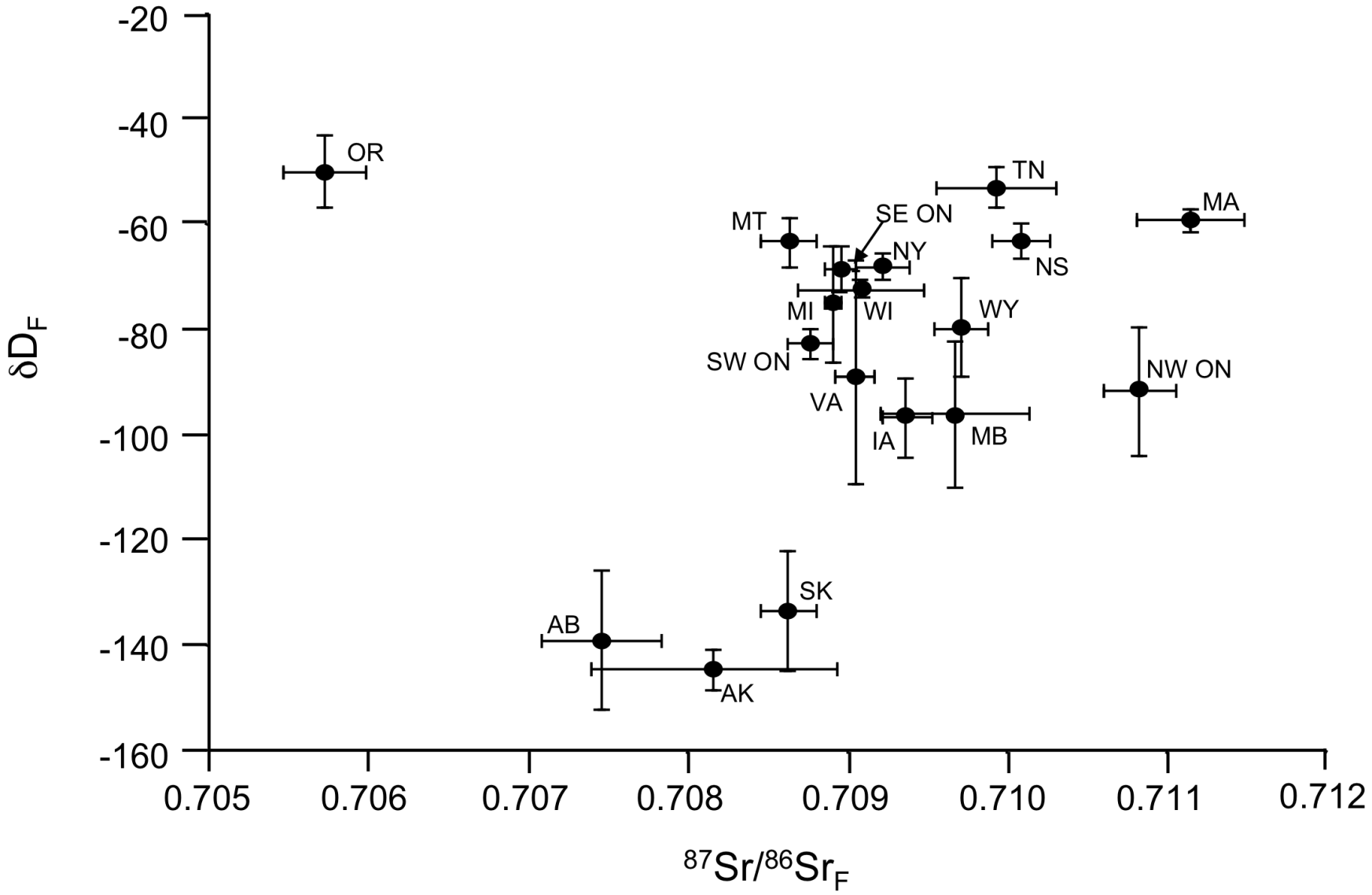
strontium and trace elements

- Tree swallows (*Tachycineta bicolor*)
- first primary from known-origin (banded) adults
- *N* = 18 sites



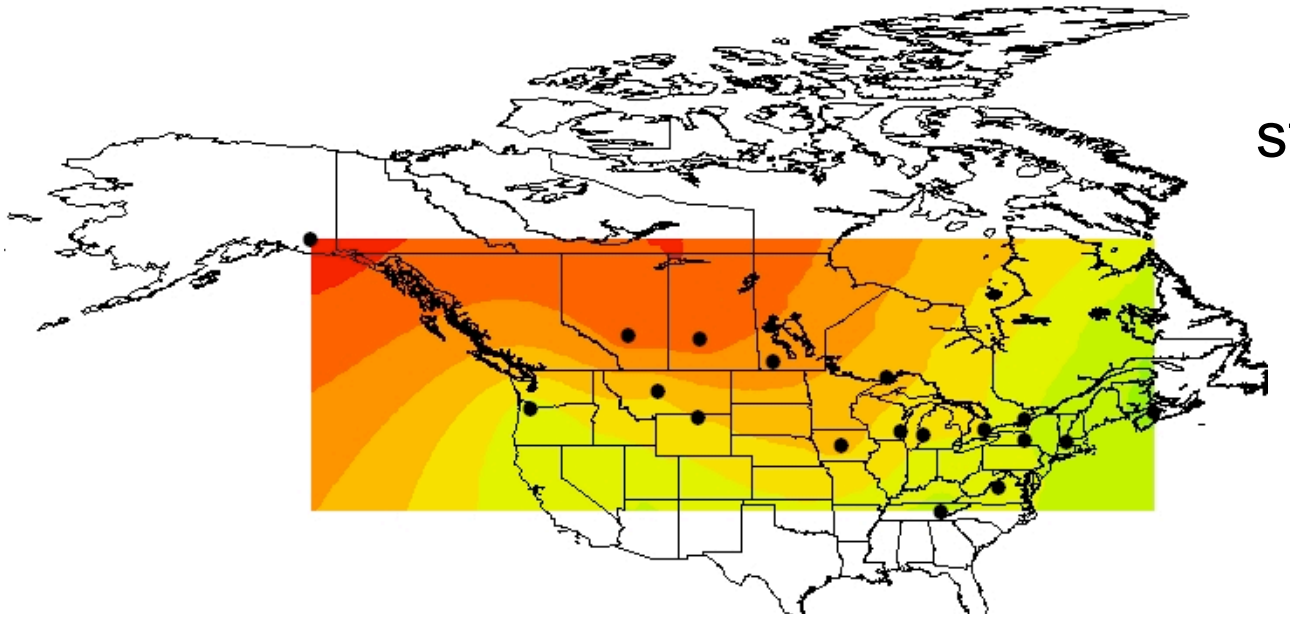
Sellick et al. 2009

strontium and trace elements

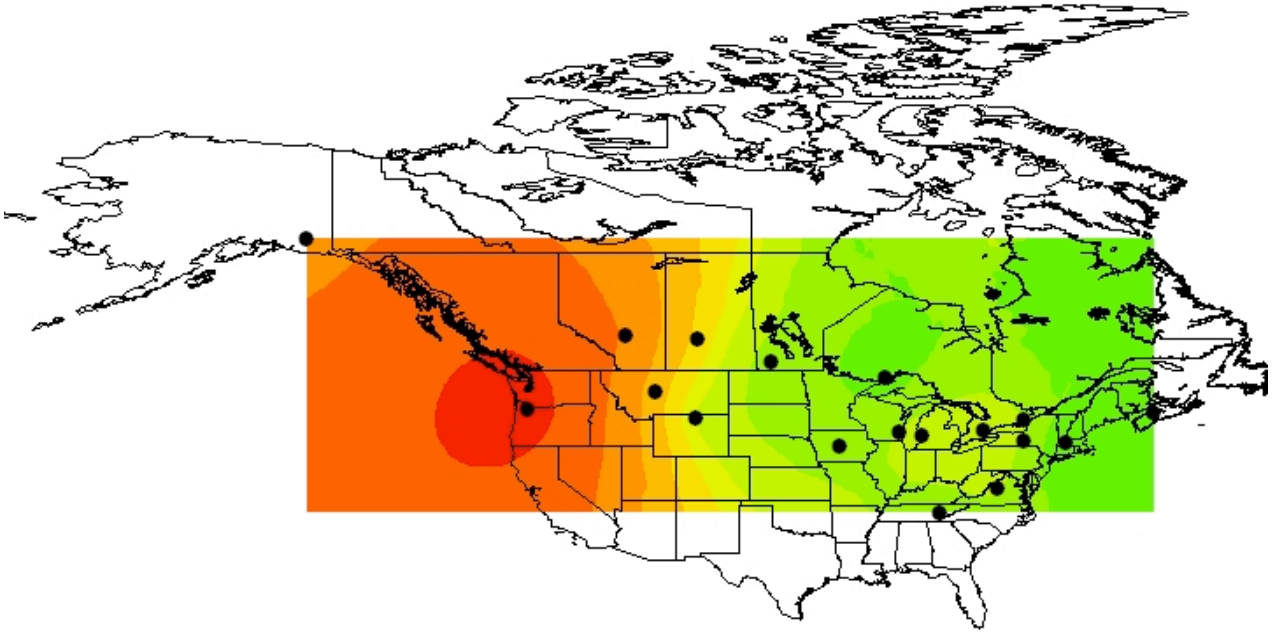


Sellick et al. 2009

strontium and trace elements



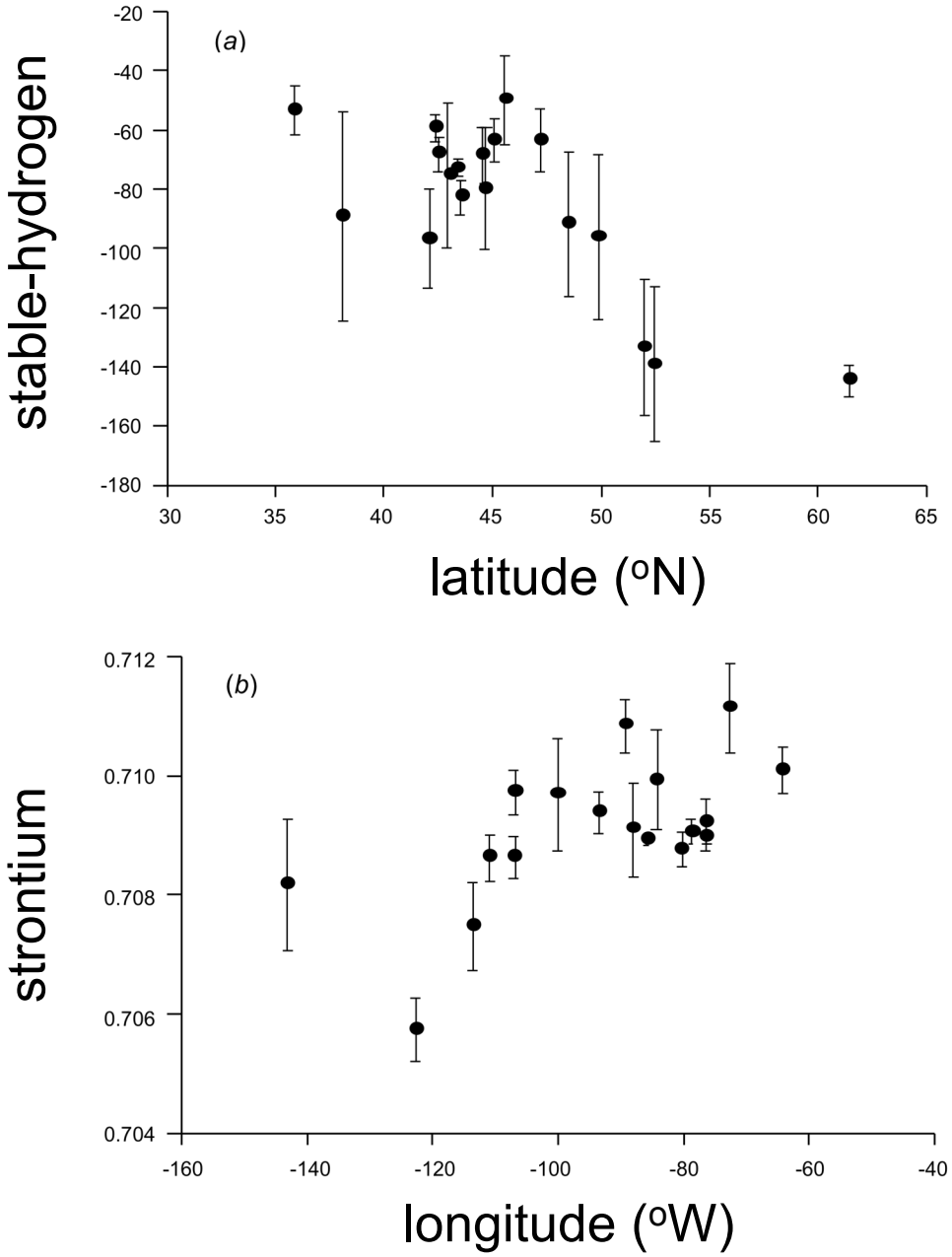
stable-hydrogen isotopes



strontium isotopes

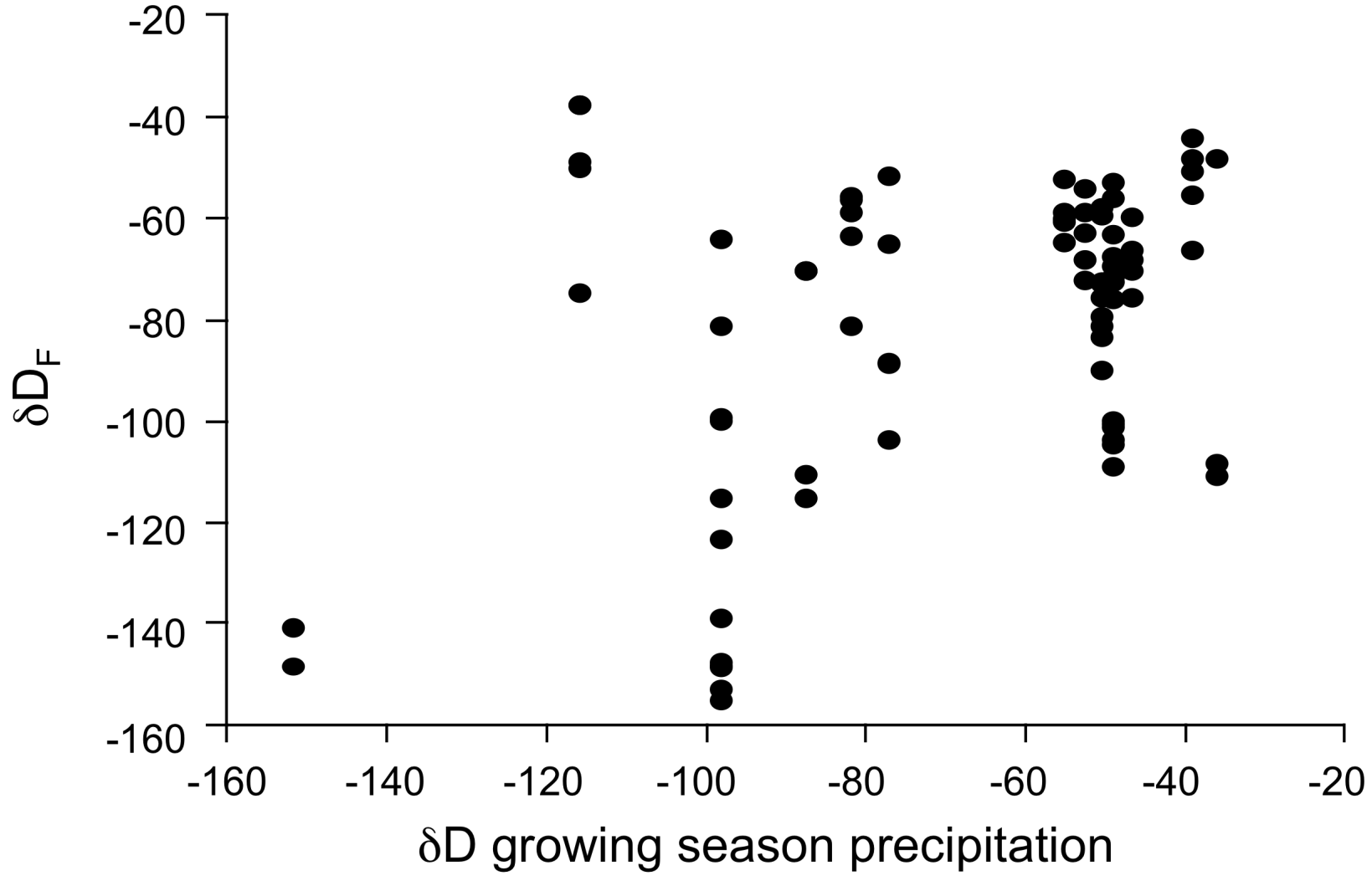
Sellick et al. 2009

strontium and trace elements



Sellick et al. 2009

strontium and trace elements



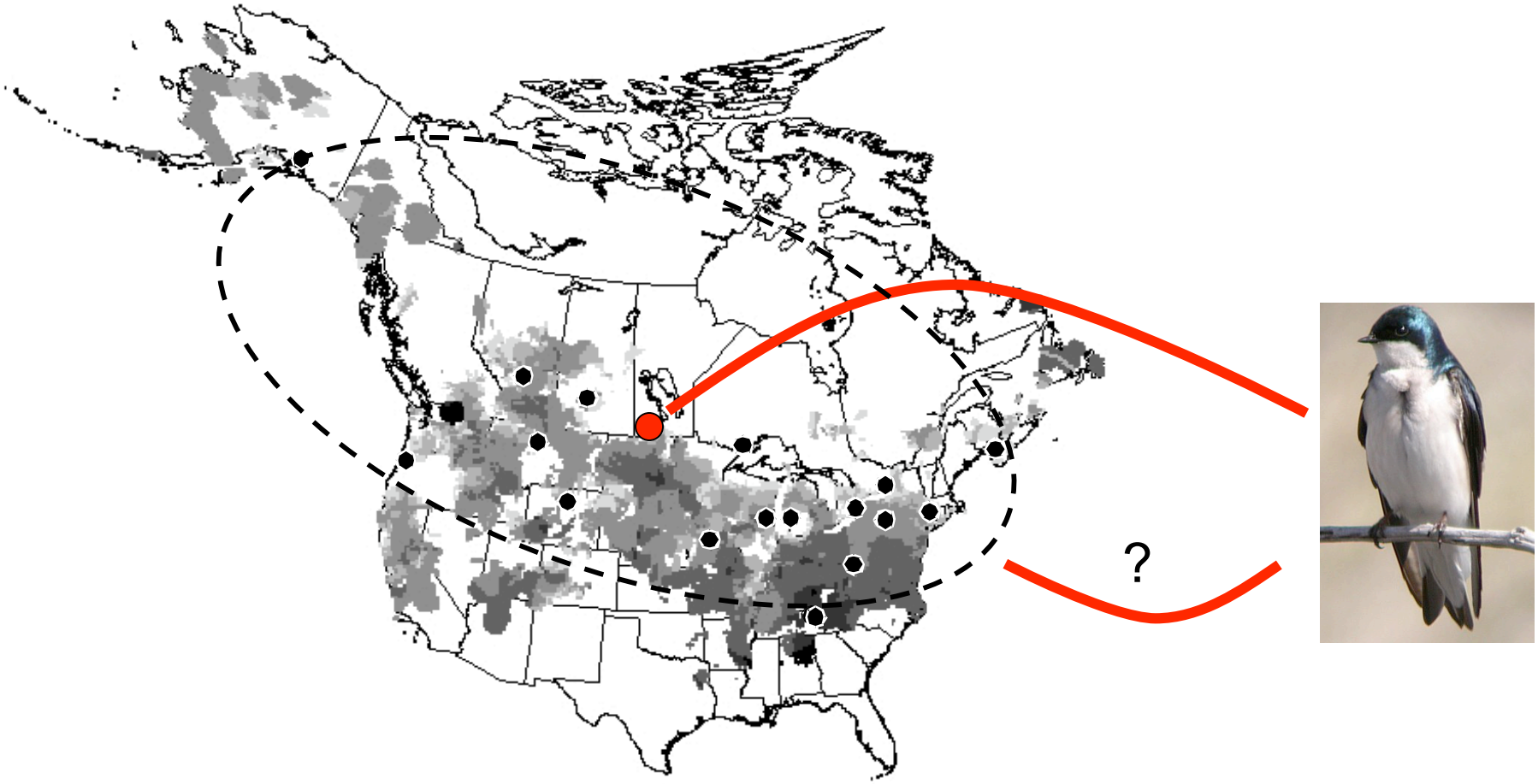
Sellick et al. 2009

strontium and trace elements

Sellick et al. 2009

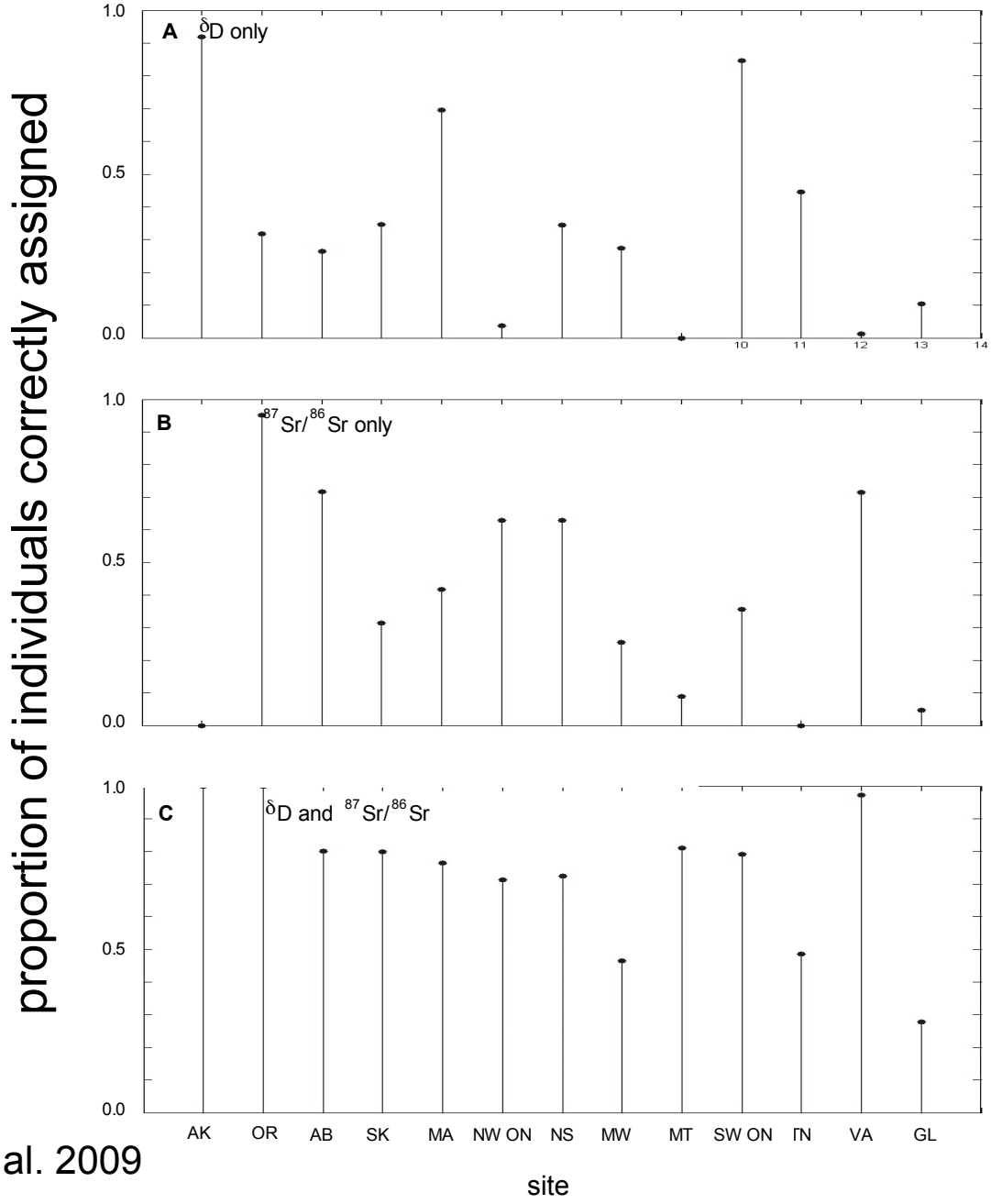
strontium and trace elements

- put the isotopes to the test



Sellick et al. 2009

strontium and trace elements



hydrogen: 34%

strontium: 39%

hydrogen & strontium: 74%

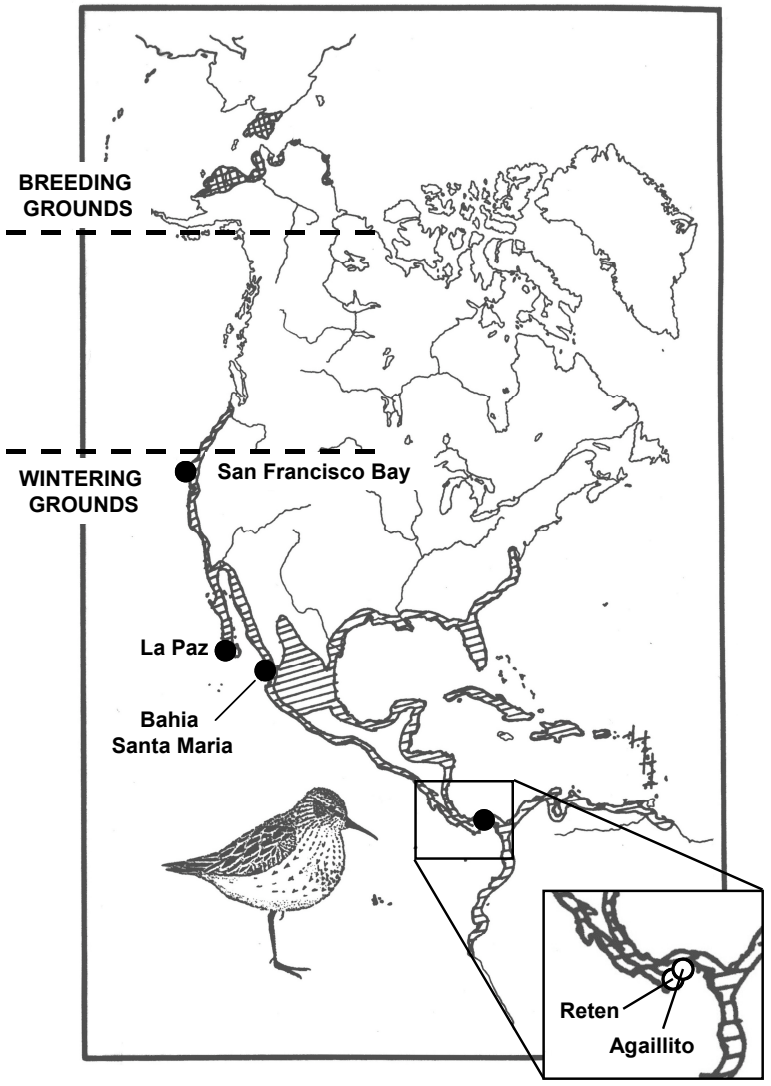
Sellick et al. 2009

strontium and trace elements

- $^{87}Sr/^{86}Sr$ and δD provide complimentary information
- is this the resolution we have been looking for to test predictions about year round population dynamics?
- higher cost, more tissue
- are there other markers?

strontium and trace elements

trace elements in Western sandpipers

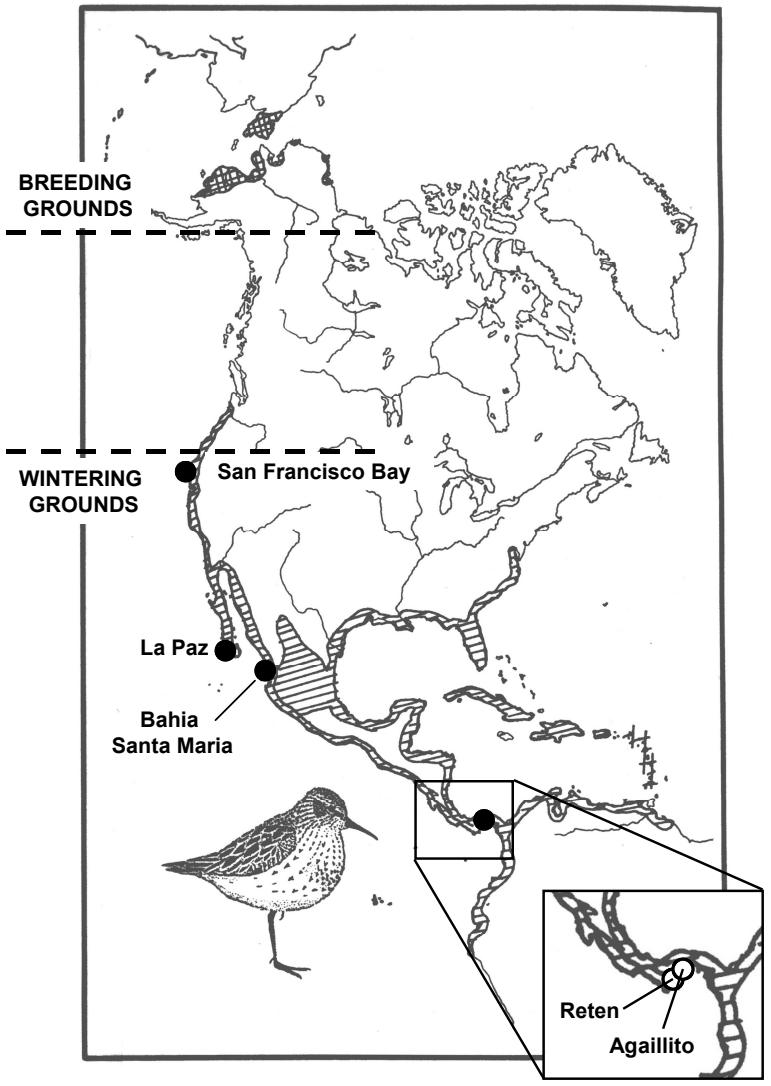


Norris et al. 2007

strontium and trace elements

trace elements in Western sandpipers

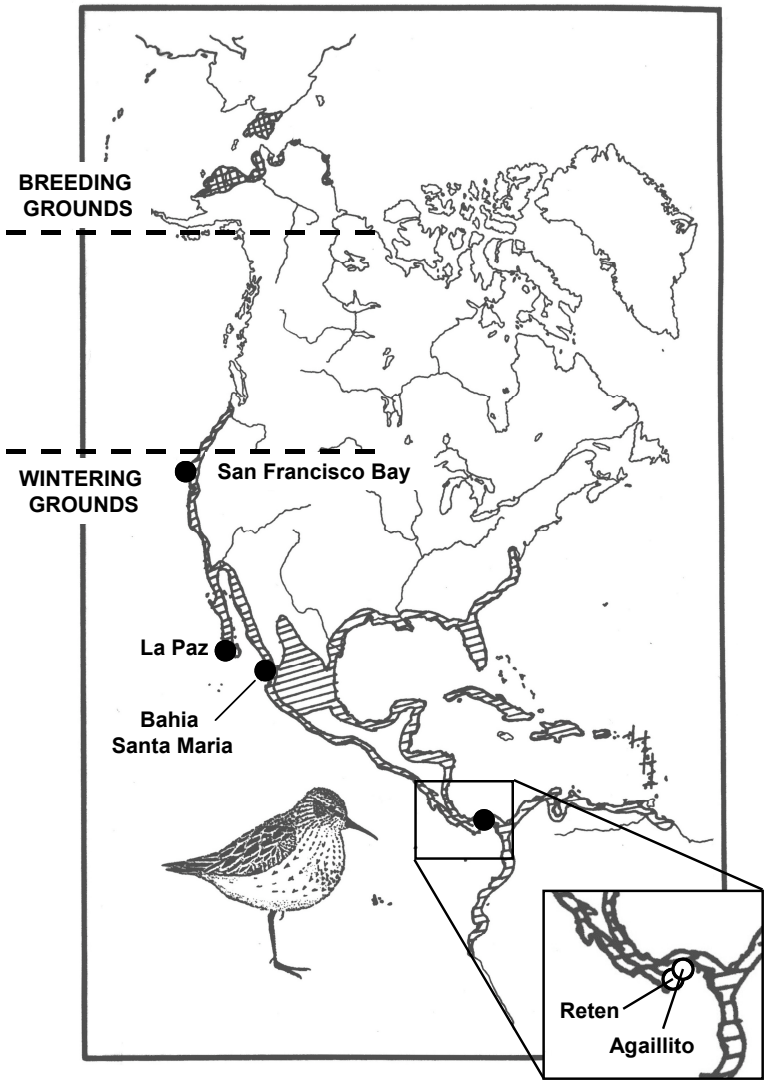
- overall goal: determine patterns of connectivity
- approach: establish trace element “base map” of the wintering grounds from feathers



Norris et al. 2007

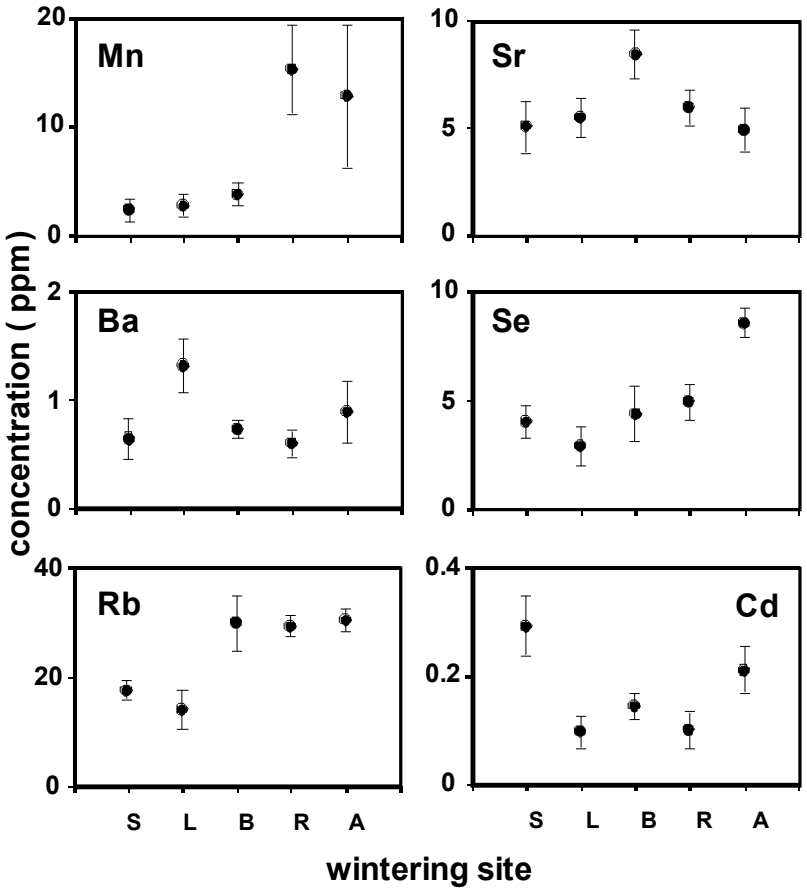
strontium and trace elements

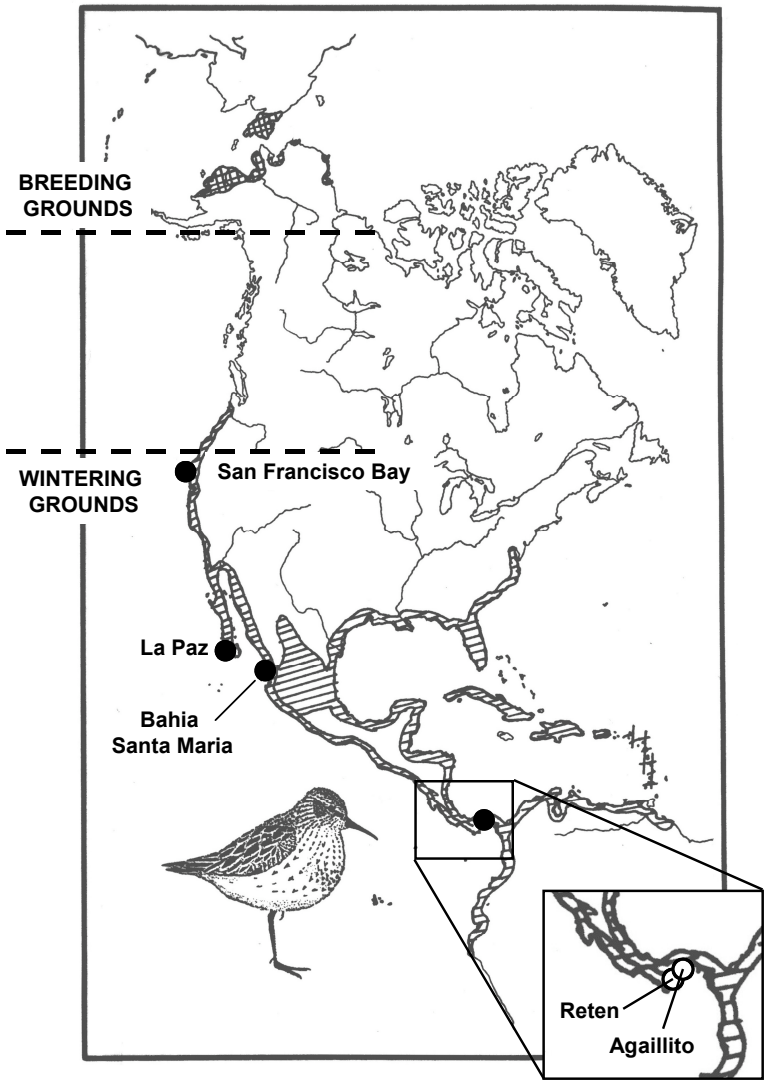
- feathers molted at wintering sites
- elemental composition (ppm) of 40 elements simultaneously



Norris et al. 2007

strontium and trace elements

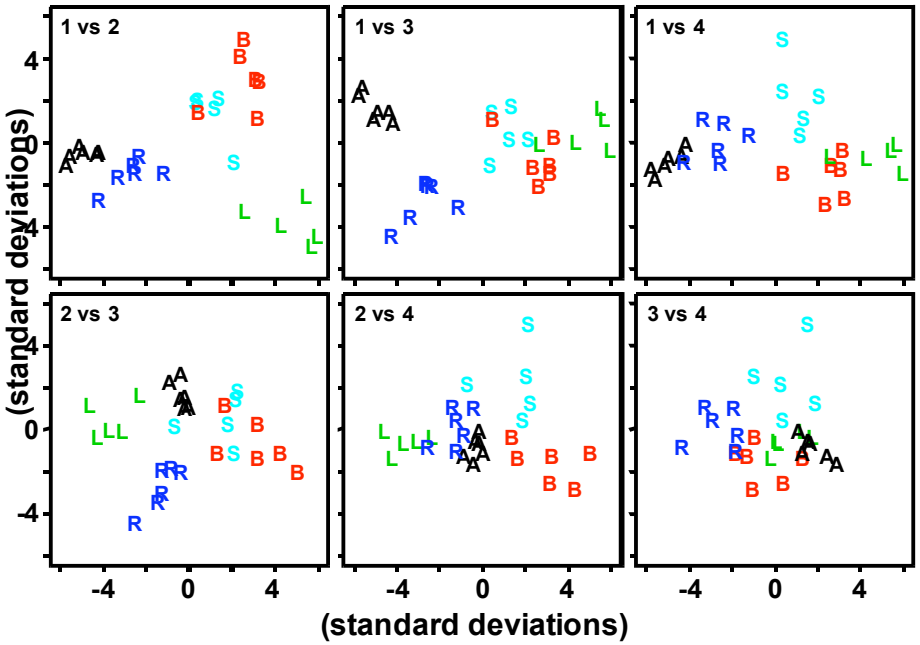


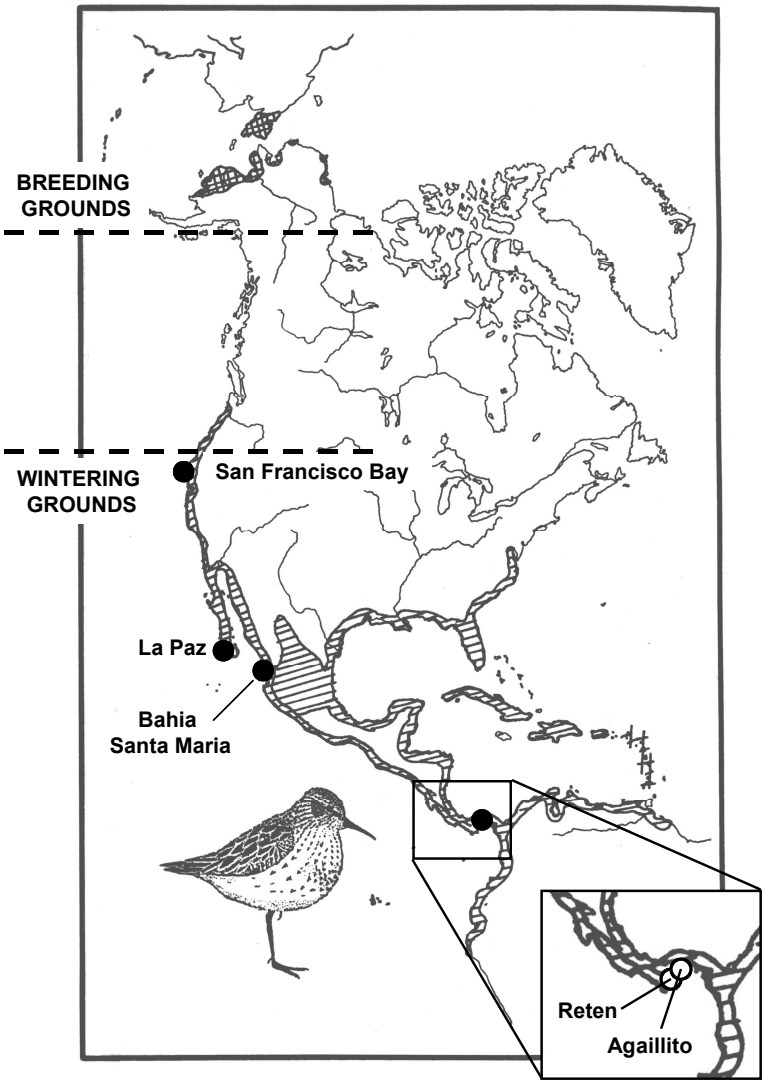


Norris et al. 2007

strontium and trace elements

discriminant function scores





Norris et al. 2007

strontium and trace elements

advantages

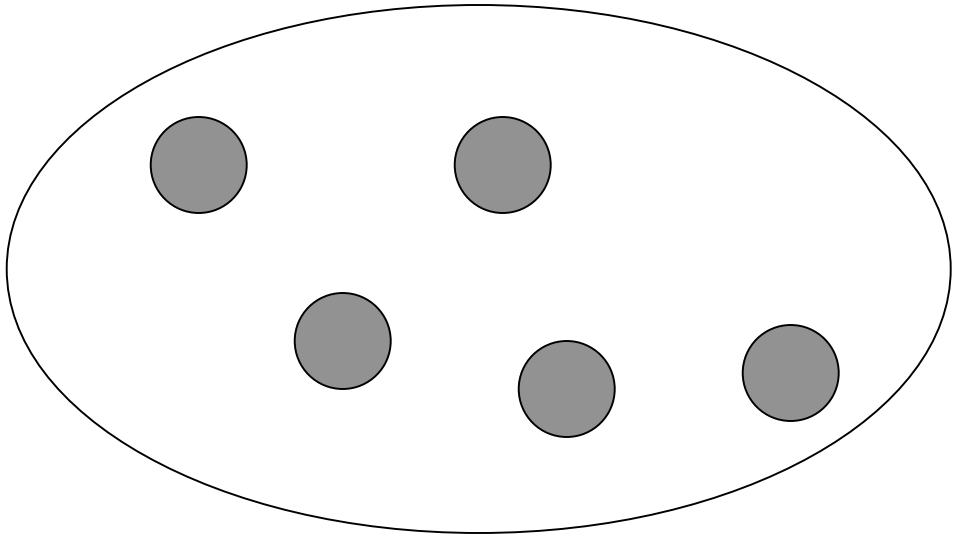
- multiple (30-40) elements simultaneously
- potentially a high degree of accuracy

disadvantages

- higher cost, more tissue
- difficult to extrapolate to non-sampled areas
- potentially **too** high degree of accuracy

strontium and trace elements

case 1

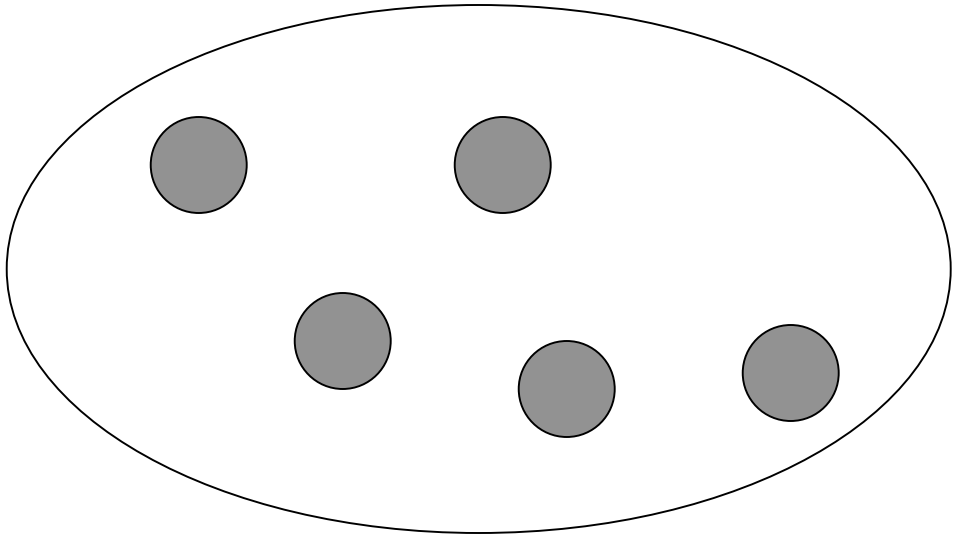


species range
AND
sampling site

✔ trace elements

strontium and trace elements

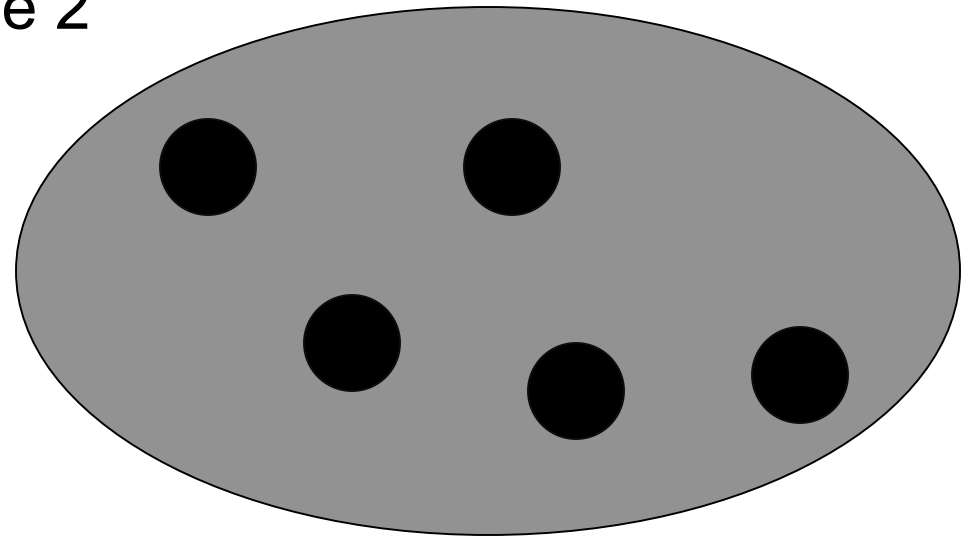
case 1



species range
AND
sampling site

✔ trace elements

case 2

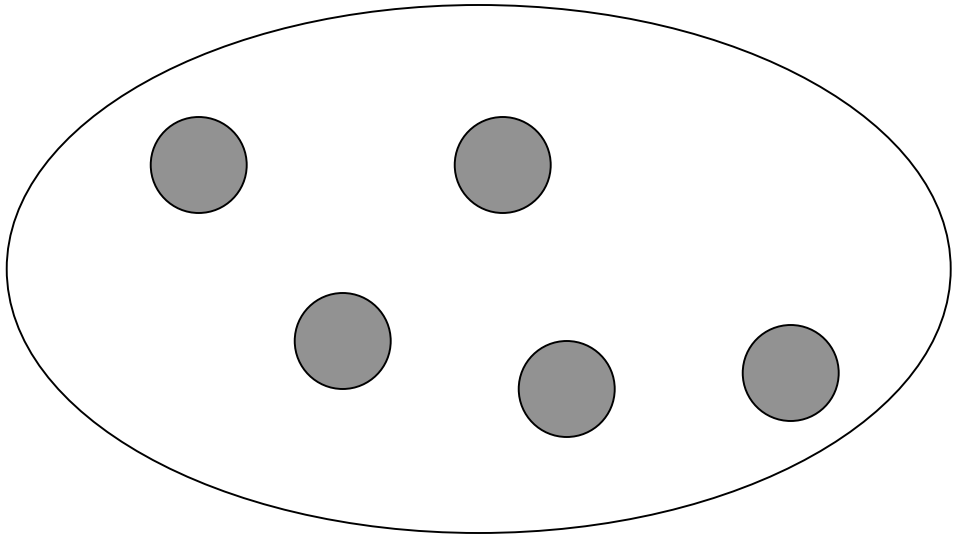


species range

sampling site

strontium and trace elements

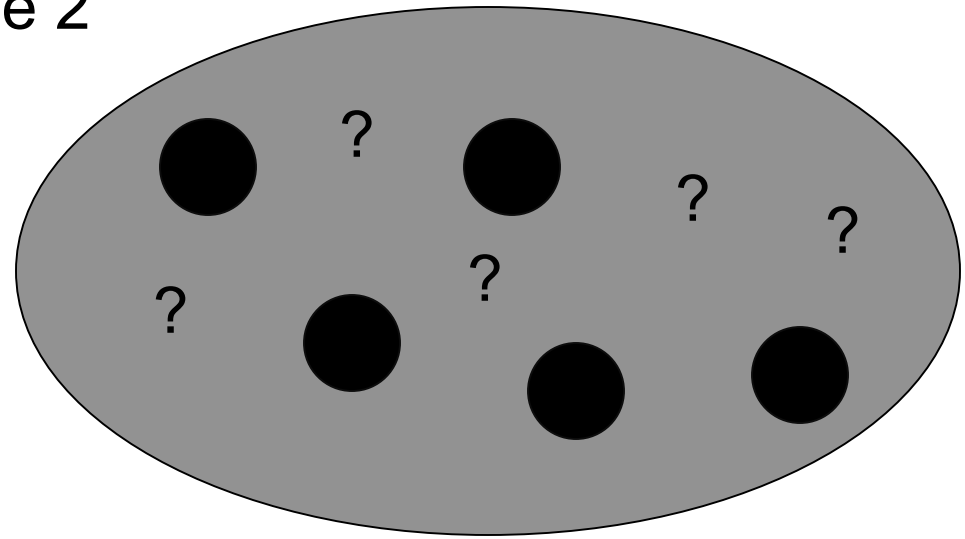
case 1



species range AND sampling site

✔ trace elements

case 2



species range

sampling site

✖ trace elements

strontium and trace elements

- isotopes control by different (and predictable) global-scale processes (hydrogen, strontium) may significantly increase tracking resolution

- for some specialized cases, trace elements offer an alternative marker with a potentially higher resolution

- remember the benefits but know the assumptions