

One of the Classic Examples of Coevolution

Prodoxid Moths and Their Host Plants

Some unknown
ancestor



Yucca
moths



Obligate
mutualist

(What we knew in 1979)

What We Now Know: Diversification of Traits and Ecological Outcomes

Prodoxid Moths and Their Host Plants



G. variabilis



G. subalba



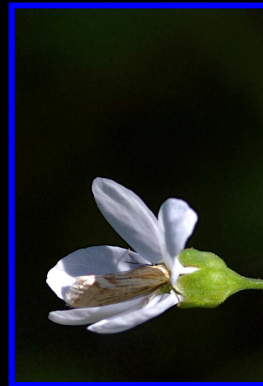
G. piperella

Greya moths

Yucca moths



G. enchrysa



G. obscura



G. mitellae



G. politella



T. maculata

Antagonist

Commensal/
Antagonist

Inefficient
Mutualist

Moderately
Efficient
Mutualist

Highly
Efficient
Mutualist,
Sometimes
Exclusive

Obligat
mutualist

Diversification of Derived Taxa in Drier Habitats

Basal Prodoxidae

Basal *Greya*

Derived *Greya*

Yucca moths



Wahlberg et al. 2013 for Prodoxidae

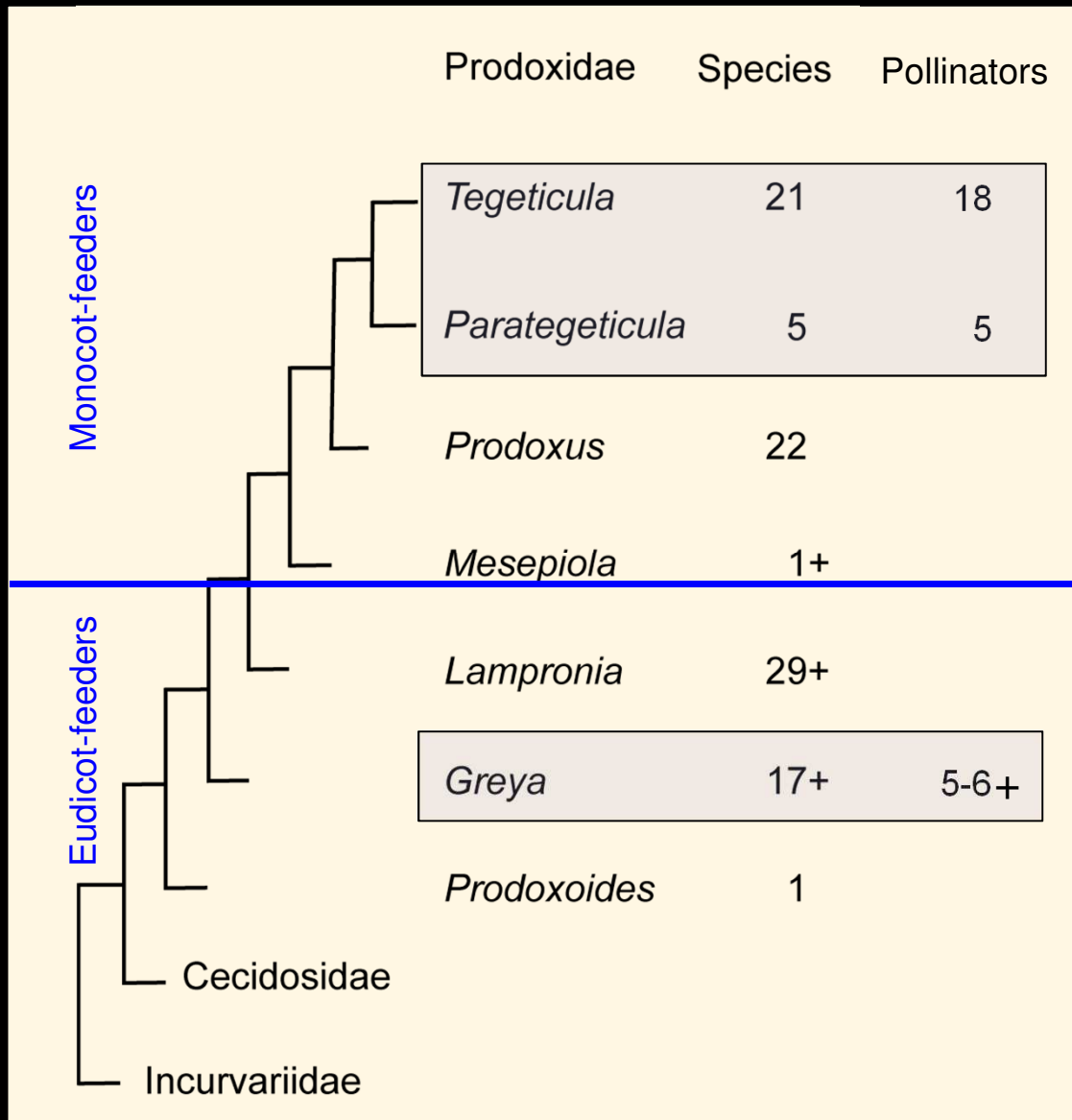
Pellmyr et al. (various) for *Yucca* moths

Thompson et al. and Pellmyr et al (various) for *Greya*

US Dept of State Geographer
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Pollination Mutualisms Evolved More than Once In Prodoxid Moths



These Mutualisms Involve Two Plant Families



The Moths Ensure Developing Seeds for Their Offspring:
Actively in Yucca Moths



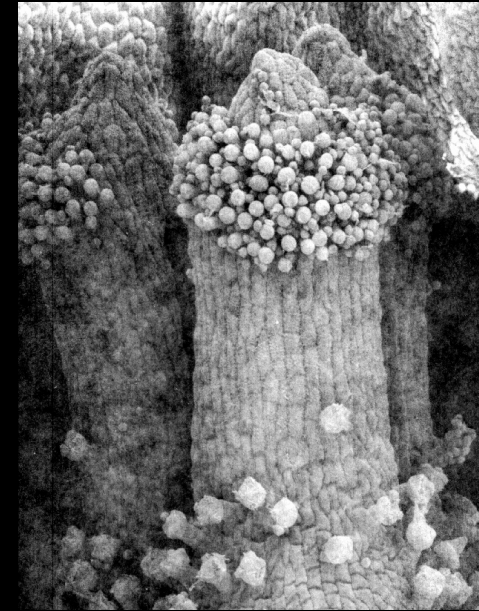
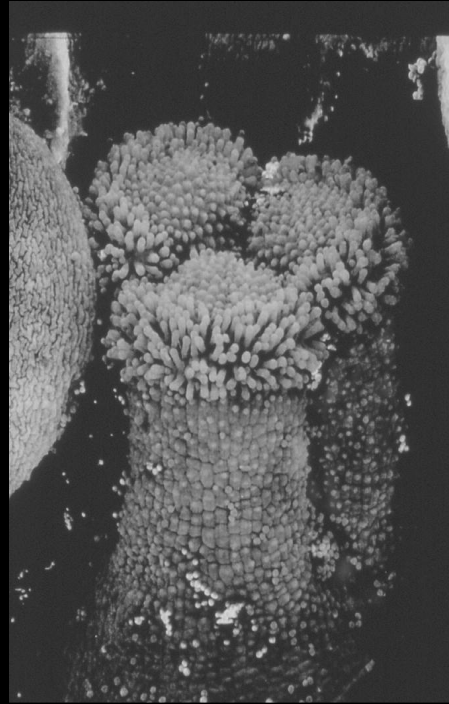
Passively in *Greya* moths:
Greya politella on Woodland Stars (Lithophragma)



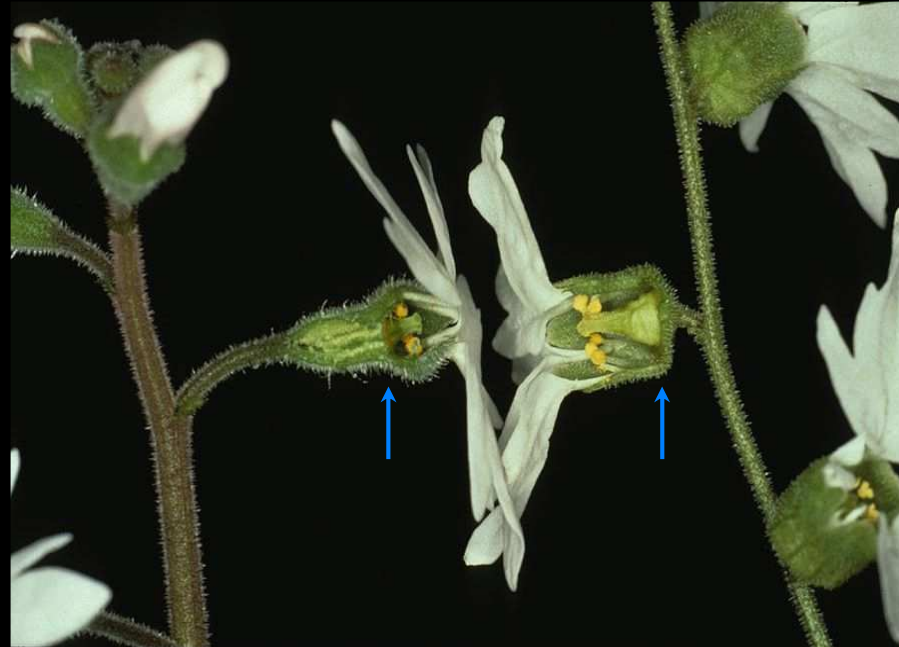
Photos: John N Thompson

Lithophragma
(Woodland star)
Traits Coevolved
With *Greya* Moths

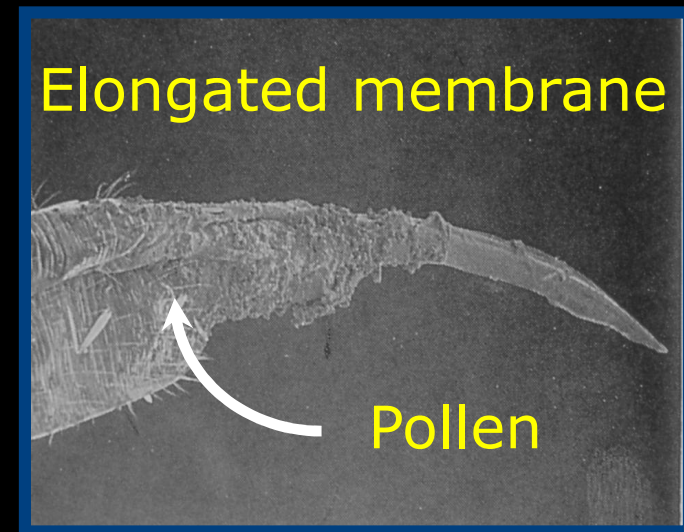
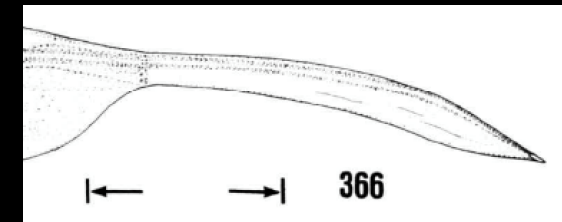
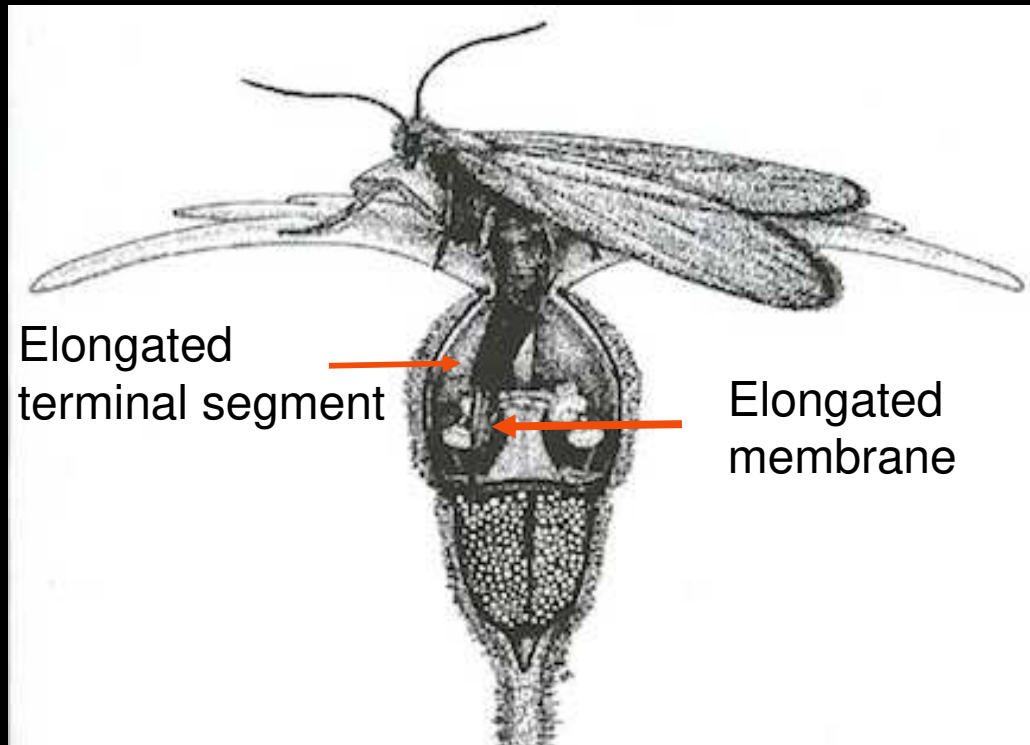
Variable stigma & style
height, shape, etc.



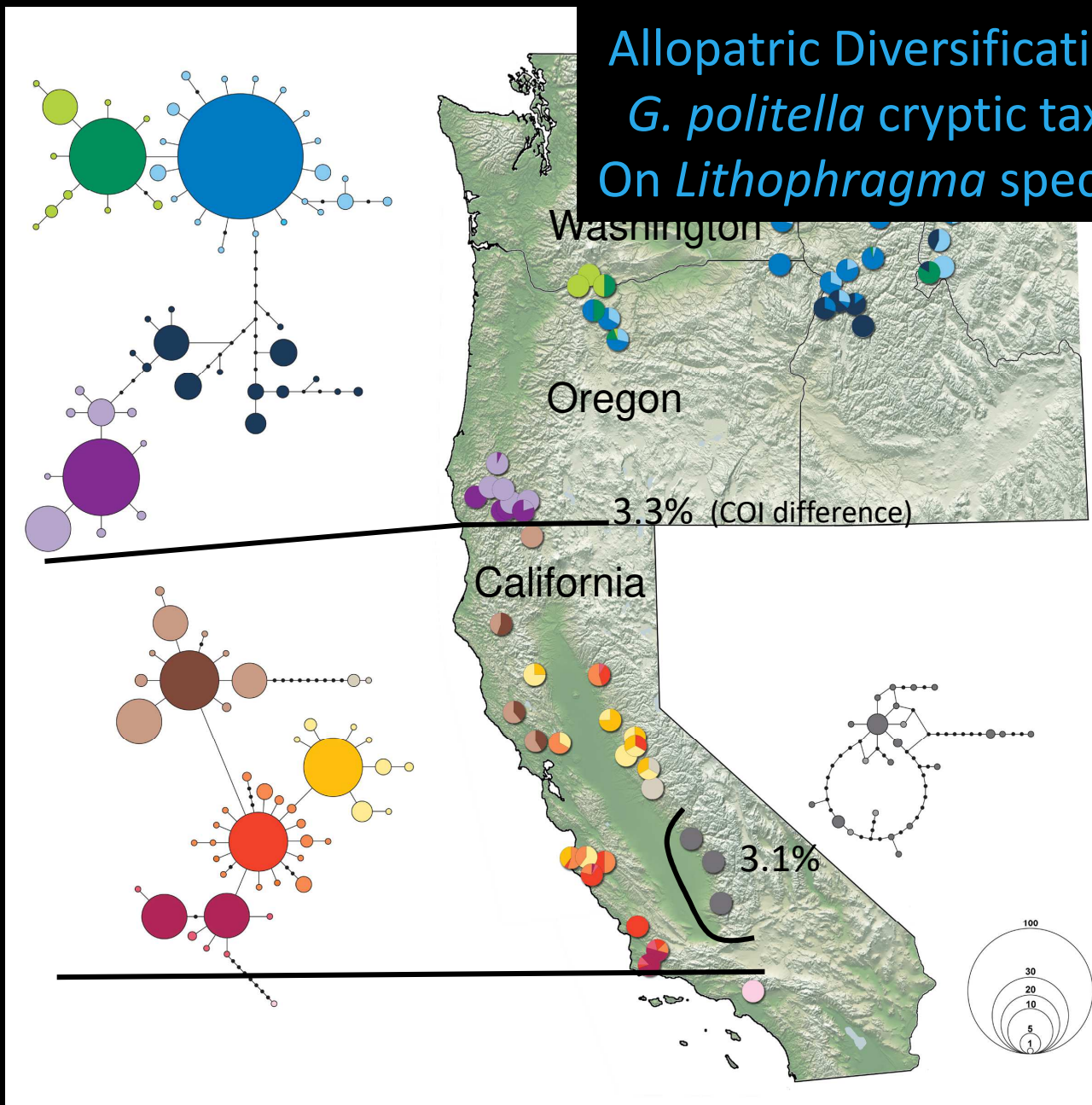
Variable
floral width
ovary depth
petal "platform"



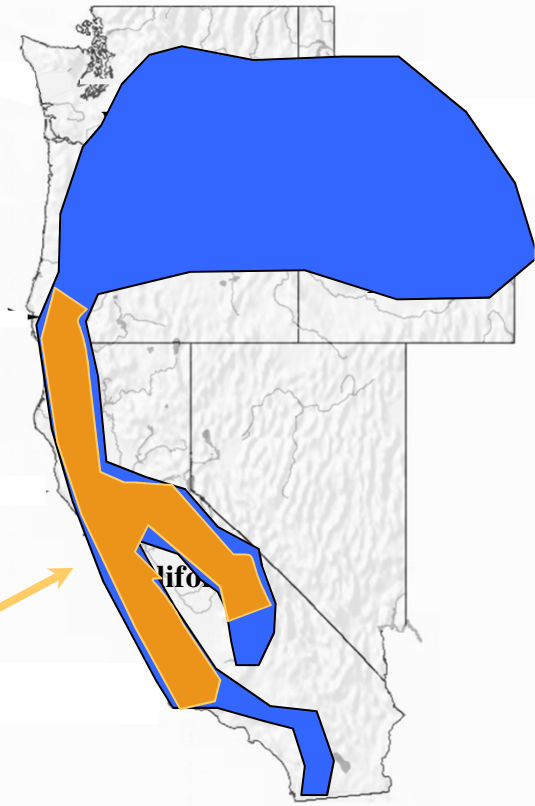
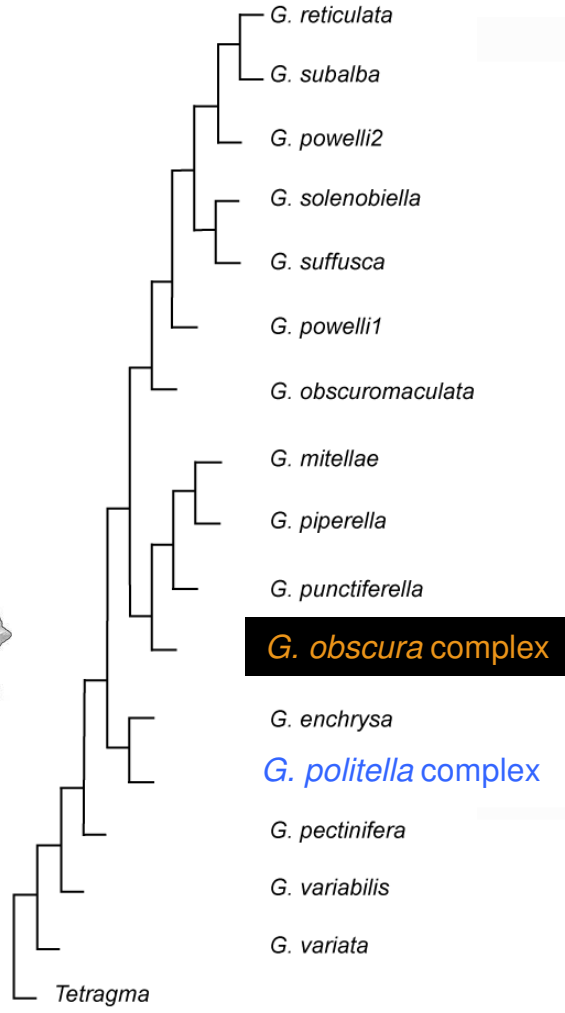
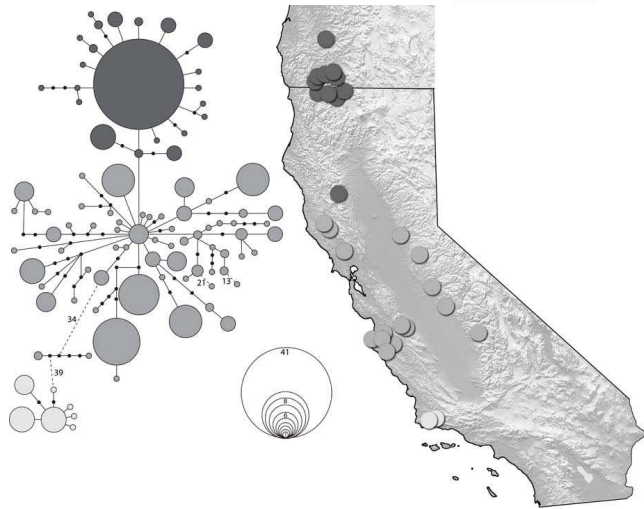
Greya: Variable coevolved traits



Allopatric Diversification: *G. politella* cryptic taxa On *Lithophragma* species



Greya obscura complex is embedded within *G. politella* range and also pollinates *Lithophragma*



Coevolution Varies Geographically: Pollination by One vs. Two Moth Species



Pollination with Head in *Greya obscura*
(Lays eggs in base of ovary or stem,
not through corolla)



Pollination mostly with abdomen
During egg-laying through corolla
in *G. politella*

Photos: John N Thompson

90 Study Sites across 1900 km
(i.e., local coevolutionary experiments)
A subset of the sites is shown here.

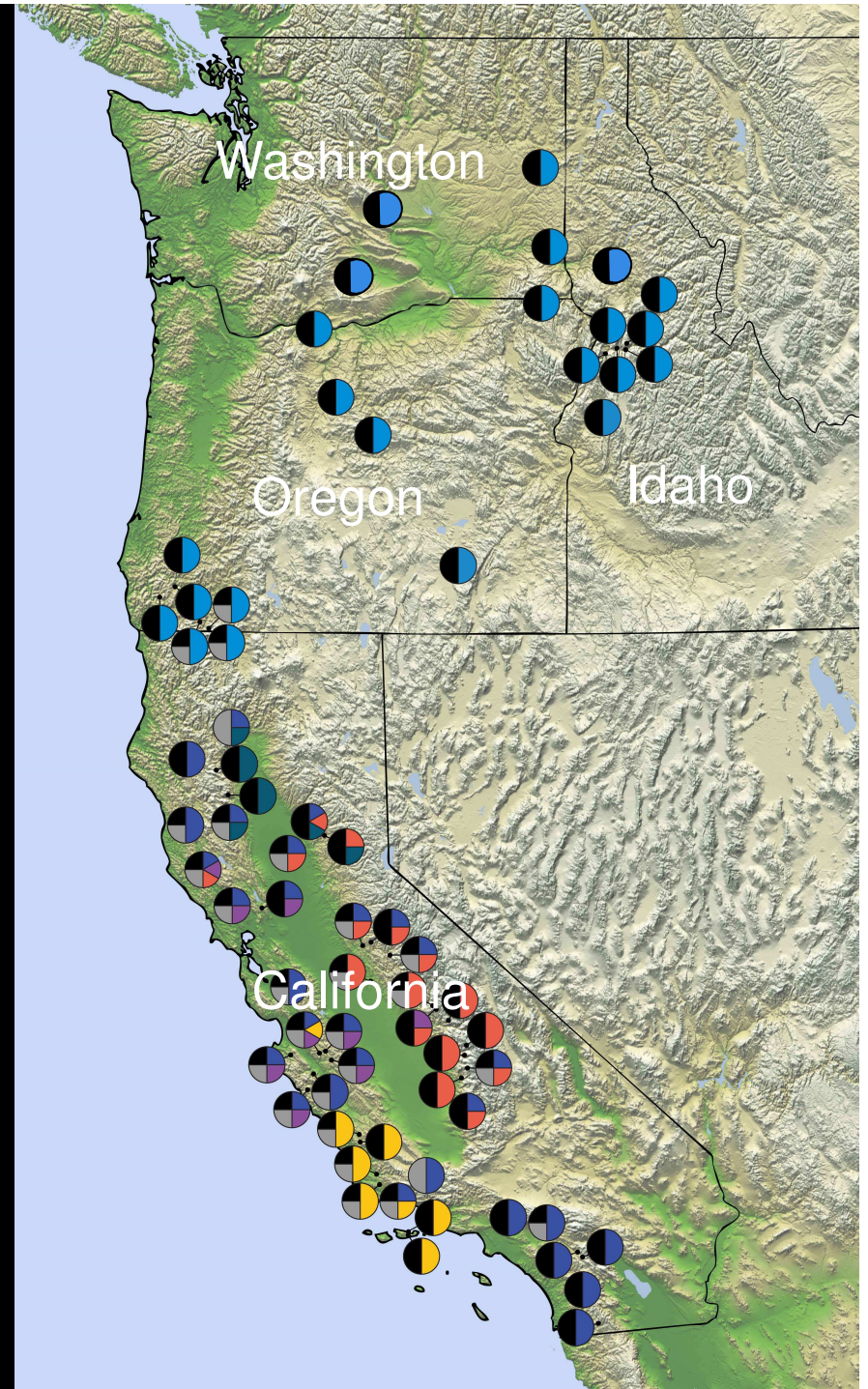
Assess:

Which species interact locally
Plant and moth traits
Ecological outcomes (subset)

Analyze:

Divergence among populations
Divergence among species

Thompson et al. 2017 Am. Nat.

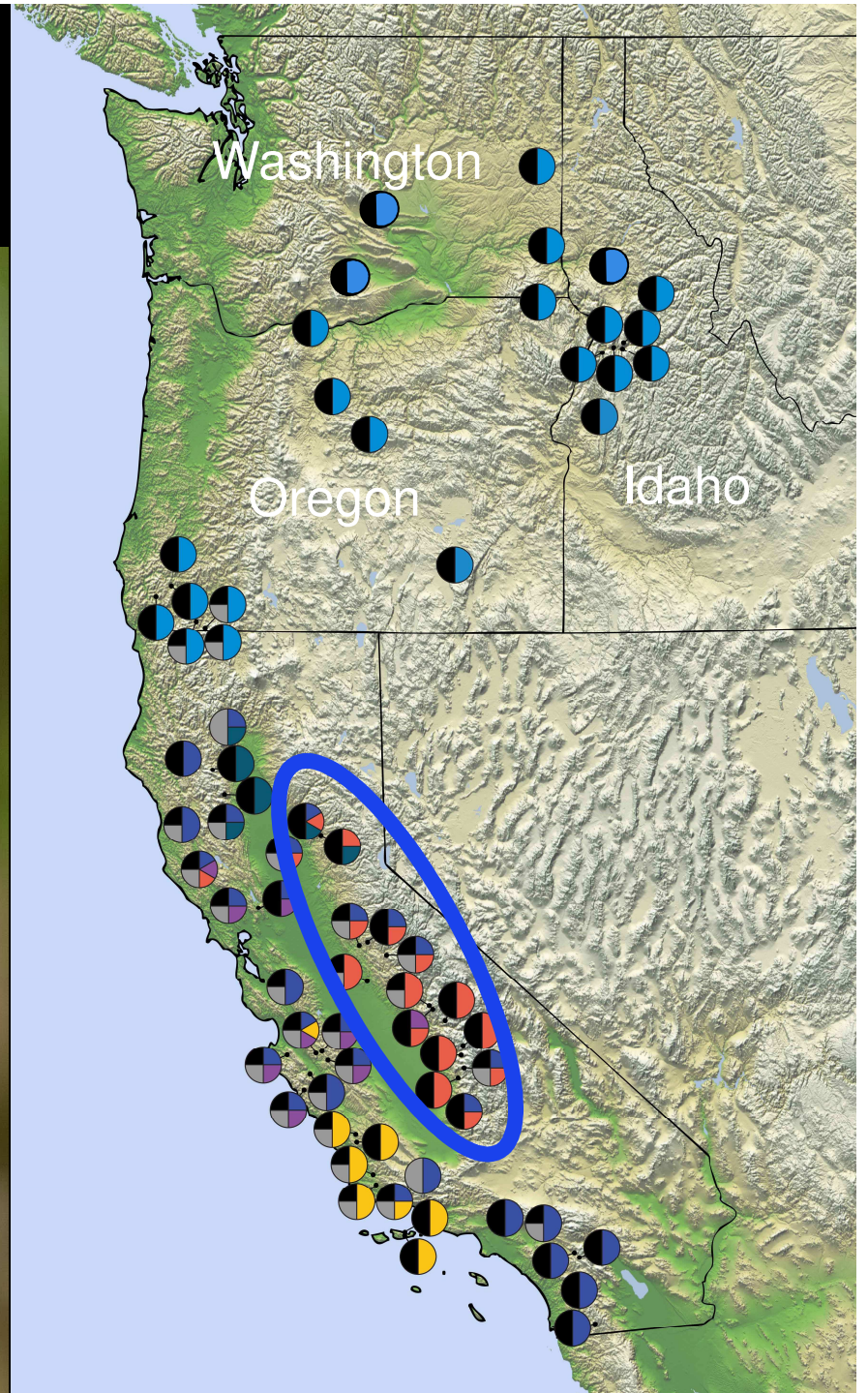


Lithophragma Floral Shapes
and Position of Pollen on *Greya politella* Moths
Differ Among Species and Geographically within Species

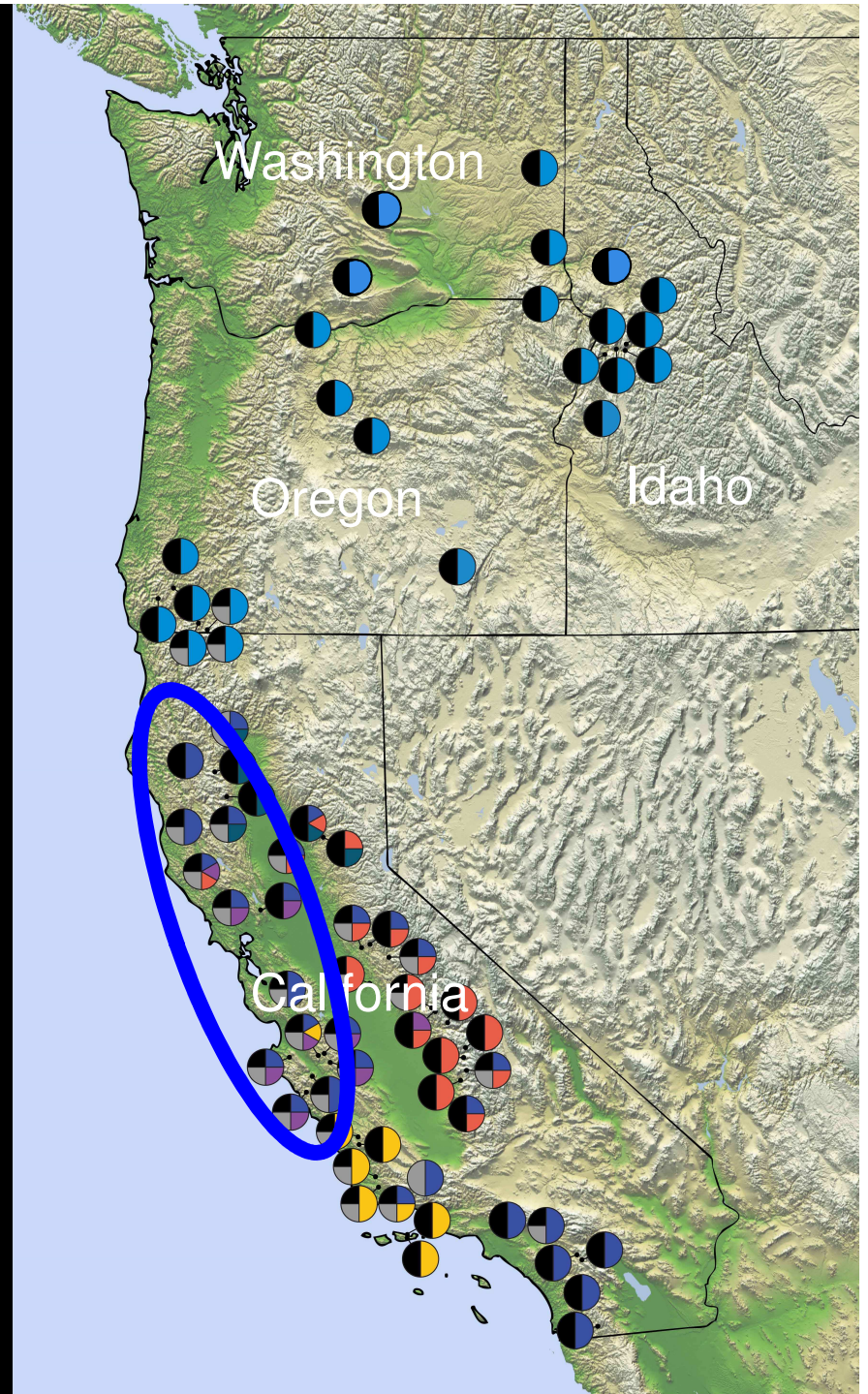


and Friberg 2013 PNAS

Geographic Mosaic of Coevolving
Network of *Lithophragma bolanderi*
and *G. politella* vs. *G. obscura*

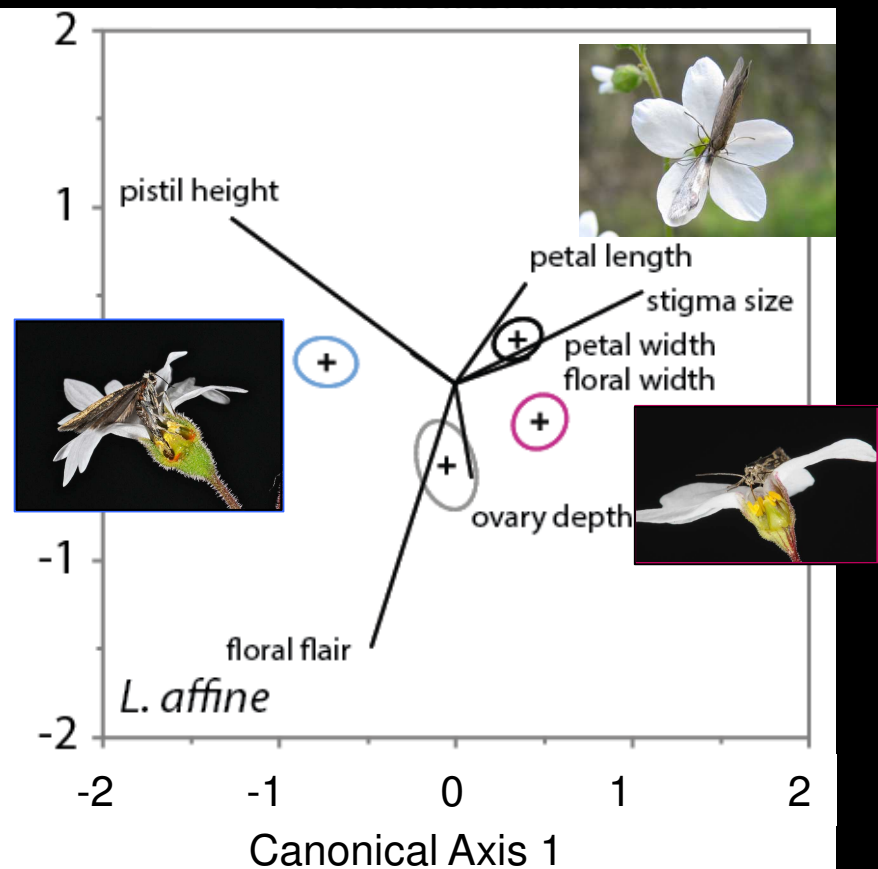
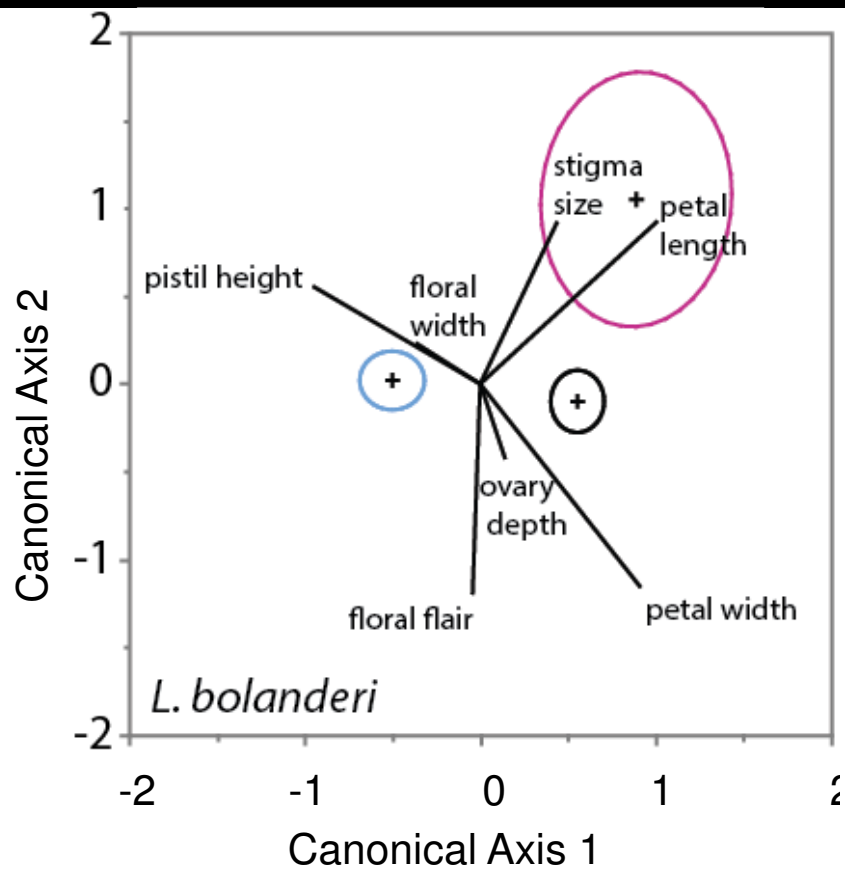


*Example 1:
Lithophragma affine*

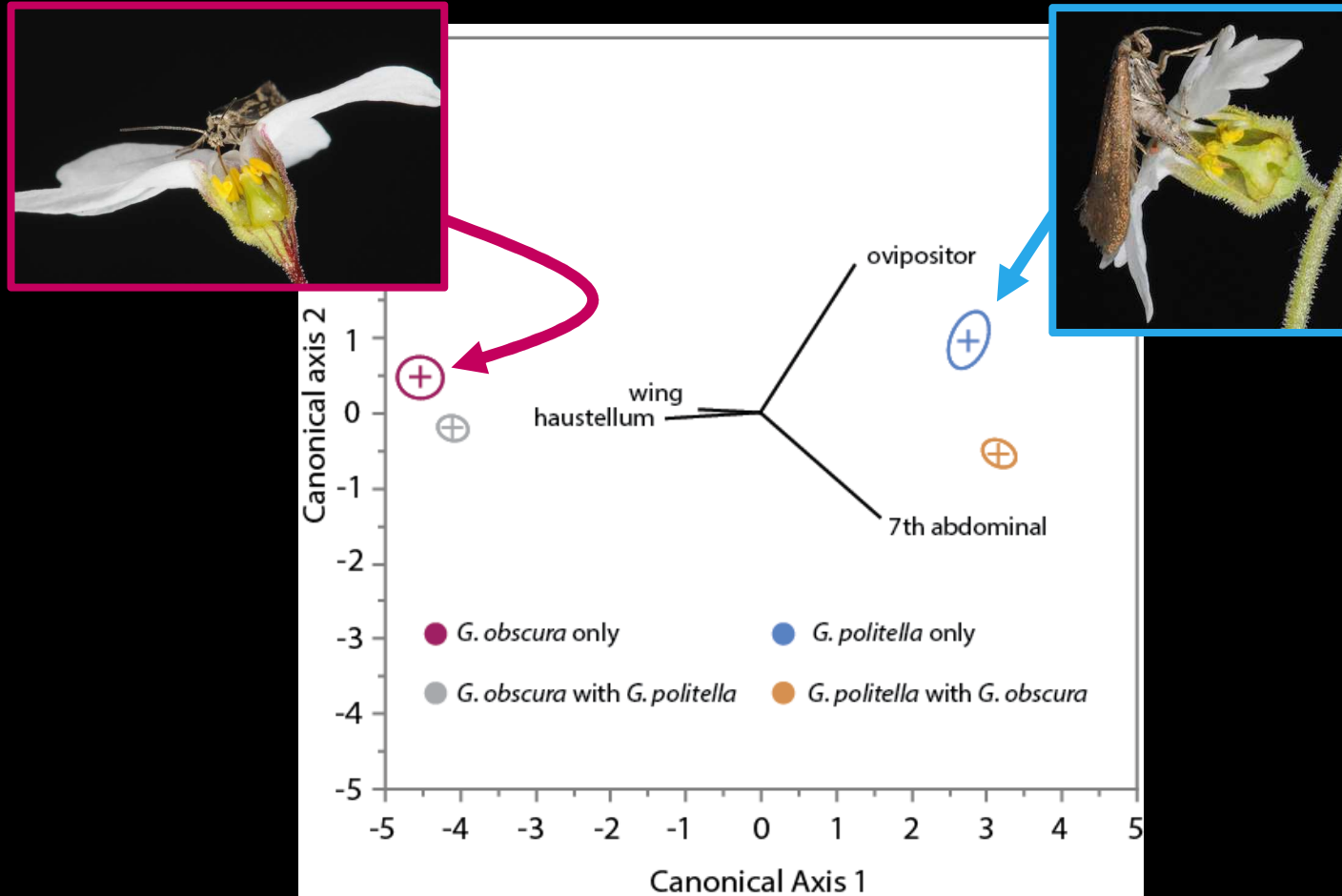


Divergence Among Populations AND Species in Correlated Traits

Blue = pollinated by *G. politella* Red = pollinated by *G. obscura* Black = both pollinators Grey = Neither *Greya* present



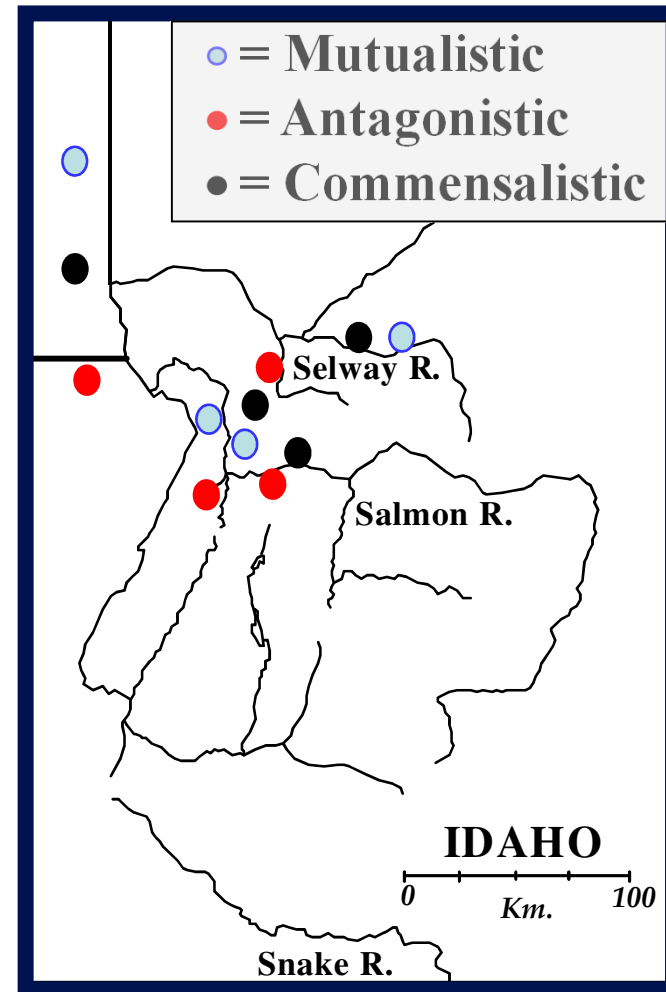
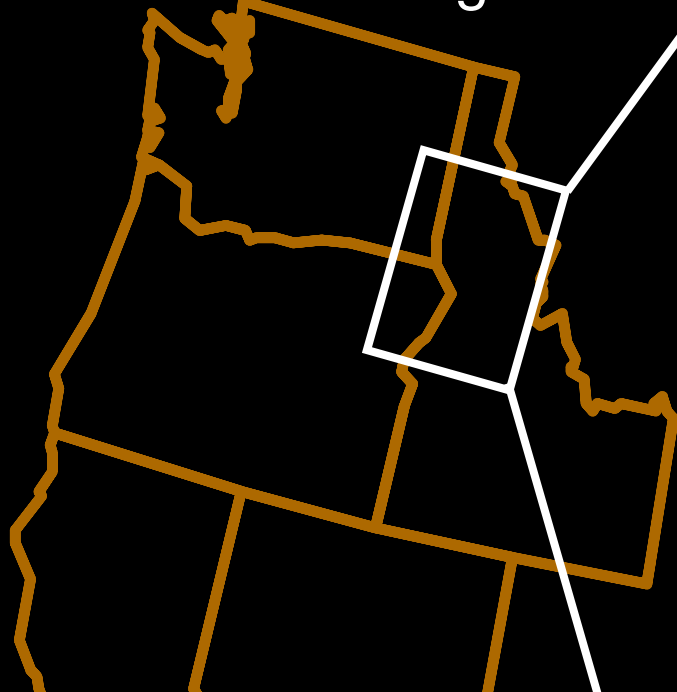
Moth Traits also Vary: Sympatry vs. Allopatry



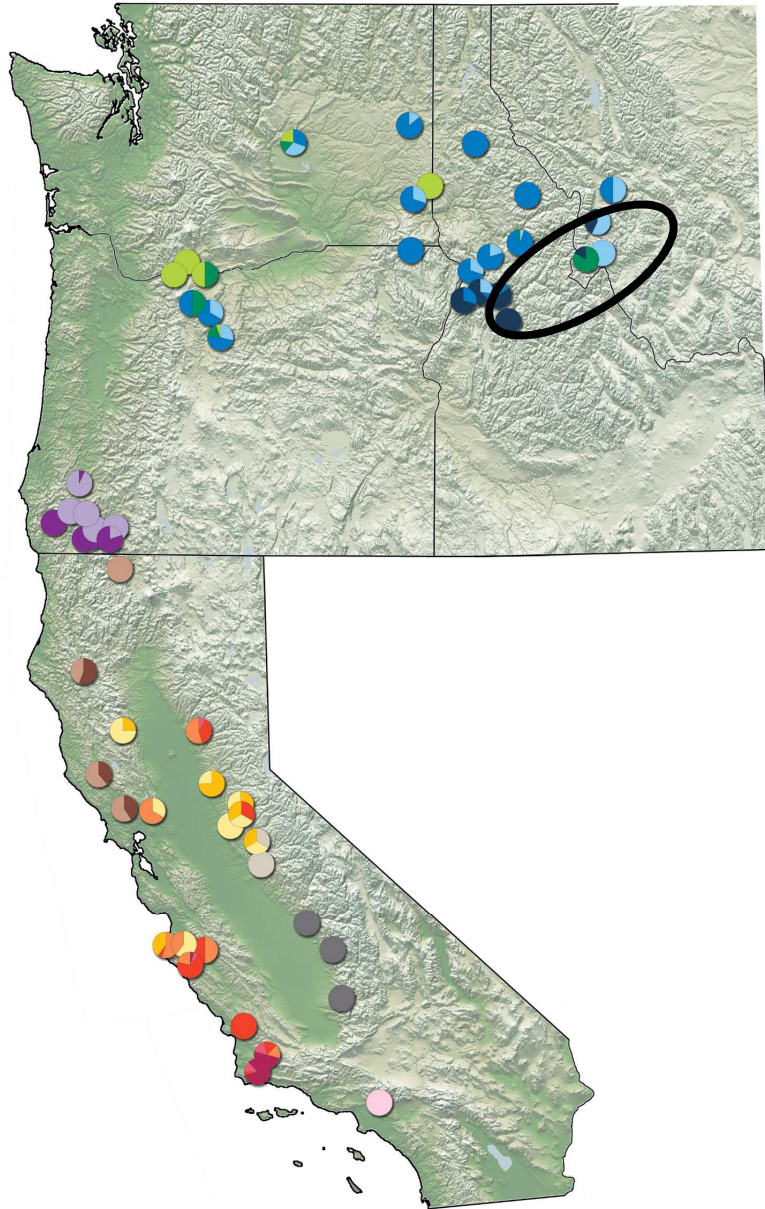
Other Tiles in this Geographic Mosaic of Coevolving Species:
Mutualism is Coopted by Other Taxa in Some Populations
Near the Northern Edge of the Range of *Lithophragma*



Ecological Outcomes of *Lithophragma/Greya* Interactions Near Northern Range Limit

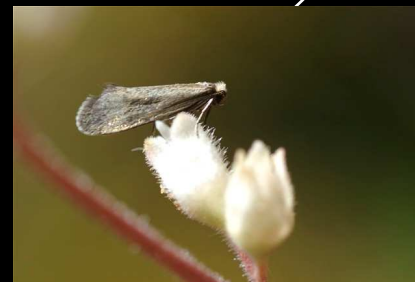


Shift of *Greya* Species onto Closely Related Genus *Heuchera* In Rocky Mountains Depends on Plant Ploidy



on 4N plants

on 2N plants

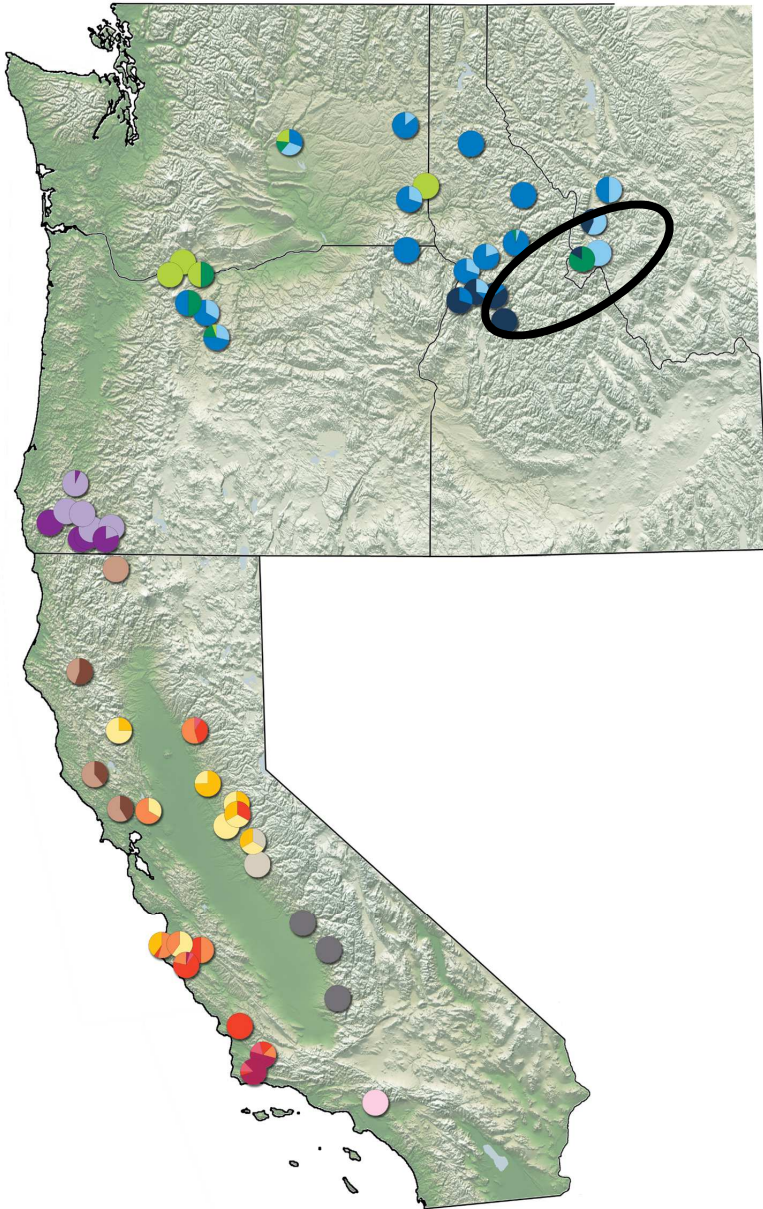


G. politella 2



G. piperella

Pattern of *Greya* Use of *Lithophragma* and *Heuchera* in Rocky Mountains

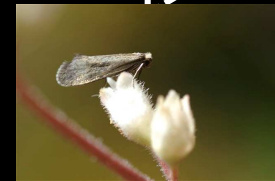


Lithophragma



G. politella 1

4N *Heuchera*



G. politella 2

2N *Heuchera*



G. piperella

“1” and “2” = possible cryptic species

G. piperella is closely related to *G. obscura*