Songbirds, snails, and soils: Calcium limitations in acidified forest ecosystems in Pennsylvania

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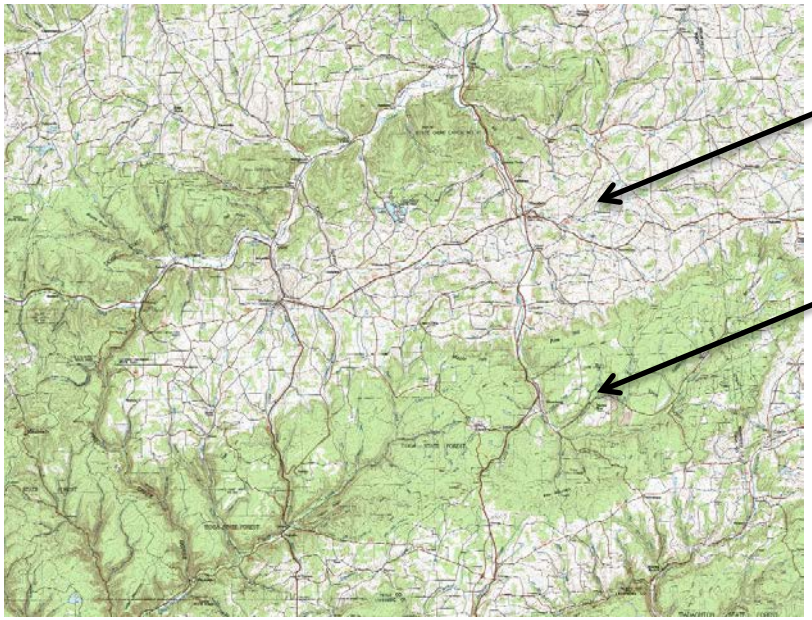
Soil

Forest soils in Pennsylvania tend to be acidic and low in many nutrients



Agriculture is located in areas with high quality soils

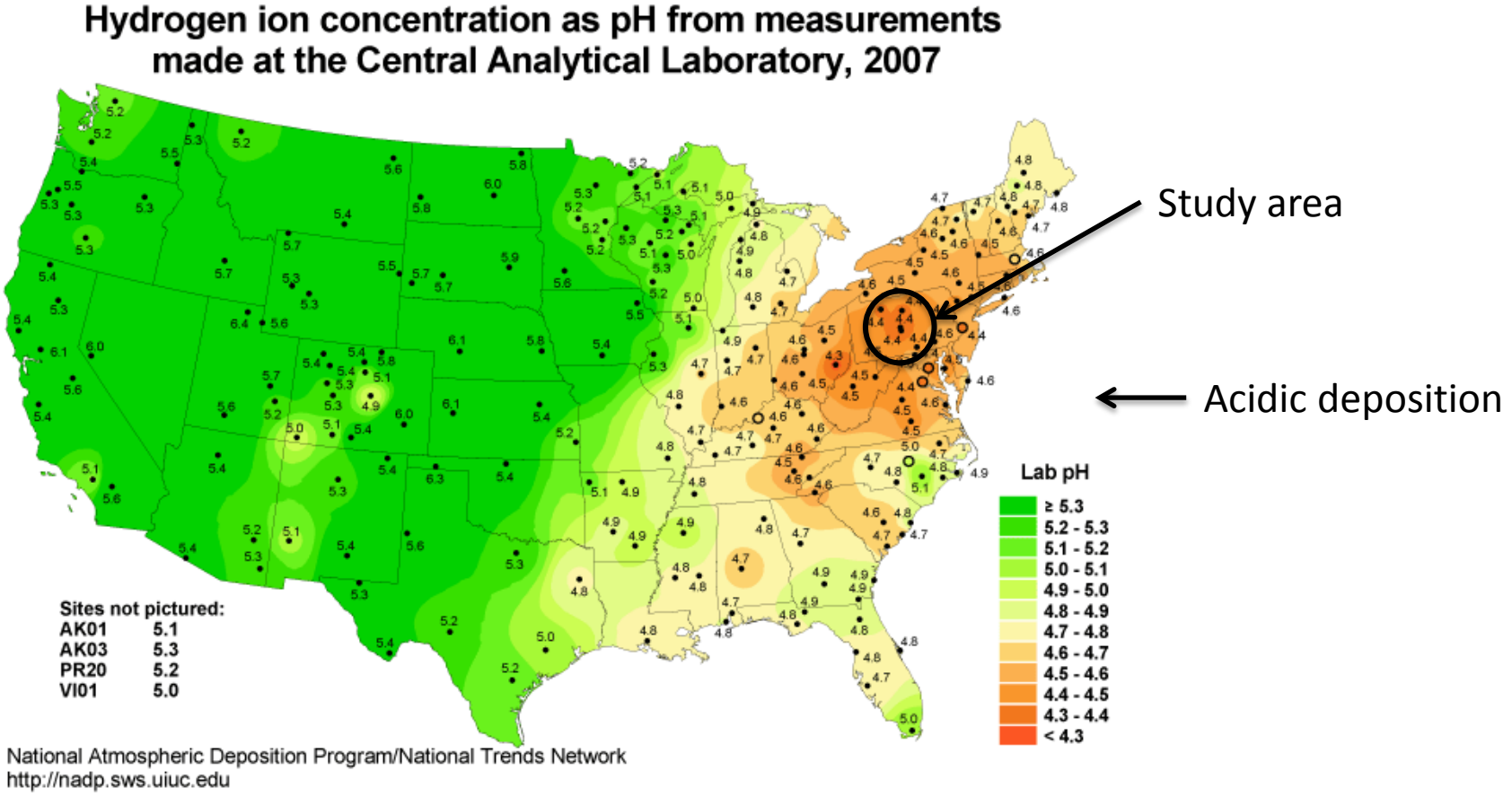
Forests remain or regenerate in areas unsuitable for agriculture

Forest growth and maturation can change soil conditions

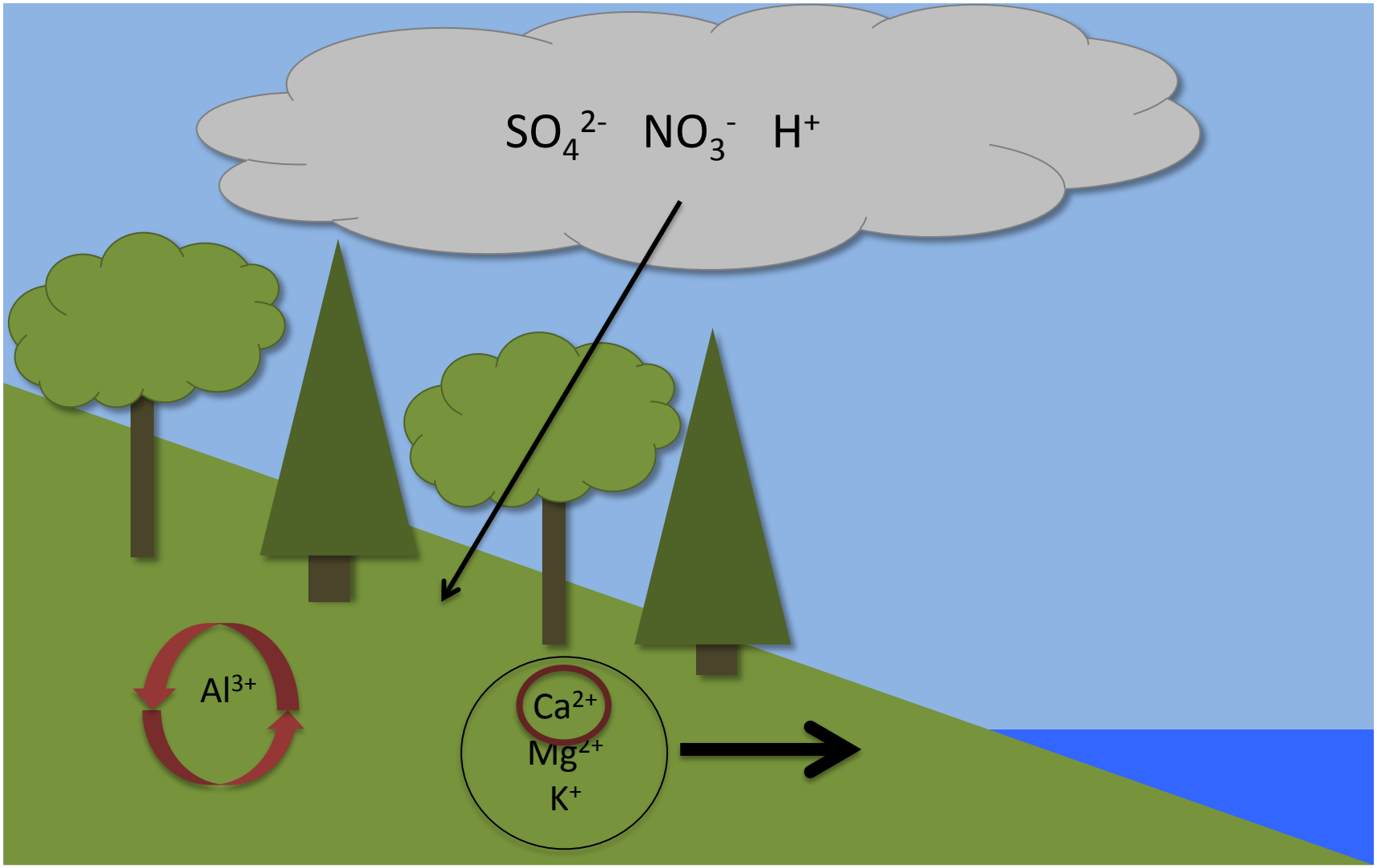
Human activities can also cause forest soils to become increasingly acidic and nutrient depleted

Forest harvesting

Human activities can also cause forest soils to become increasingly acidic and nutrient depleted



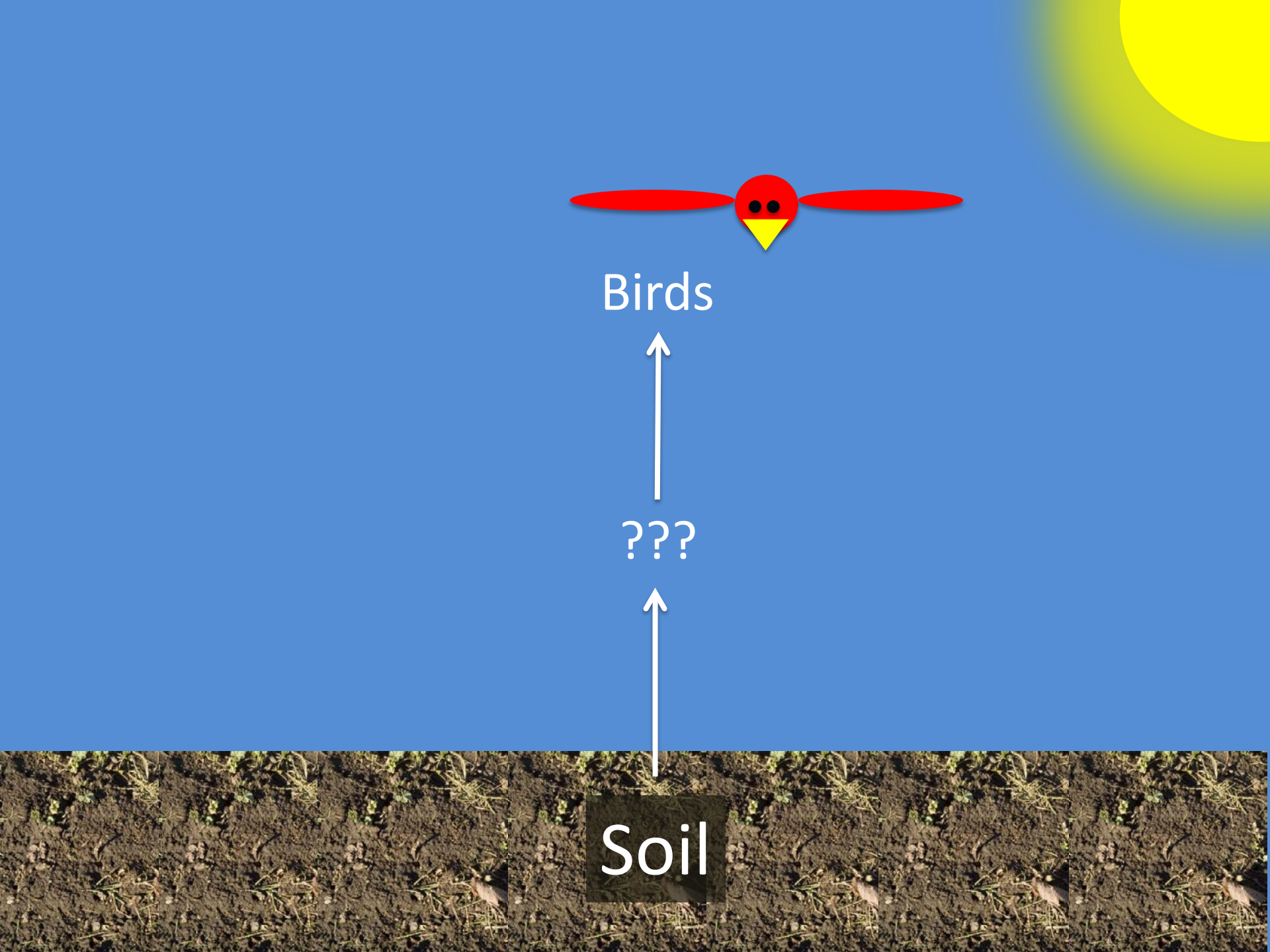
Acidic deposition causes the depletion of soil nutrients



Soil calcium and pH have decreased in PA forests

1967 to 1997 (Bailey et al. 2005): Oa/A-horizon soil calcium went from 4.7 to 1.1 $cmol_c/kg$
pH went from 3.9 to 2.9

1957 to 1993 (Drohan and Sharpe 1997): A-horizon soil Ca went from 0.33 to 0.08 meq/100g
pH went from 4.42 to 4.19


Birds
???
Soil

Evidence that changes in soil conditions are affecting bird populations in the USA

Pockets of declining bird abundances in high elevation forests (James et al. 1996)

Low probability of observing breeding Wood Thrushes in areas receiving high levels of acidic deposition
(Hames et al. 2002)

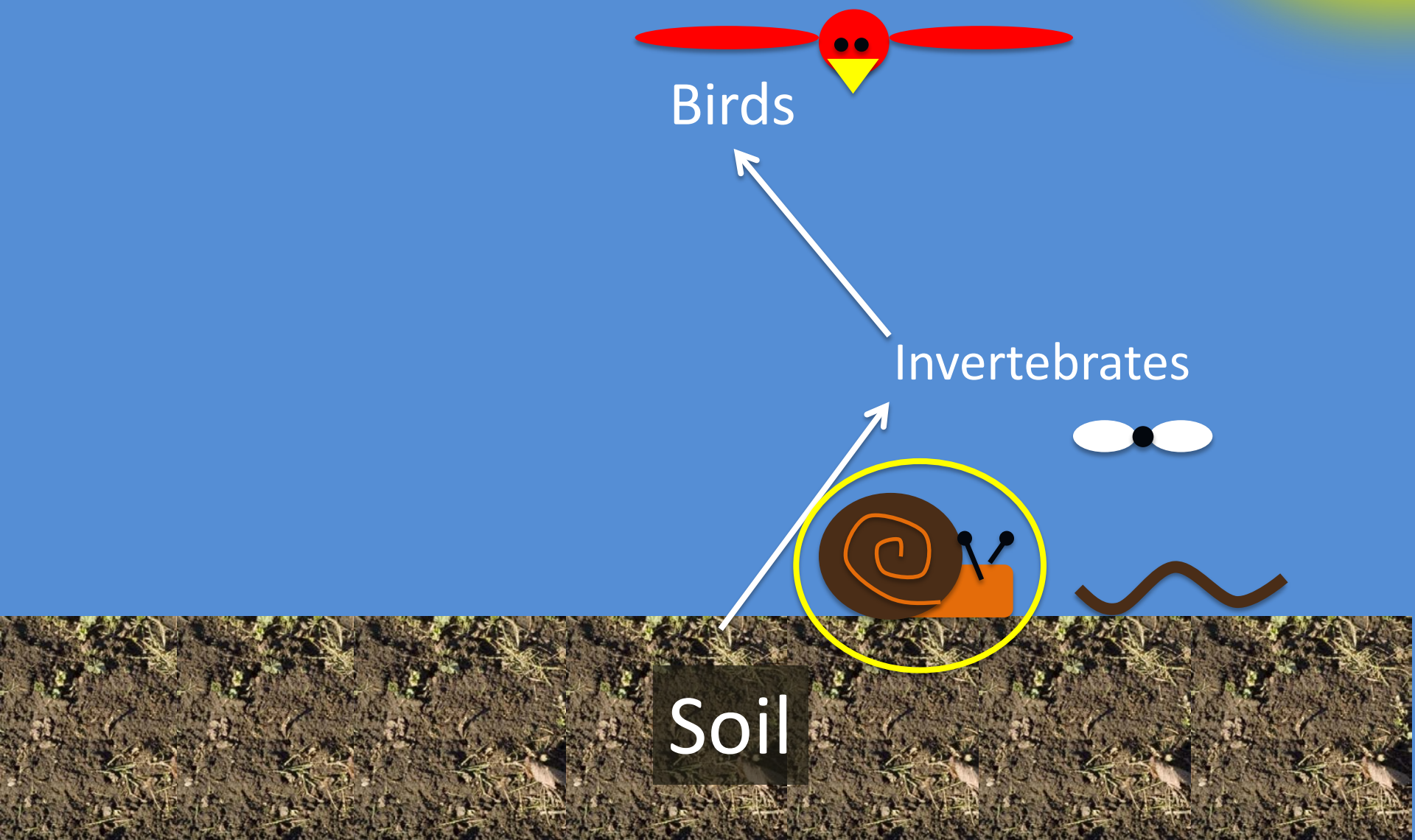
How are birds related to soils?

Birds

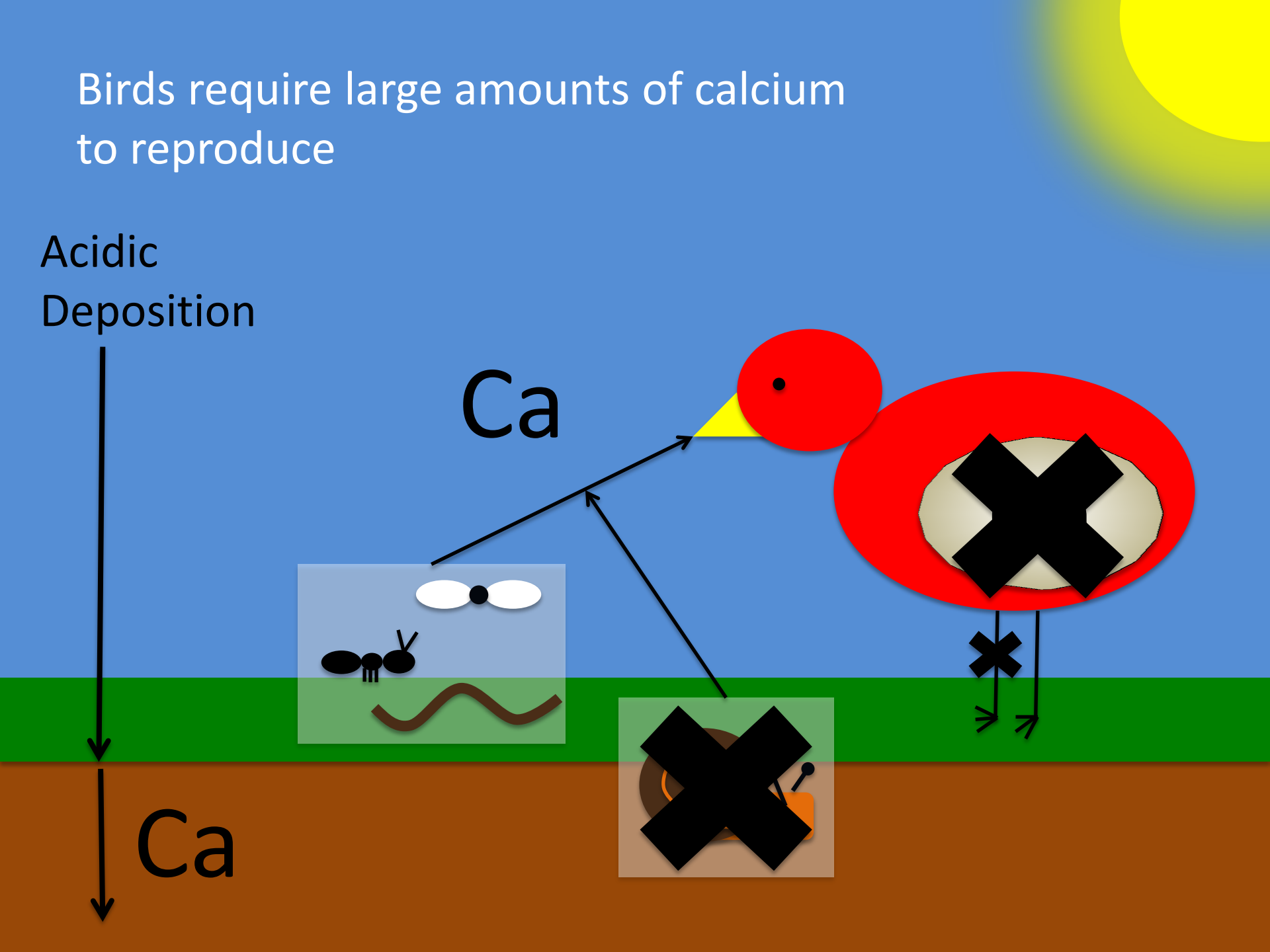
???

Soil

How are birds related to soils?



Birds require large amounts of calcium to reproduce



Reproductive anomalies in forest birds in Europe

Great tits laid eggs with thin or no eggshells in forests impacted by acidic deposition
(Graveland et al. 1994)

Model

Bird abundance and reproductive output

Snail abundance

Soil Calcium

We observed Ovenbird territory size and reproduction under different soil calcium levels

We experimentally manipulated soil calcium levels using limestone sand

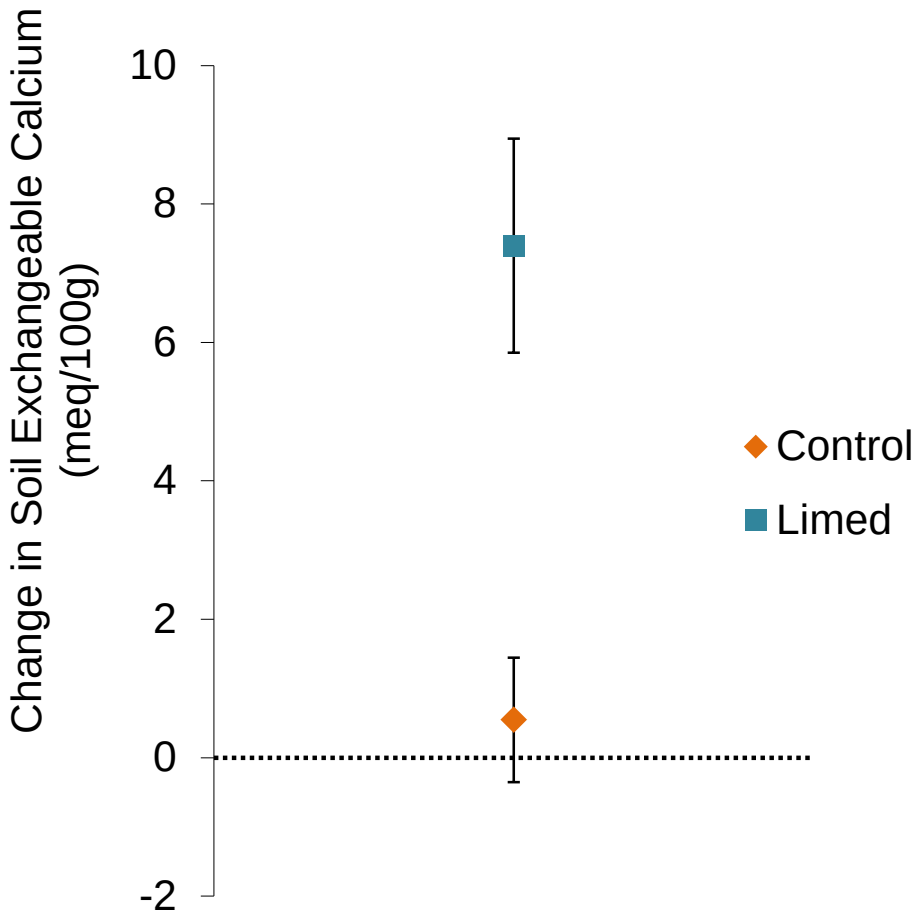
We used a modified log skidder to apply lime to two, 100-ha forest watersheds

We used a BACI design

- 2003: Before
- 2004-2008: After
- 2 Control, 2 lime-treated sites

4500 kg/ha dolomitic limestone sand

Positive effect of liming on soil calcium

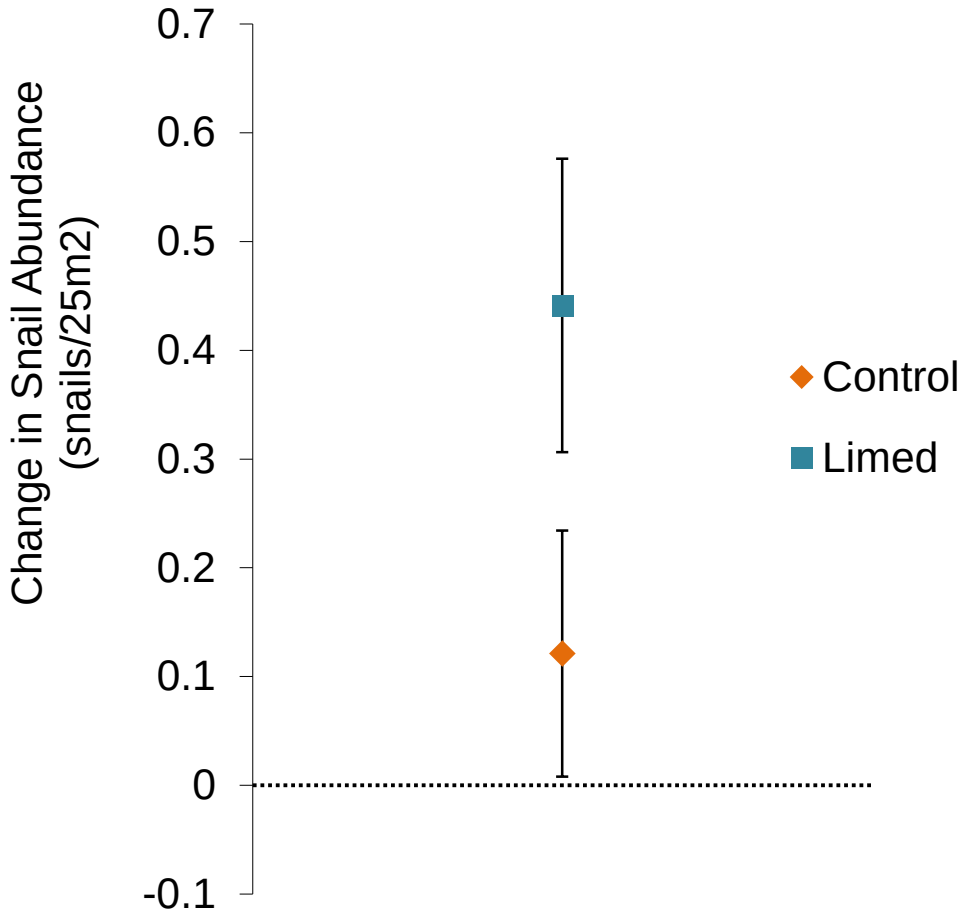


Ca: 5.3 to 13.3 meq/100g

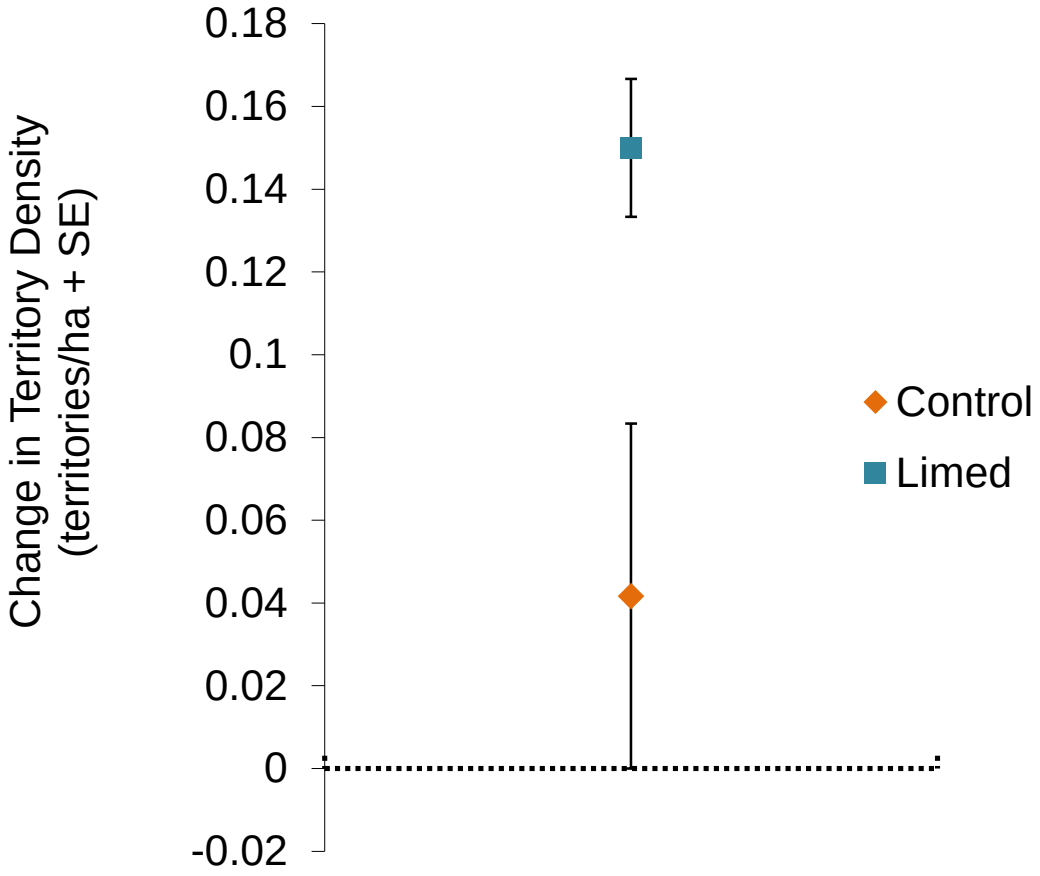
Mg: 1.5 to 8.3 meq/100g

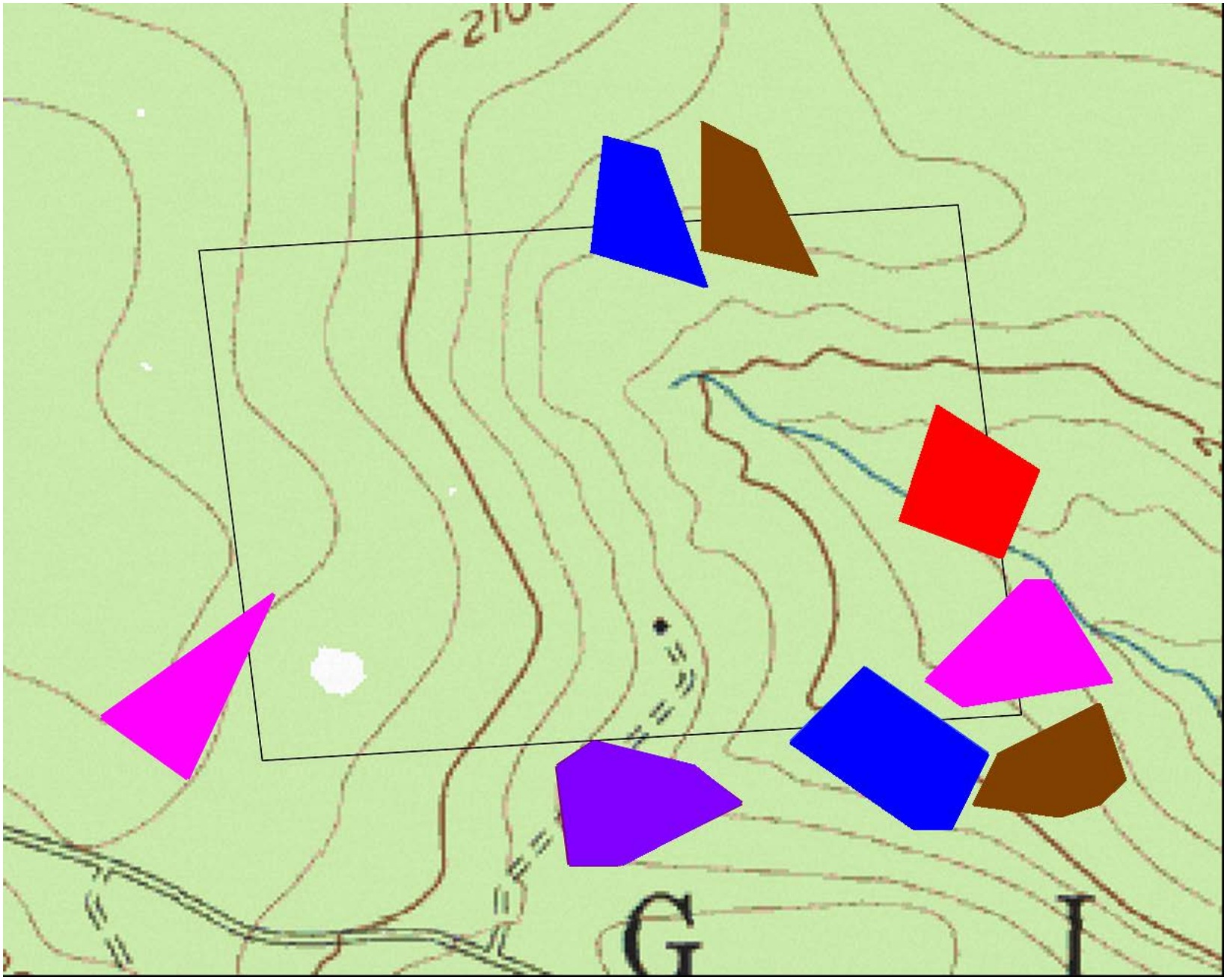
pH: 3.8 to 4.7

Positive effect of liming on snail abundance



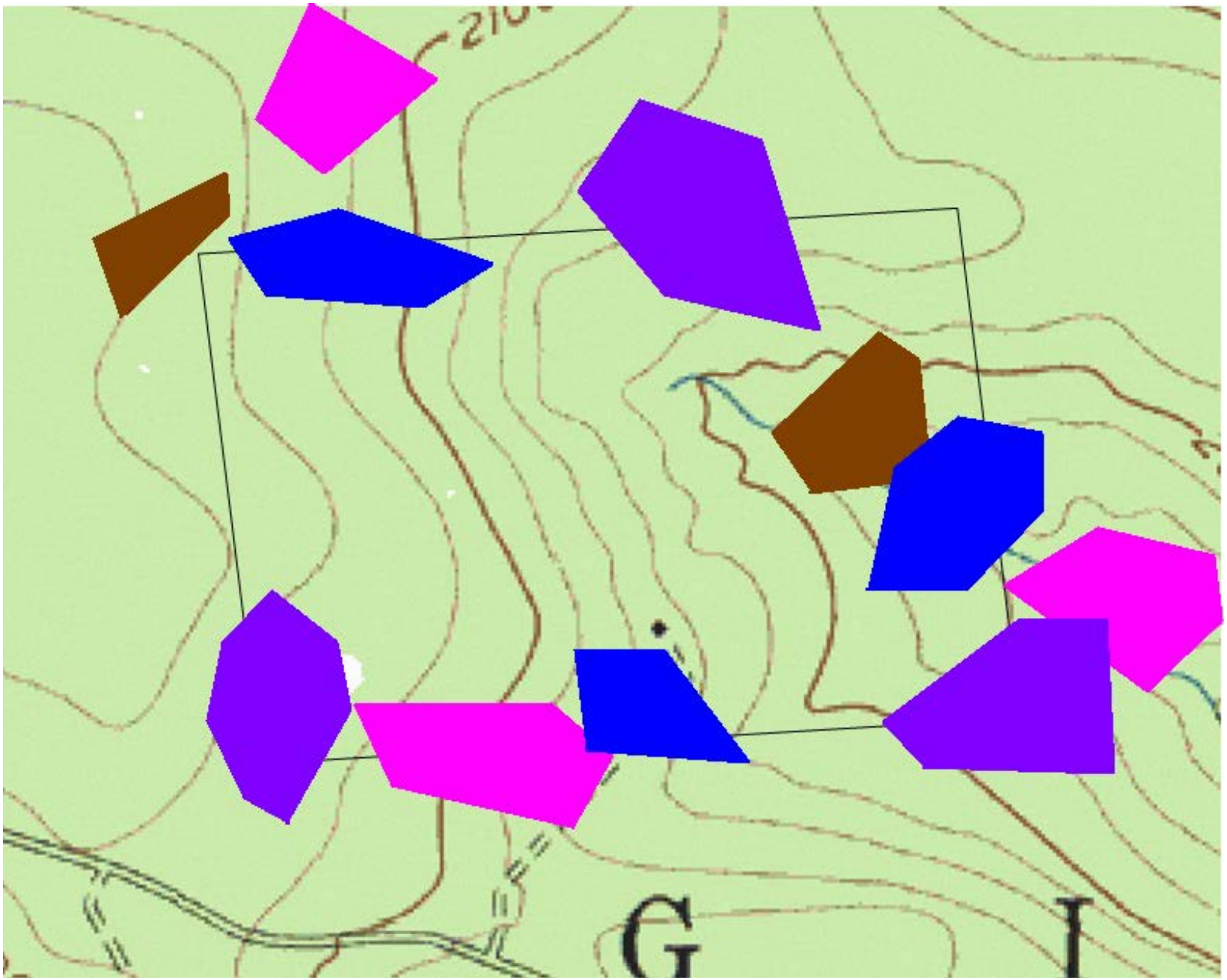
Positive effect of liming on Ovenbird territory density



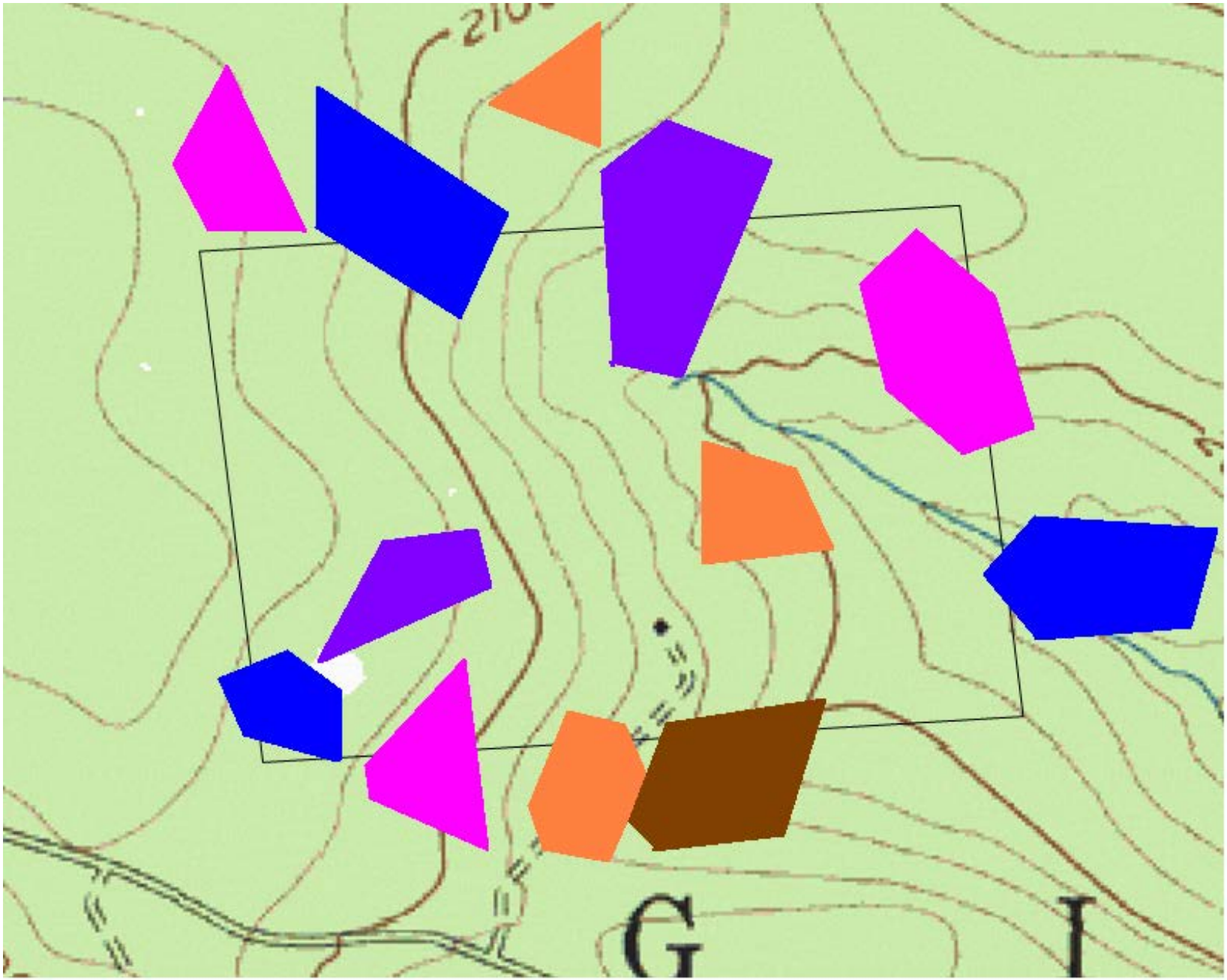


2003

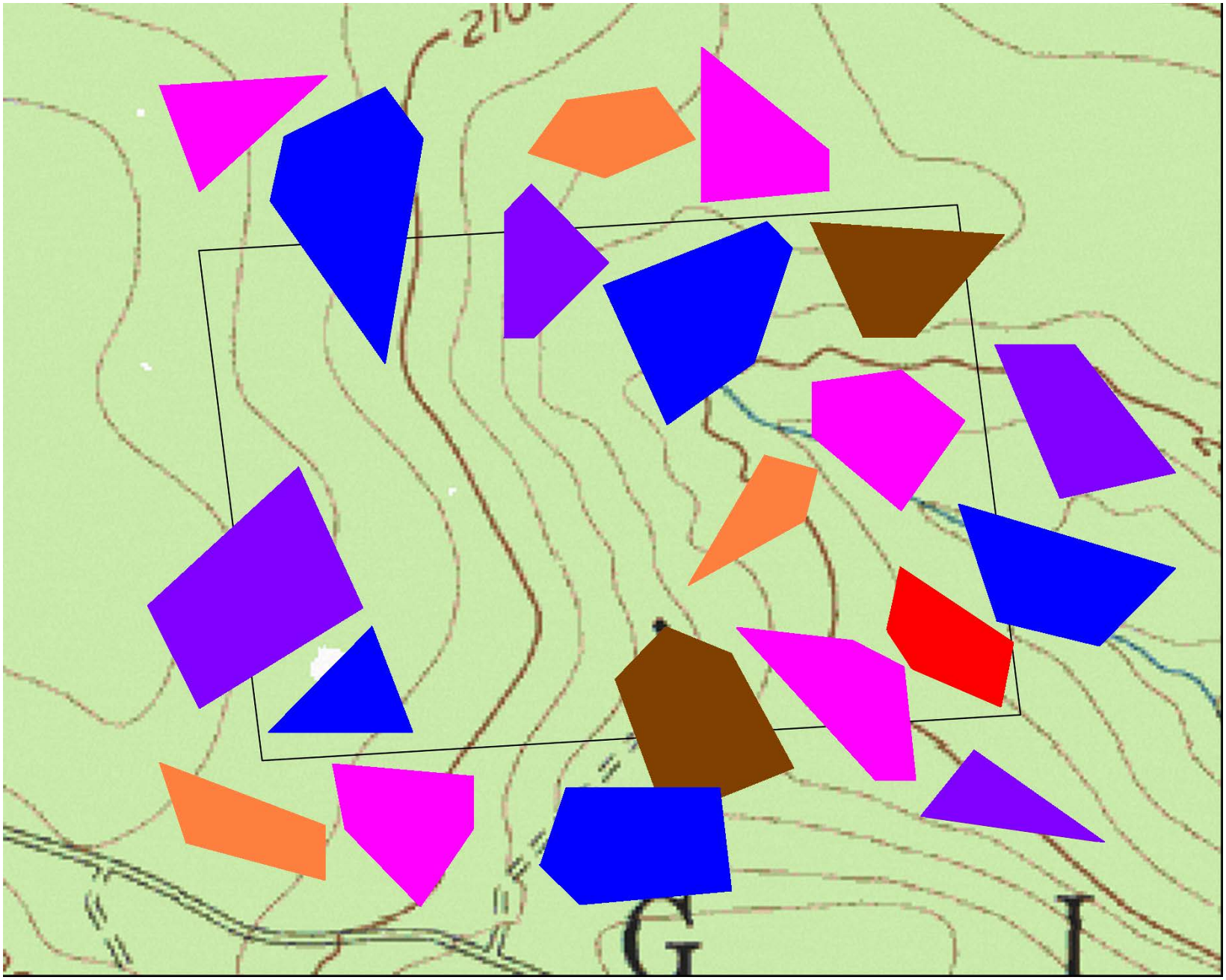
2004



2005

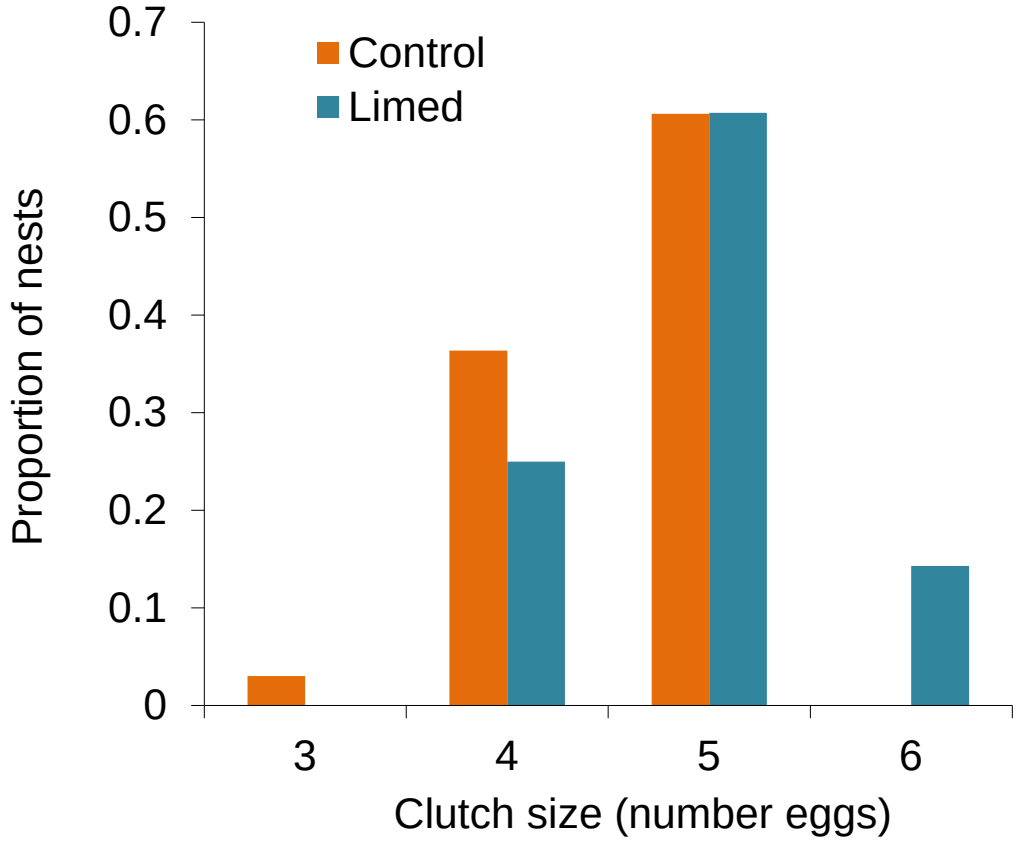


2006

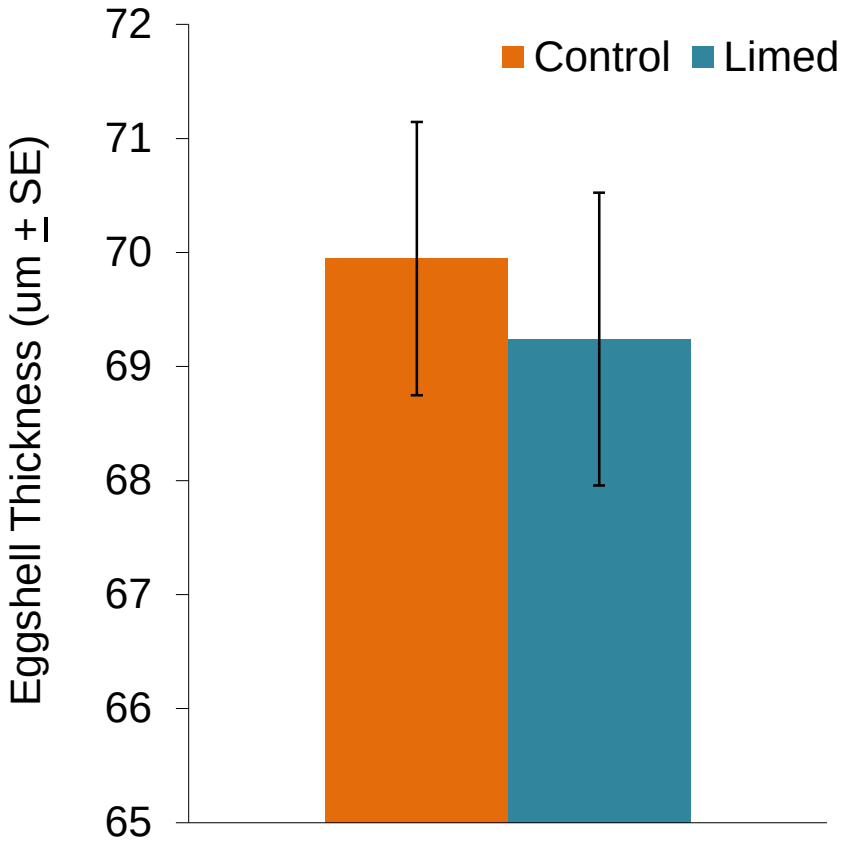


2008

Larger Ovenbird clutch sizes in limed sites



No effect of liming on Ovenbird eggshell thickness

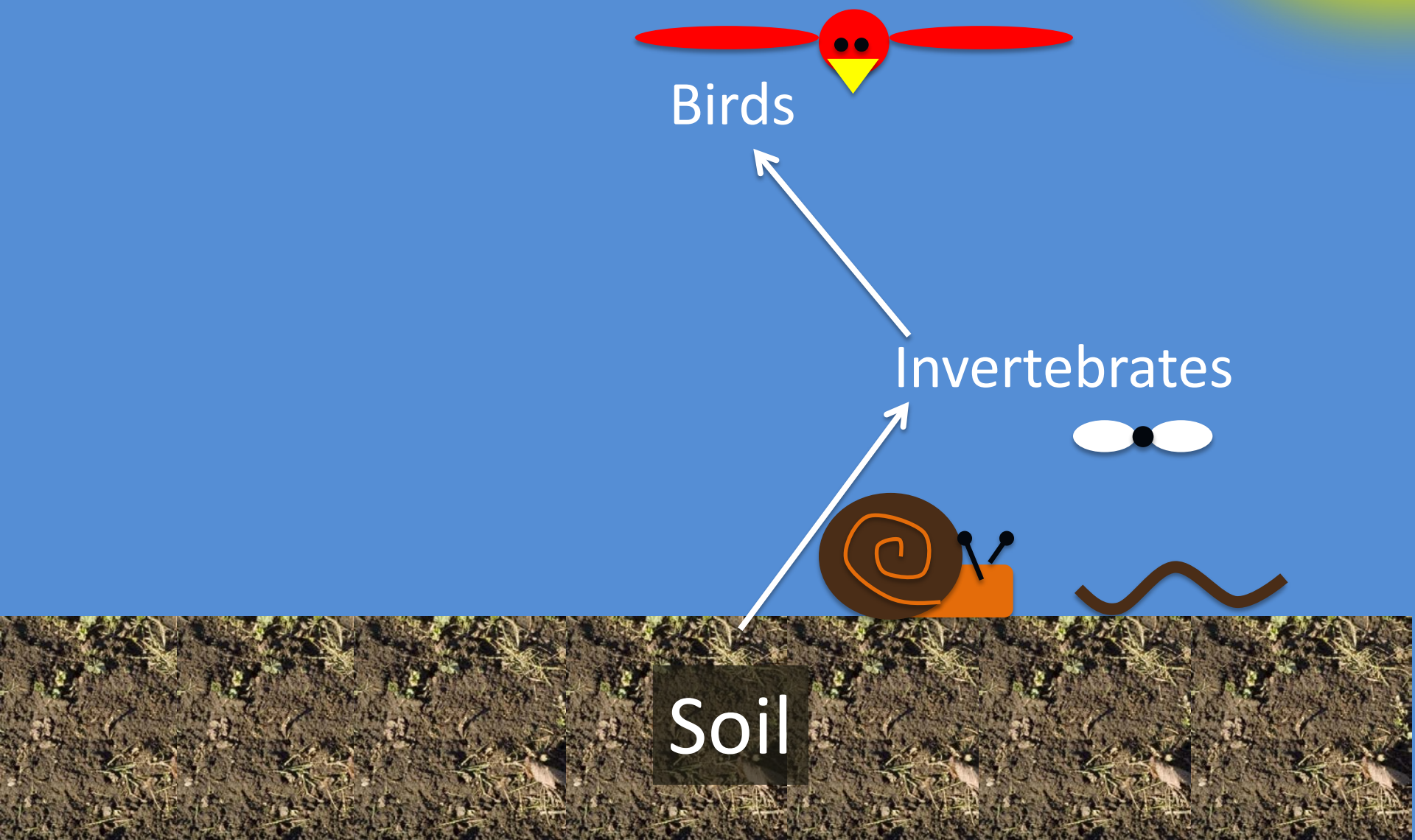


Liming improved habitat quality for the Ovenbird

Ovenbird productivity and abundance were limited by Ca without having thin eggshells

Because vegetation did not change, increased calcium-rich foods was the most likely mechanism

How are birds related to soils?



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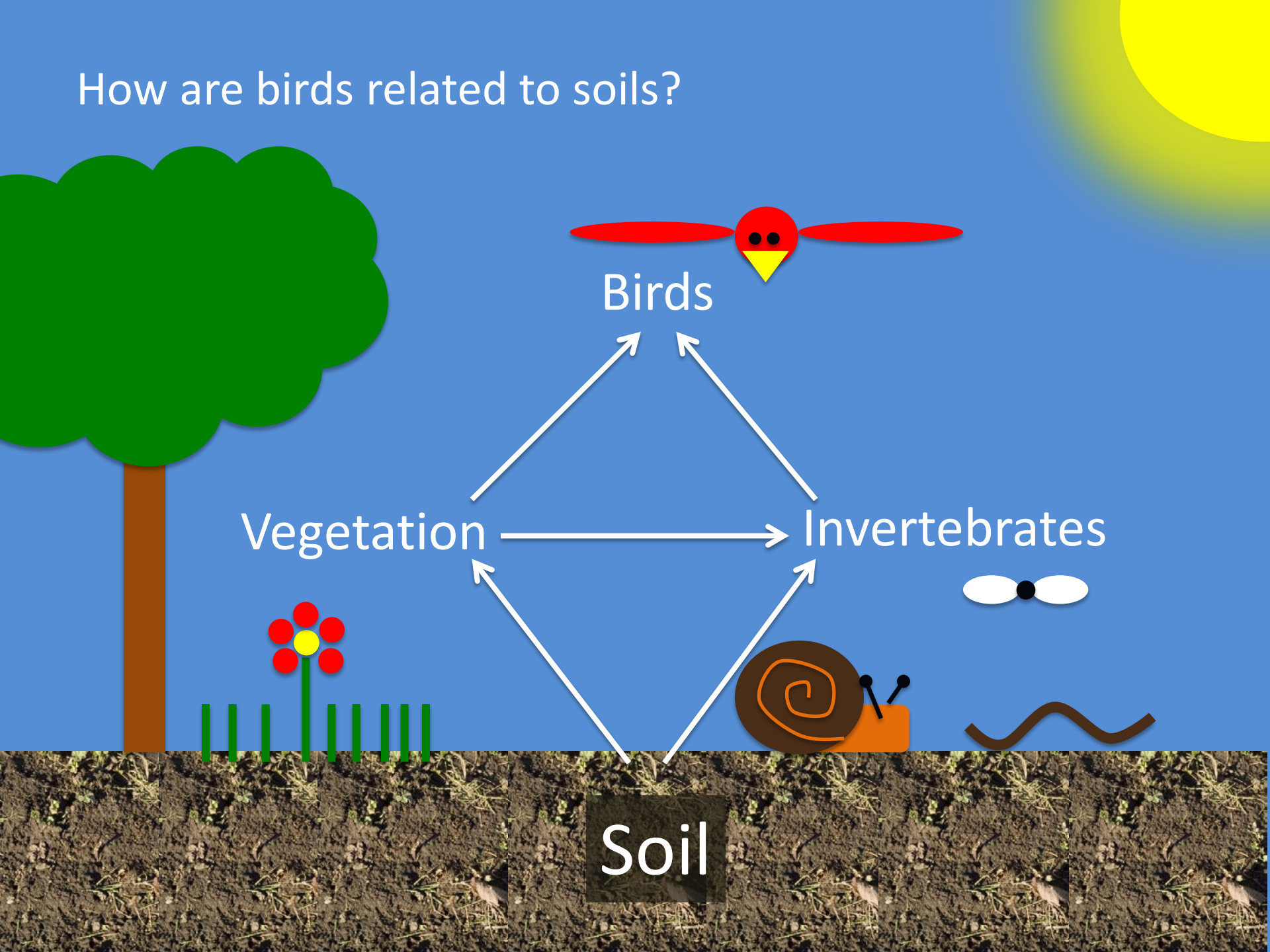
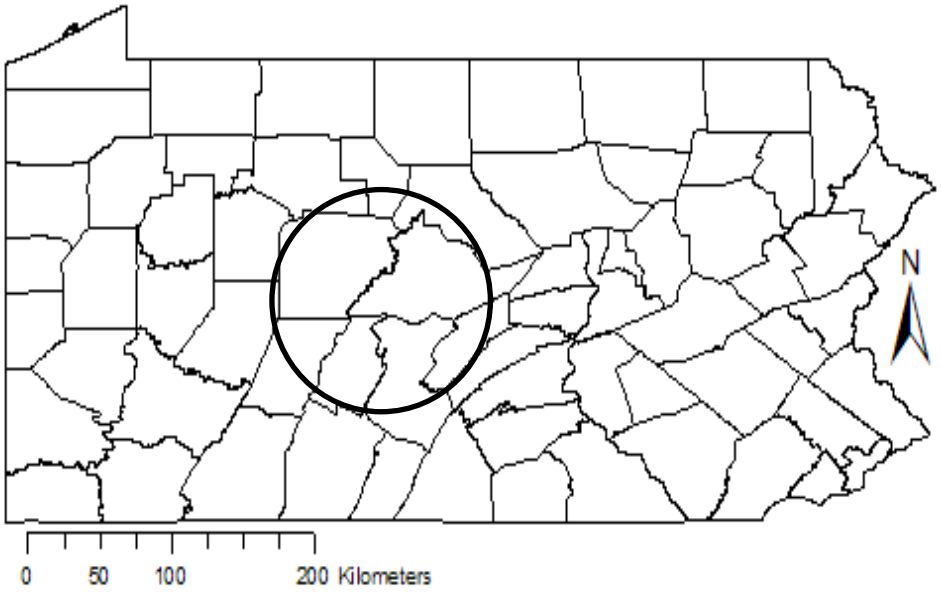
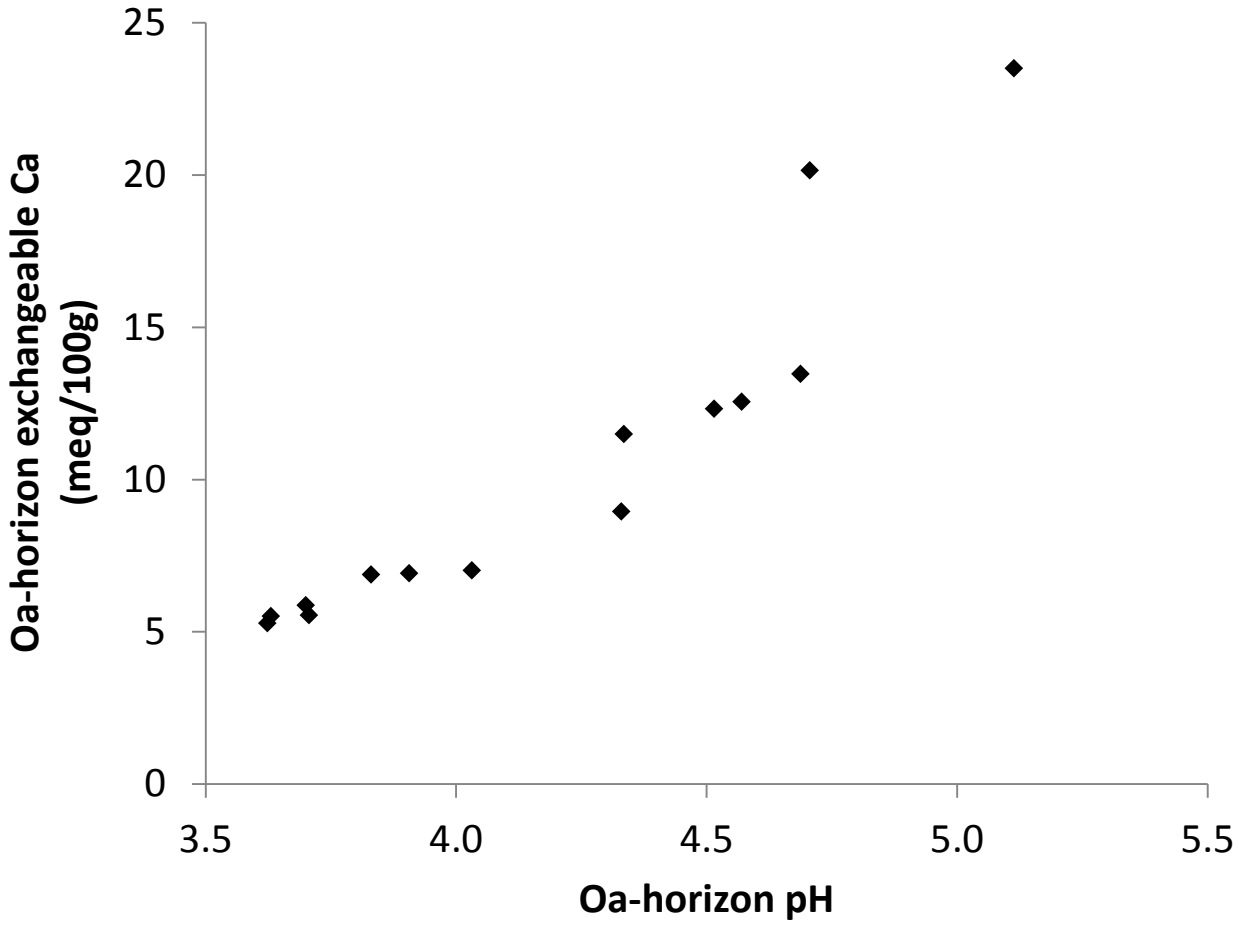


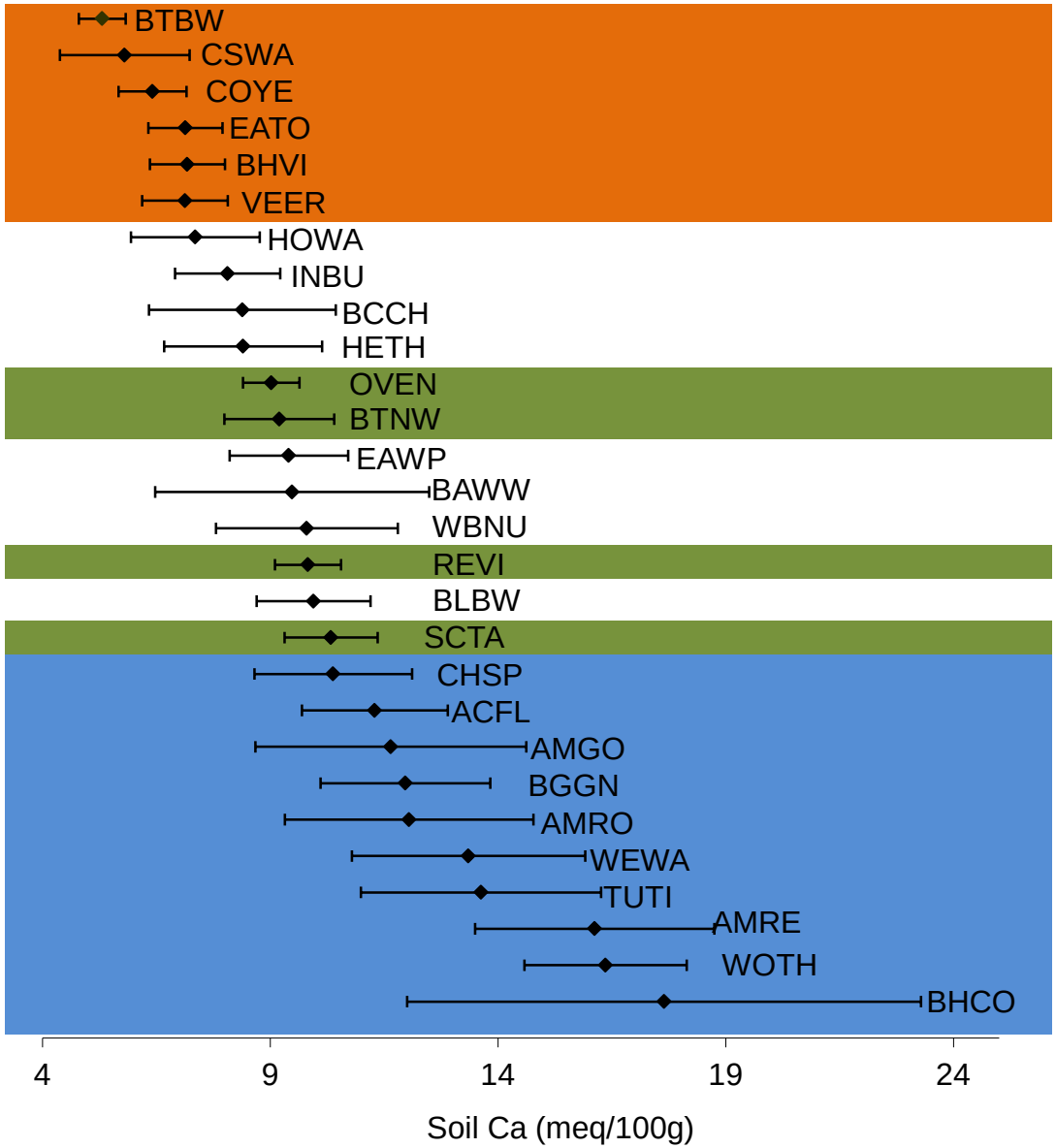
We studied bird community composition in forests with a range of soil calcium availabilities

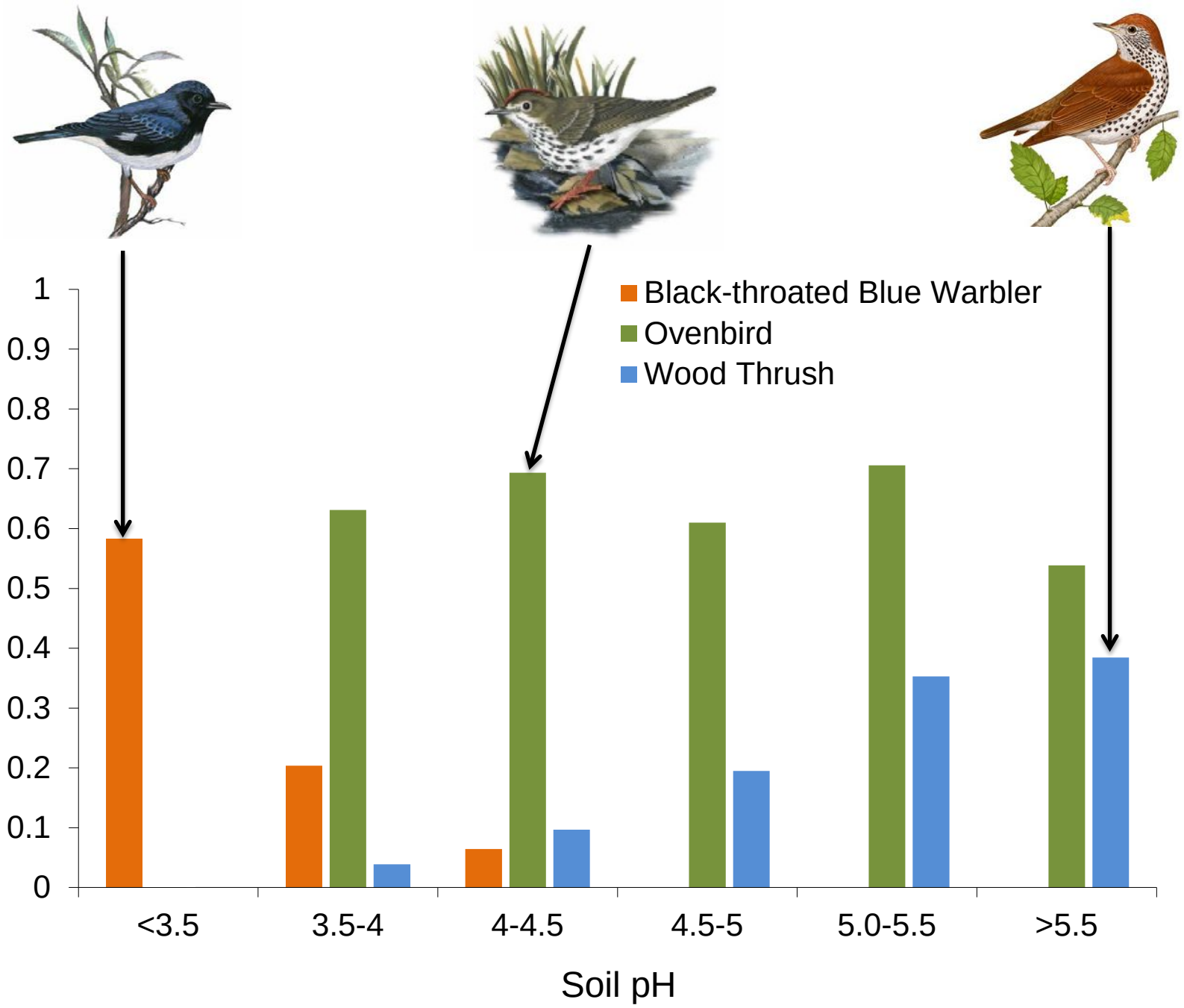


14 forest sited across central Pennsylvania with a range of soil calcium conditions

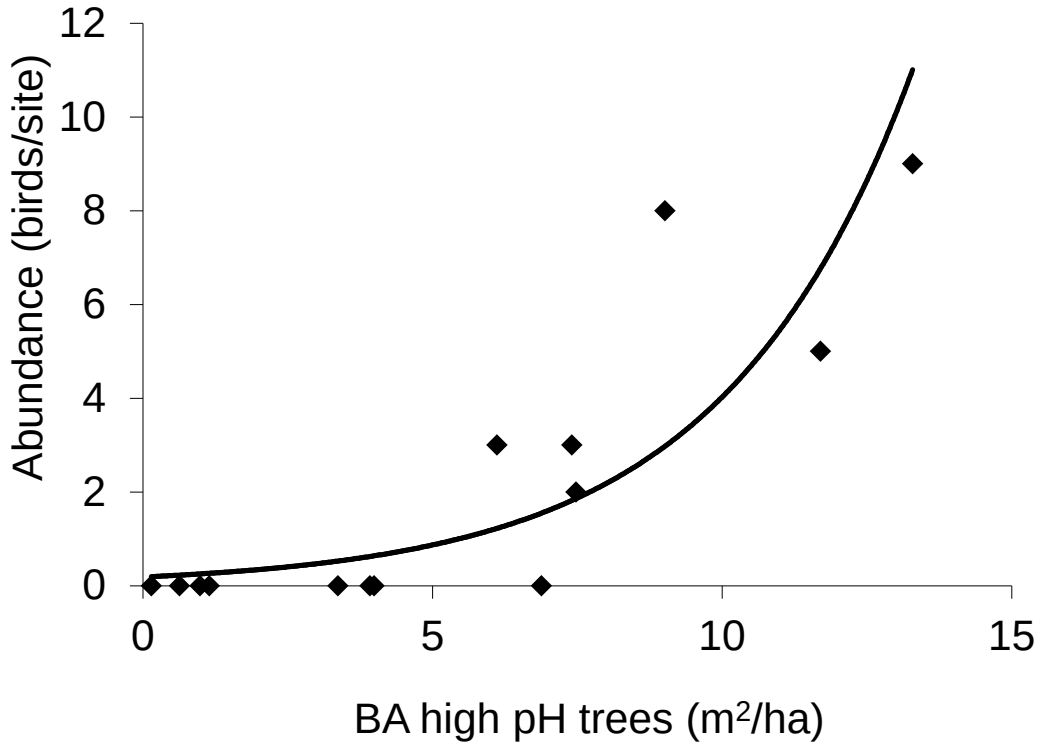
Determined how bird community composition is related to soil calcium and examined linking mechanisms


Oa-horizon exchangeable Ca (meq/100g)
25
20
15
10
5
0
3.5
4.0
4.5
5.0
5.5
Oa-horizon pH

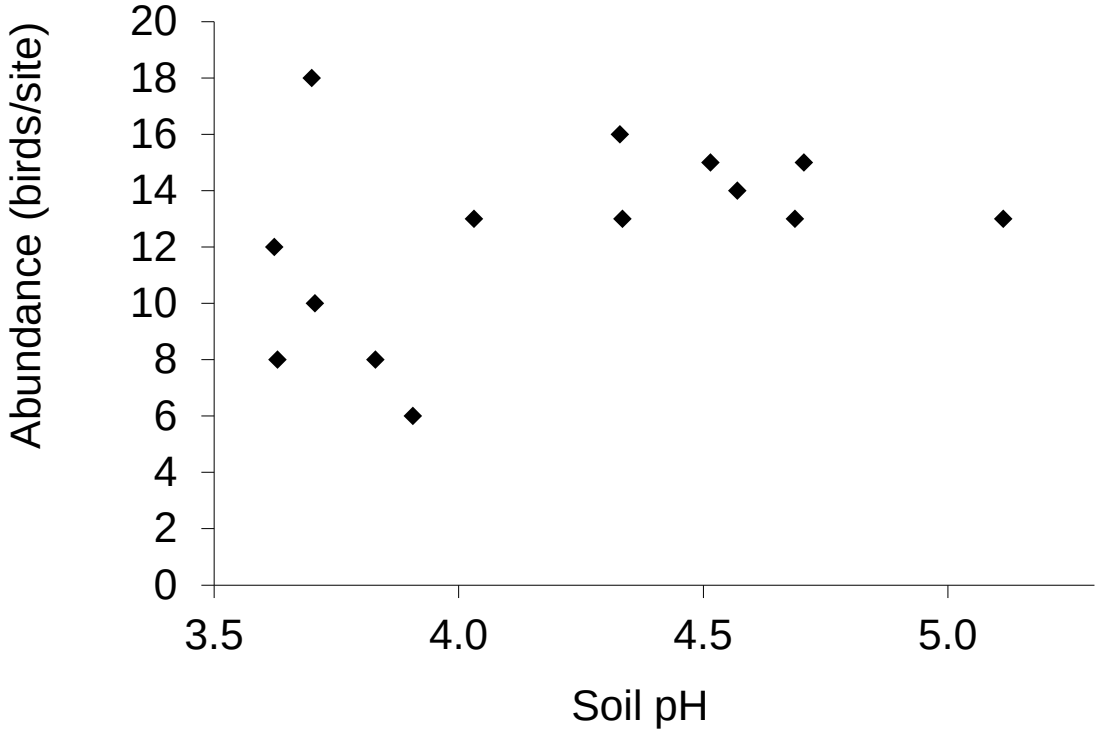

BTBW
CSWA
COYE
EATO
BHVI
VEER
HOWA
INBU
BCCH
HETH
OVEN
BTNW
EAWP
BAWW
WBNU
REVI
BLBW
SCTA
CHSP
ACFL
AMGO
BGGN
AMRO
WEWA
TUTI
AMRE
WOTH
BHCO
4
9
14
19
24
Soil Ca (meq/100g)


Black-throated Blue Warbler
Ovenbird
Wood Thrush
Abundance (birds/point)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
<3.5
3.5-4
4-4.5
4.5-5
5.0-5.5
>5.5
Soil pH

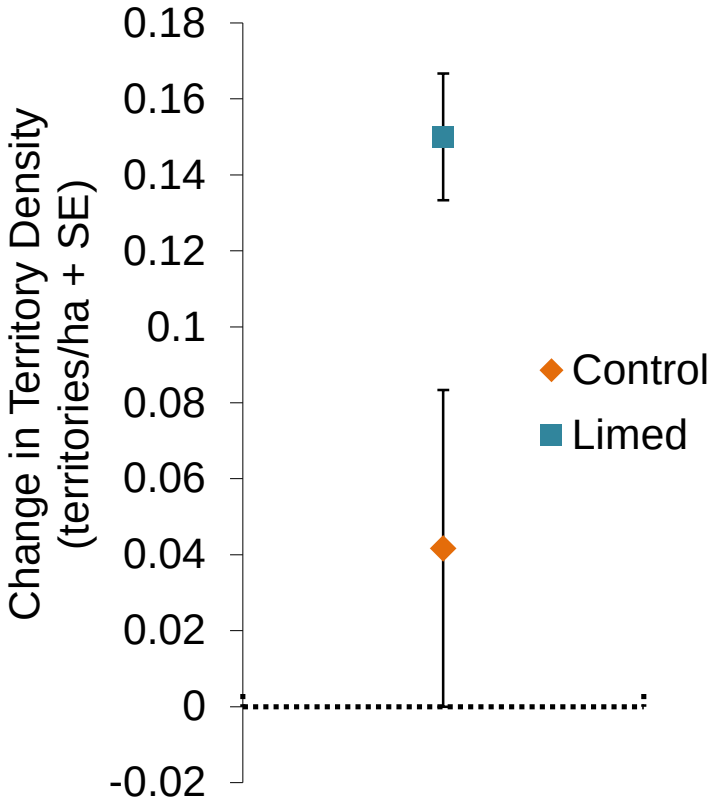
Wood Thrush abundances were best explained by the basal area of acid-sensitive trees

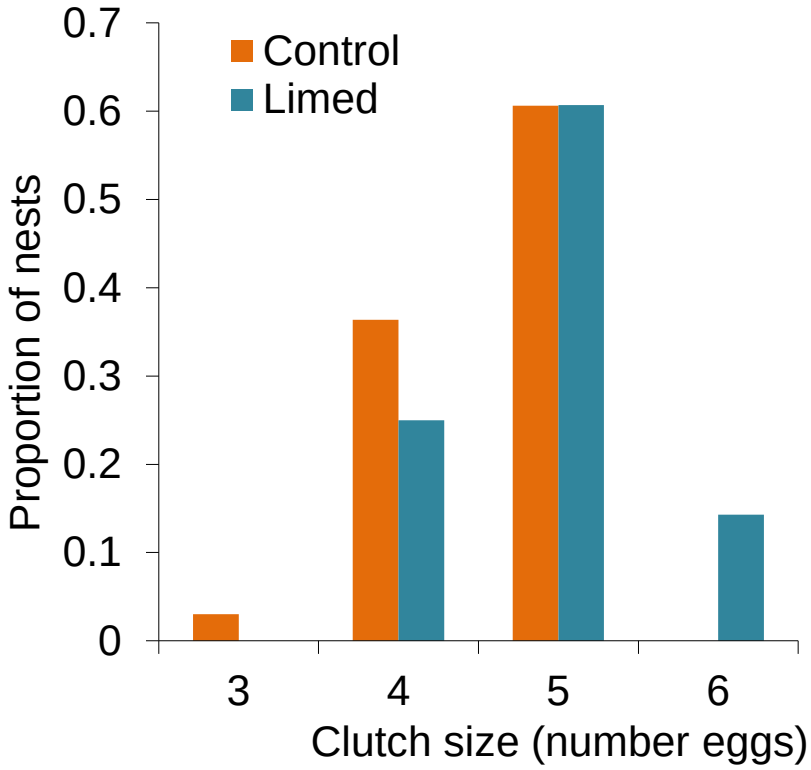


Ovenbird were abundant in all forests

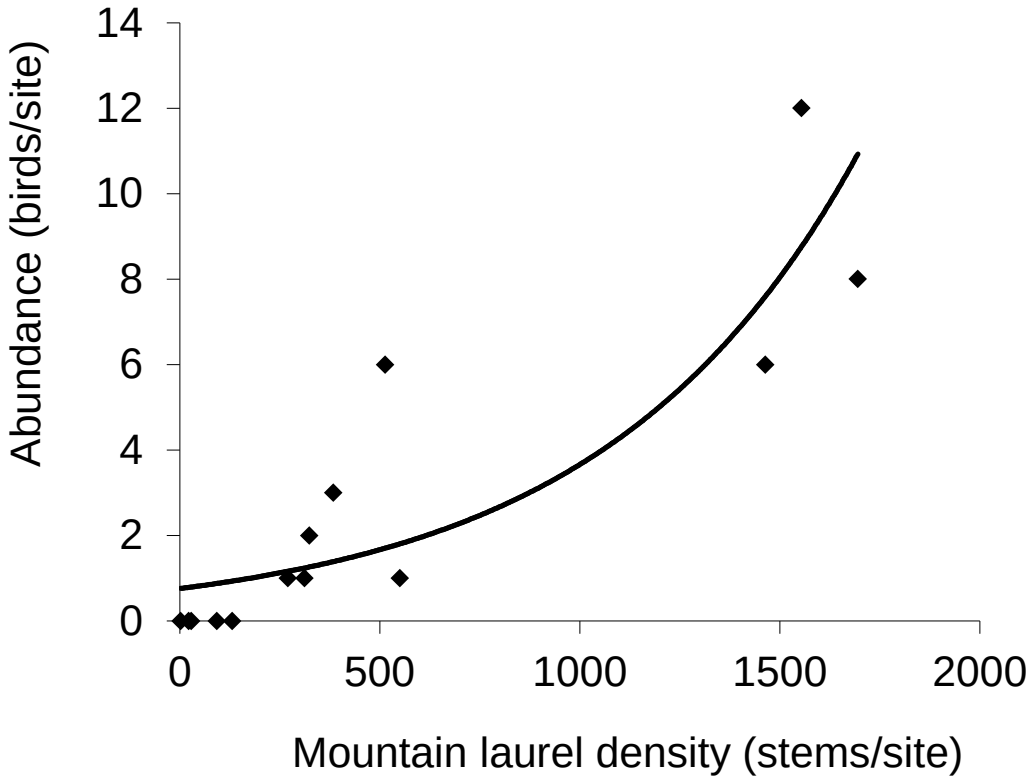


Ovenbird were calcium-limited in forests with low-calcium soils

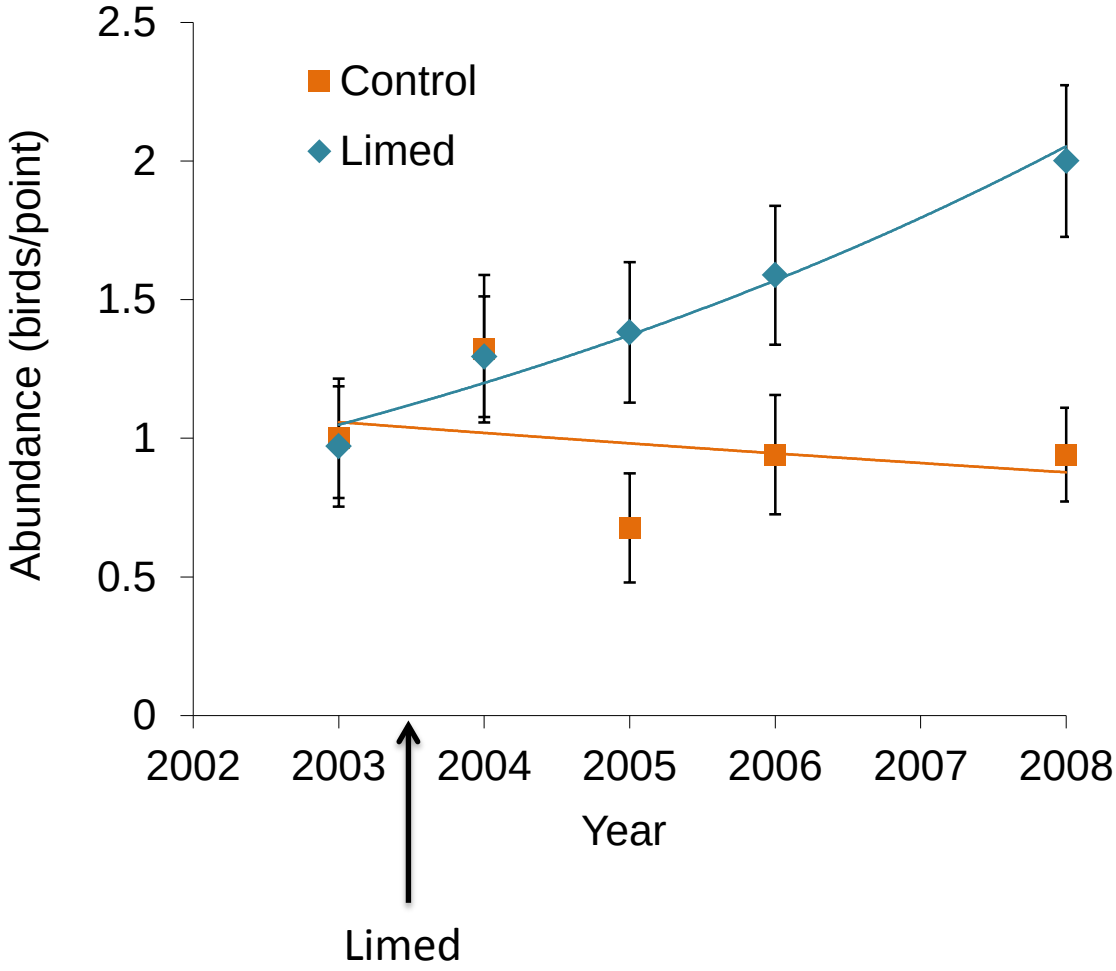




Black-throated Blue Warbler abundances were best explained by mountain laurel density



Black-throated Blue Warbler abundances were limited by calcium in the liming study



Based on observational results:

Low Ca

Soil

High Ca

Based on experimental results:

Really Low Ca

Kind of low Ca

Based on experimental results:

Less productive

Lower densities

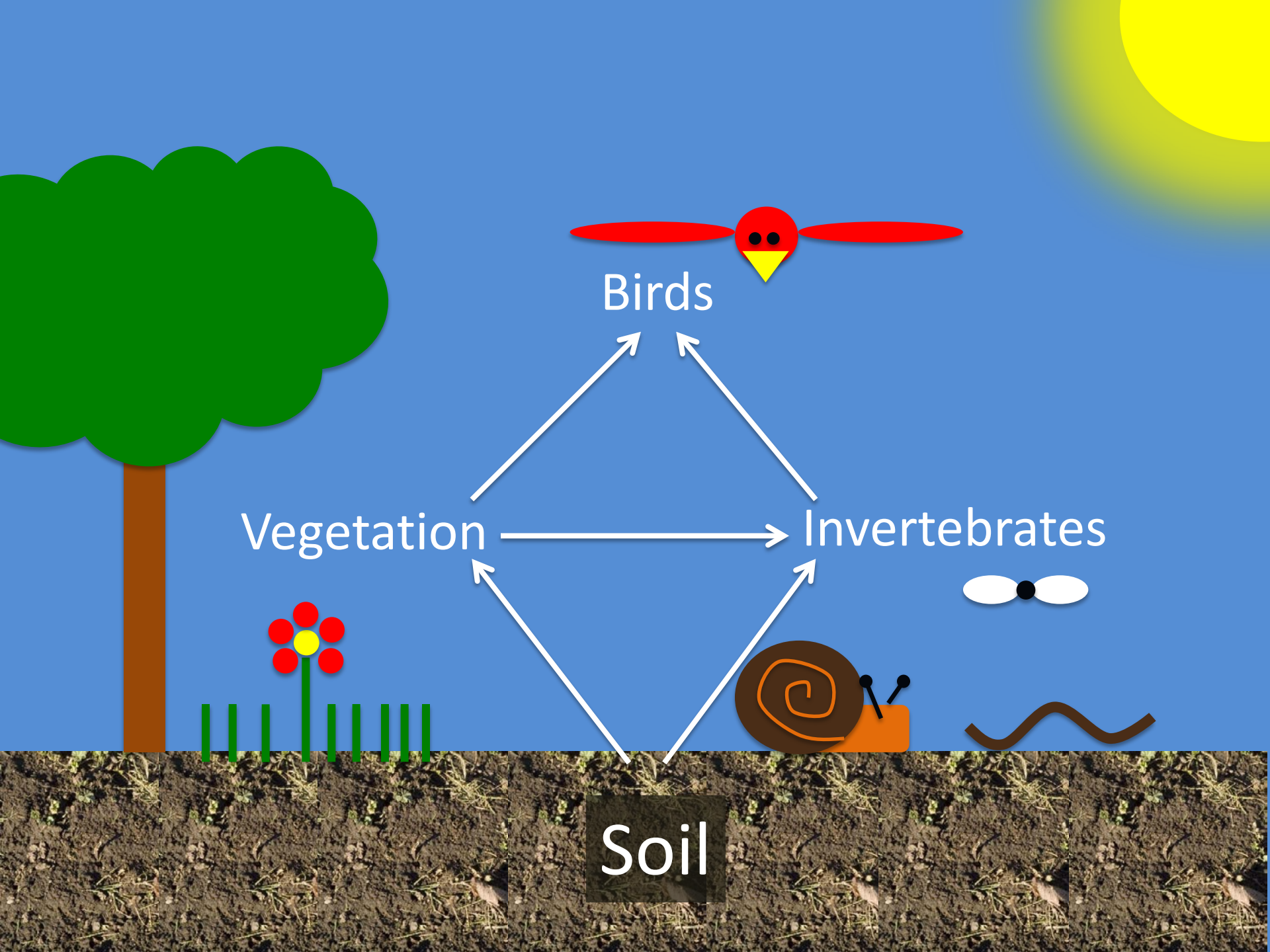
More productive

Higher densities

Really Low Ca

Liming

High Ca


Birds
Vegetation
Invertebrates
Soil

All forest songbird species could potentially be negatively affected by soil acidification

Birds that are associated with vegetation on high-calcium soils are at risk of losing habitat

Birds that are associated with vegetation on low-calcium soils may be calcium-limited

Generalist forest birds may be calcium-limited in much of their habitat

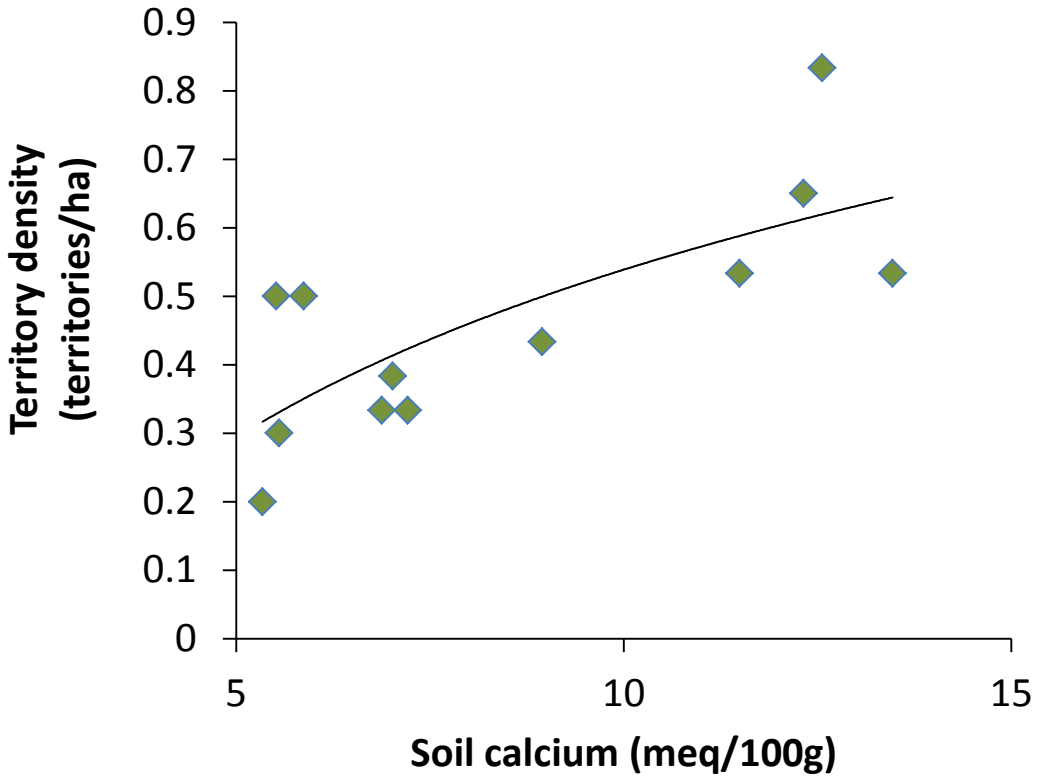
Thank you!

Margaret Brittingham
William Sharpe
Walter Tzilkowski
Erica Smithwick

PA Wild Resources Conservation Program
PA Agricultural Experiment Station
PA Game Commission
PA Department of Conservation and Natural Resources

Field assistants: D. Behrend, D. Becker, S. Chiavacci, N. Cohen, C. Coverstone, N. Ermer, D. Grear, J. Kauffman, T. Keller, K. Lynott, P. Manning, N. Mizel, S. Rummel, L. Sisitki, G. Stokke, E. Stuber, T. Weidman, T. Wertz

We observed similar relationships with natural variation in soil calcium



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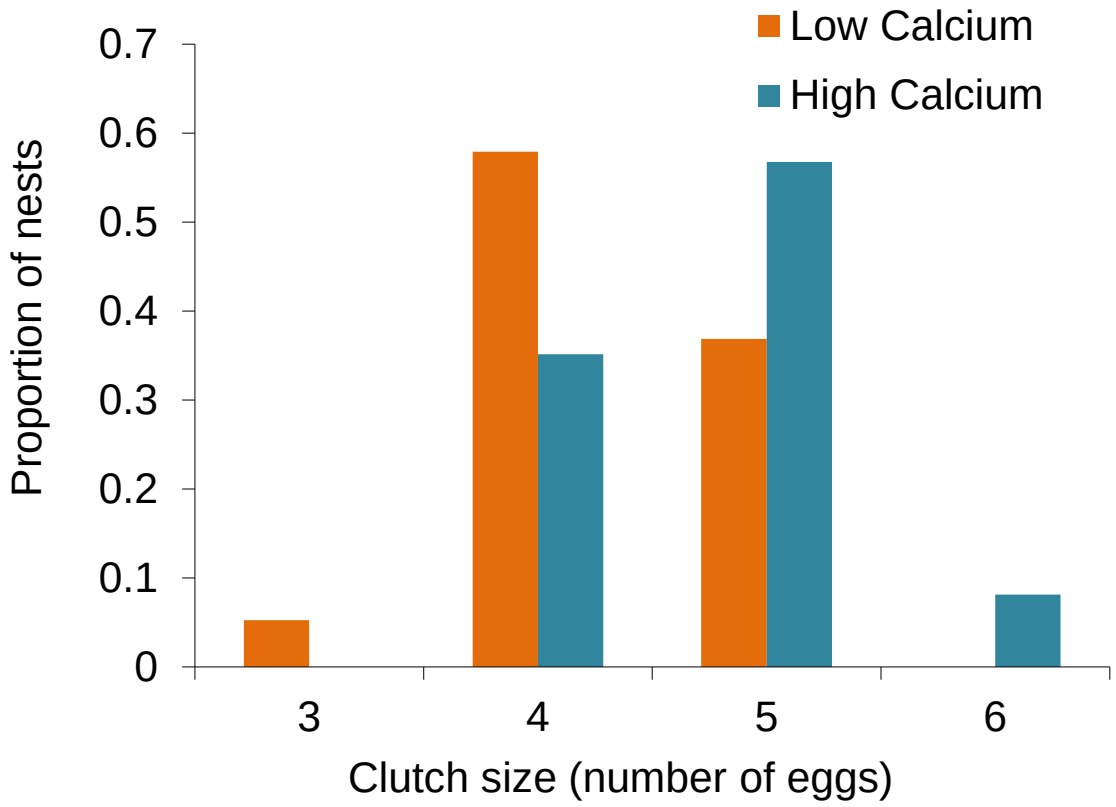

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