A close-up photograph of a dense carpet of green moss. The moss consists of numerous small, leafy stems that are bright green and have a slightly fuzzy texture. The stems are arranged in a somewhat regular, overlapping pattern. A semi-transparent grey rectangular box is overlaid on the top left portion of the image, containing white text. The background is dark and out of focus, making the green moss stand out.

**New insights into the evolutionary  
history and floristics of California's  
non-vascular plants**

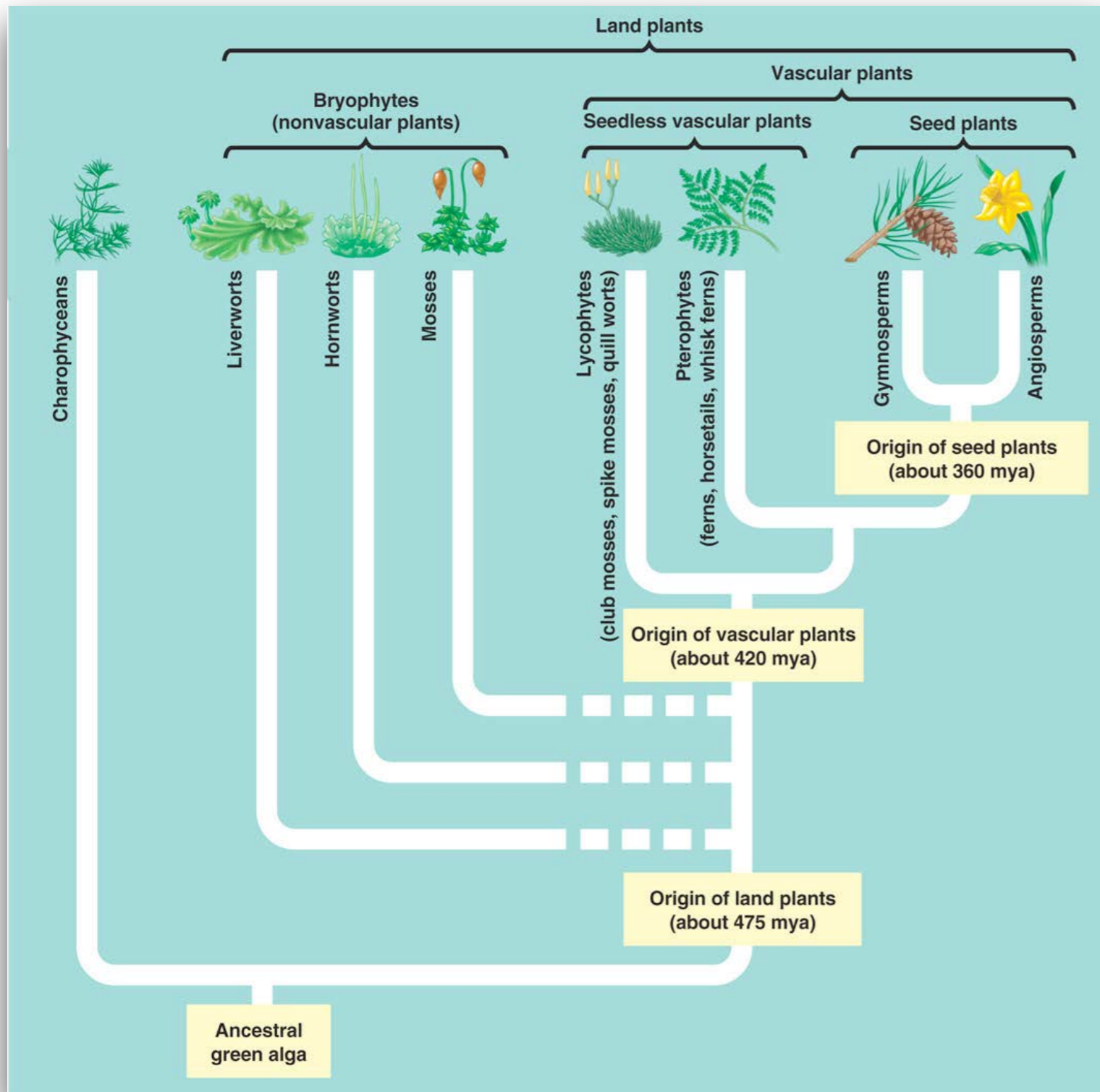
**Ben Carter  
Sharsmith Herbarium  
SJSU**

# Outline

- I. What are the non-vascular plants of CA
- II. Recent efforts in collecting, floristics, conservation
- III. Emerging biogeographic patterns across the state
- IV. Ongoing & future work



# The bryophytes



Hornwort

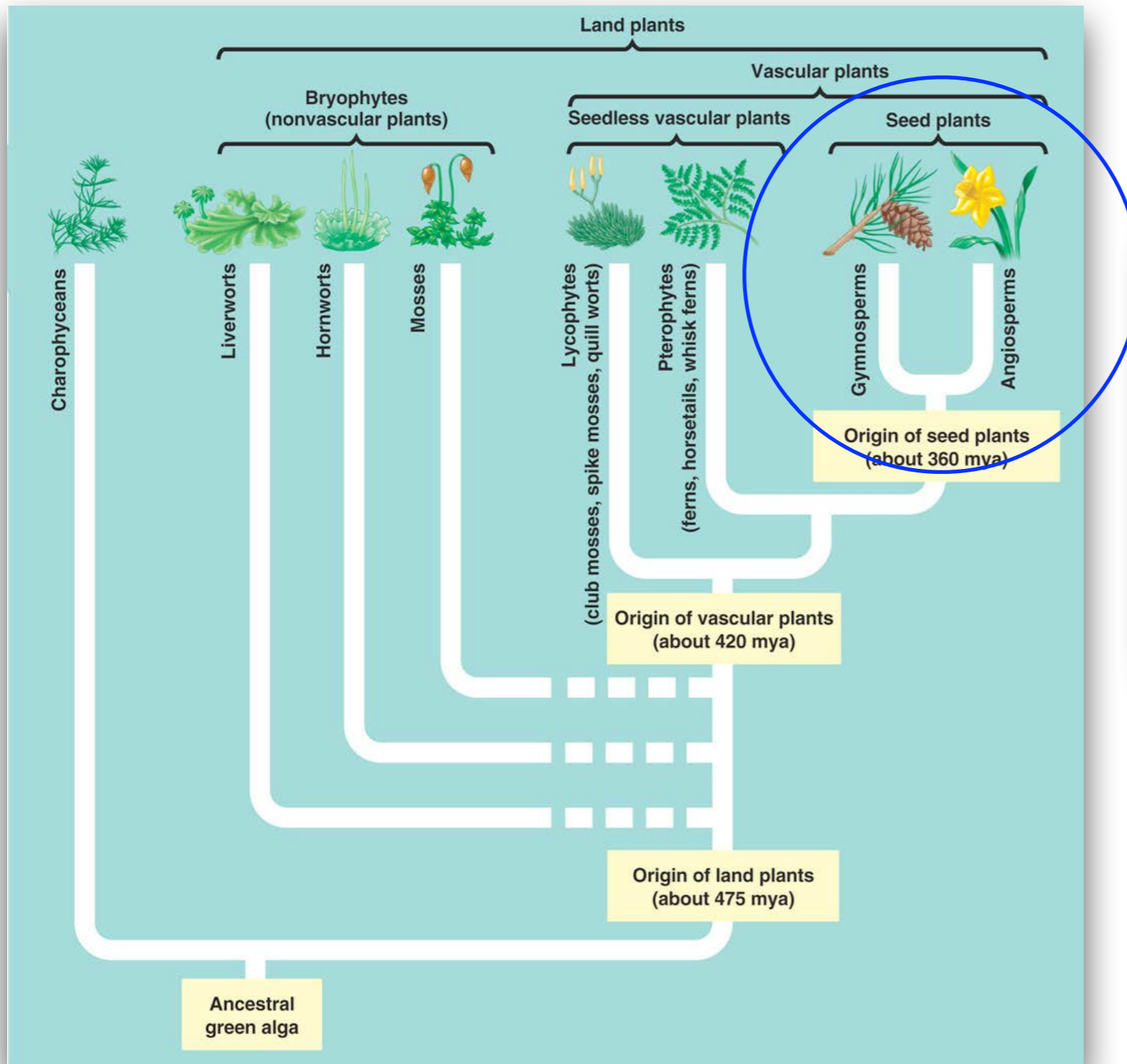


Liverwort



Moss

# The bryophytes



Hornwort

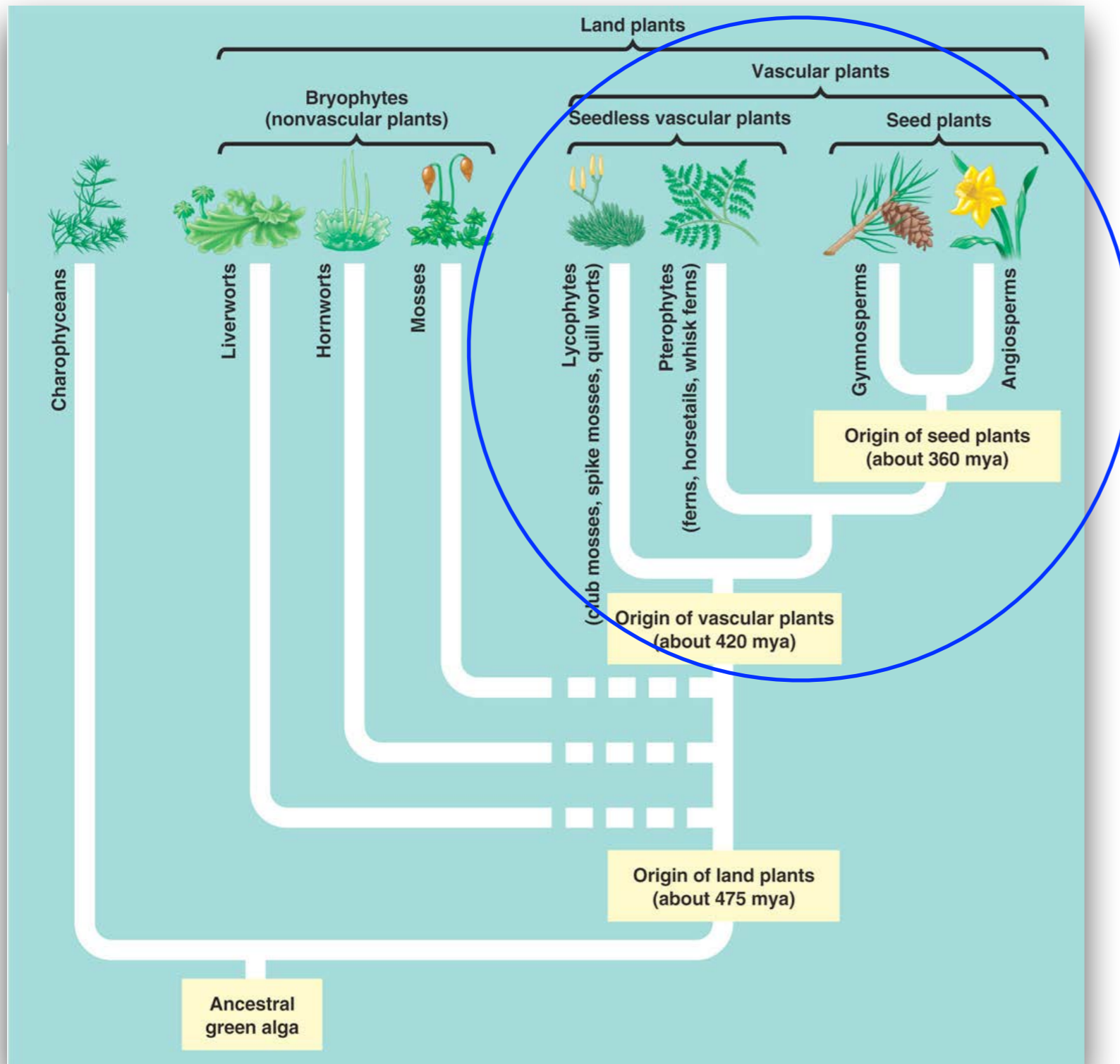


Liverwort



Moss

# The bryophytes



Hornwort

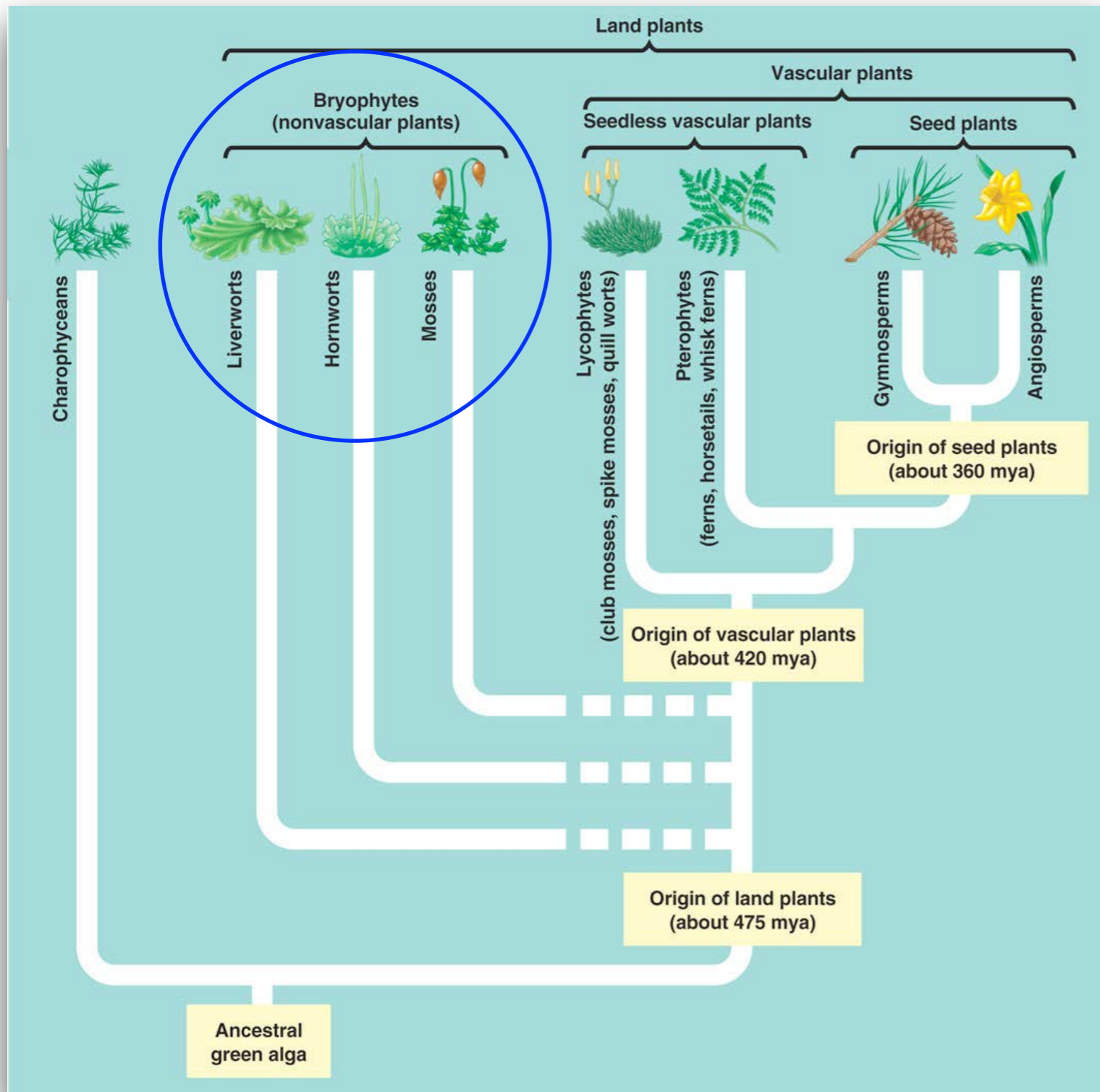


Liverwort



Moss

# The bryophytes



Hornwort



Liverwort

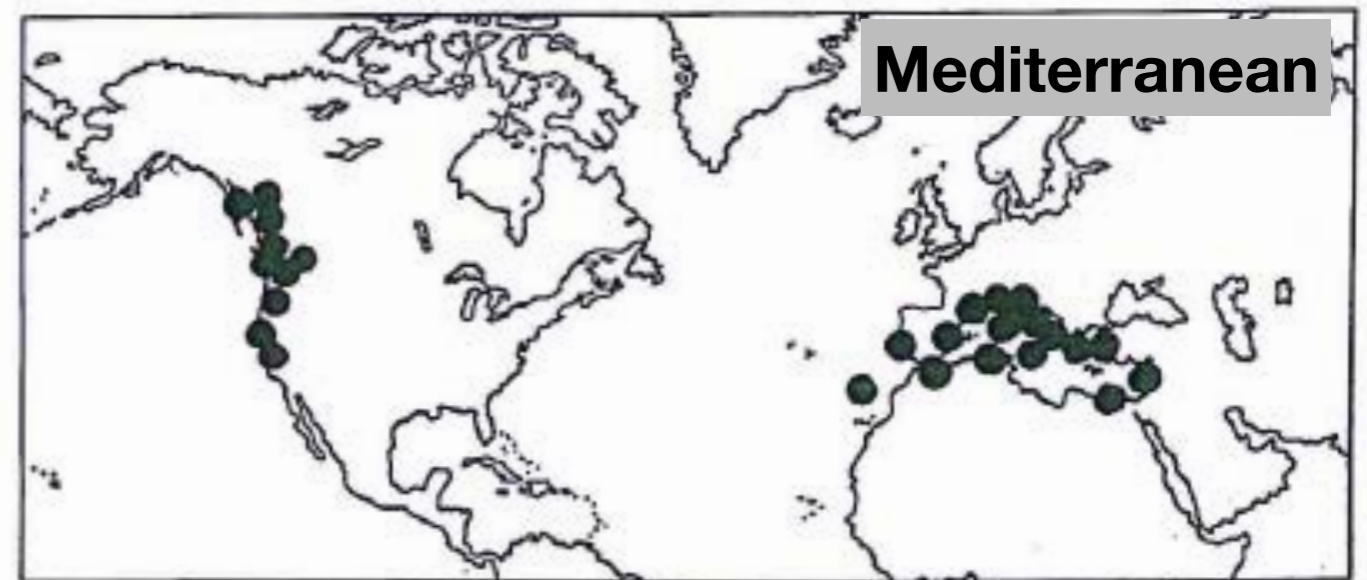
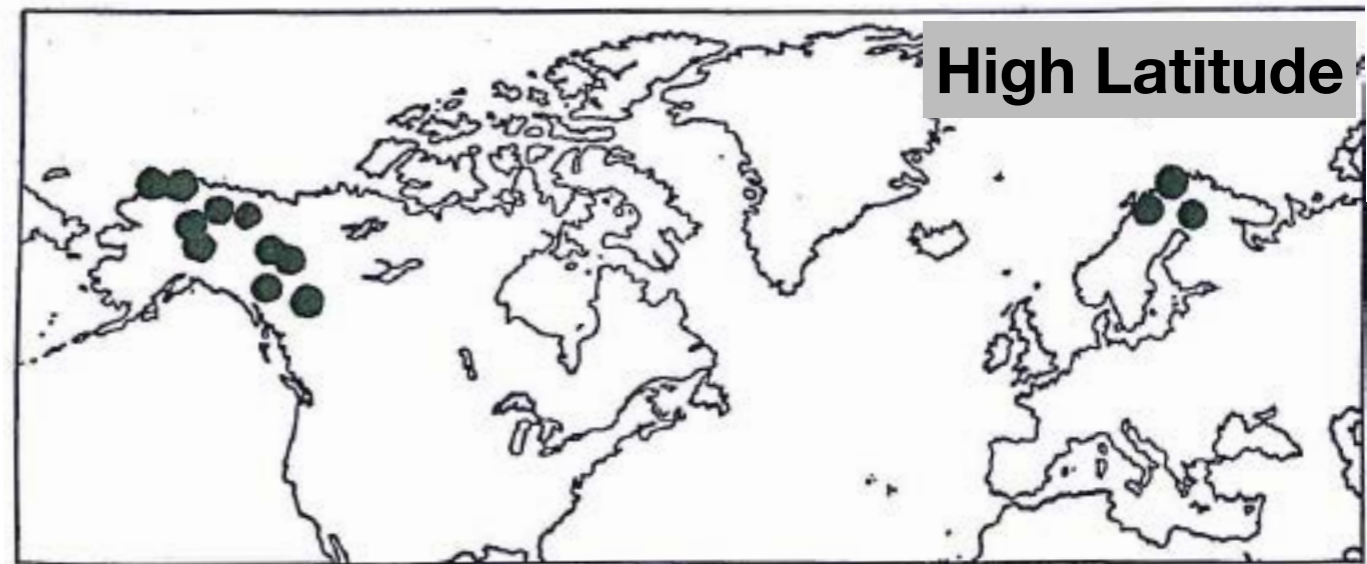


Moss

# Bryophyte biogeography

## **Spore dispersal, Small size, Frequent asexual reproduction:**

Many bryophytes have intercontinental distributions because bryophytes tend to be good at *dispersing* and *persisting*



Schofield 1980

# Bryophyte biogeography

## **Desiccation tolerance, Small size:**

Tend to favor niches where they can avoid direct competition with angiosperms.

These include small microsites (e.g. tree trunks & rock outcrops in temperate zones, but also entire biomes (e.g. tundra, taiga and understory of temperate rainforests))



Temperate Rainforest



Mossy Oak Trunk



# The bryophyte flora of California

Mosses: 652 spp (as of 2023)

Liverworts: 145 spp (as of 2006)

Hornworts: 6 spp (as of 2006)

ca. 800 spp of bryophytes...

ca. 4500 spp of native vasculars...

... ~ 15% of CA native plants are  
bryophytes (!!!)



Thanks to Jim Shevock, Cal Academy of Sciences, for the updated moss numbers!!

# Invasive species

Most of the species that can live in California (presumably) arrived before the Europeans did

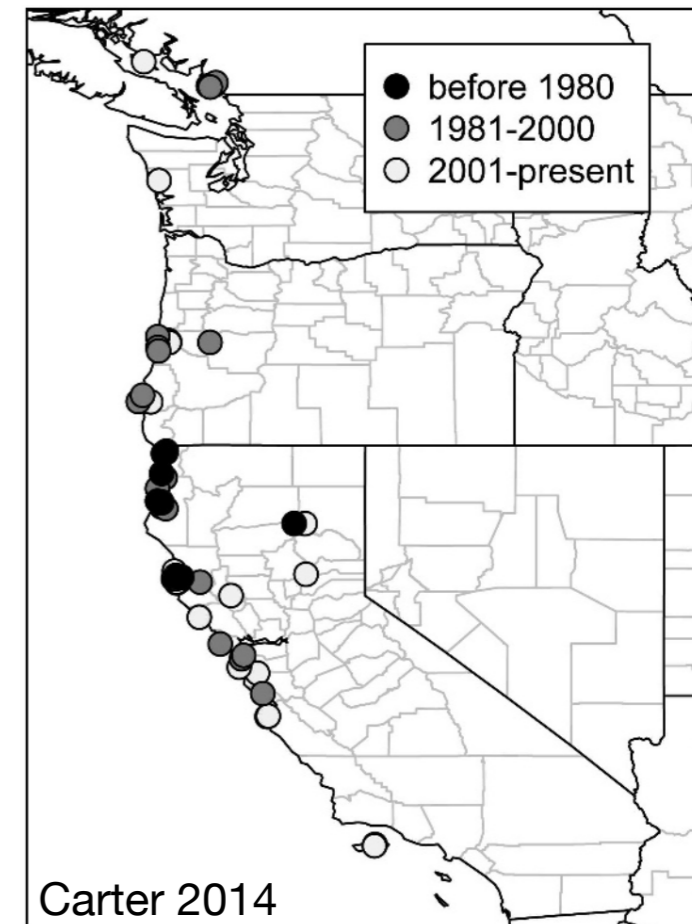
There are fewer than a dozen documented introduced spp and only a couple are 'invasive' (i.e. introduced and ecologically problematic)



*Campylopus introflexus*- a presumably introduced moss that appears to be spreading across the state

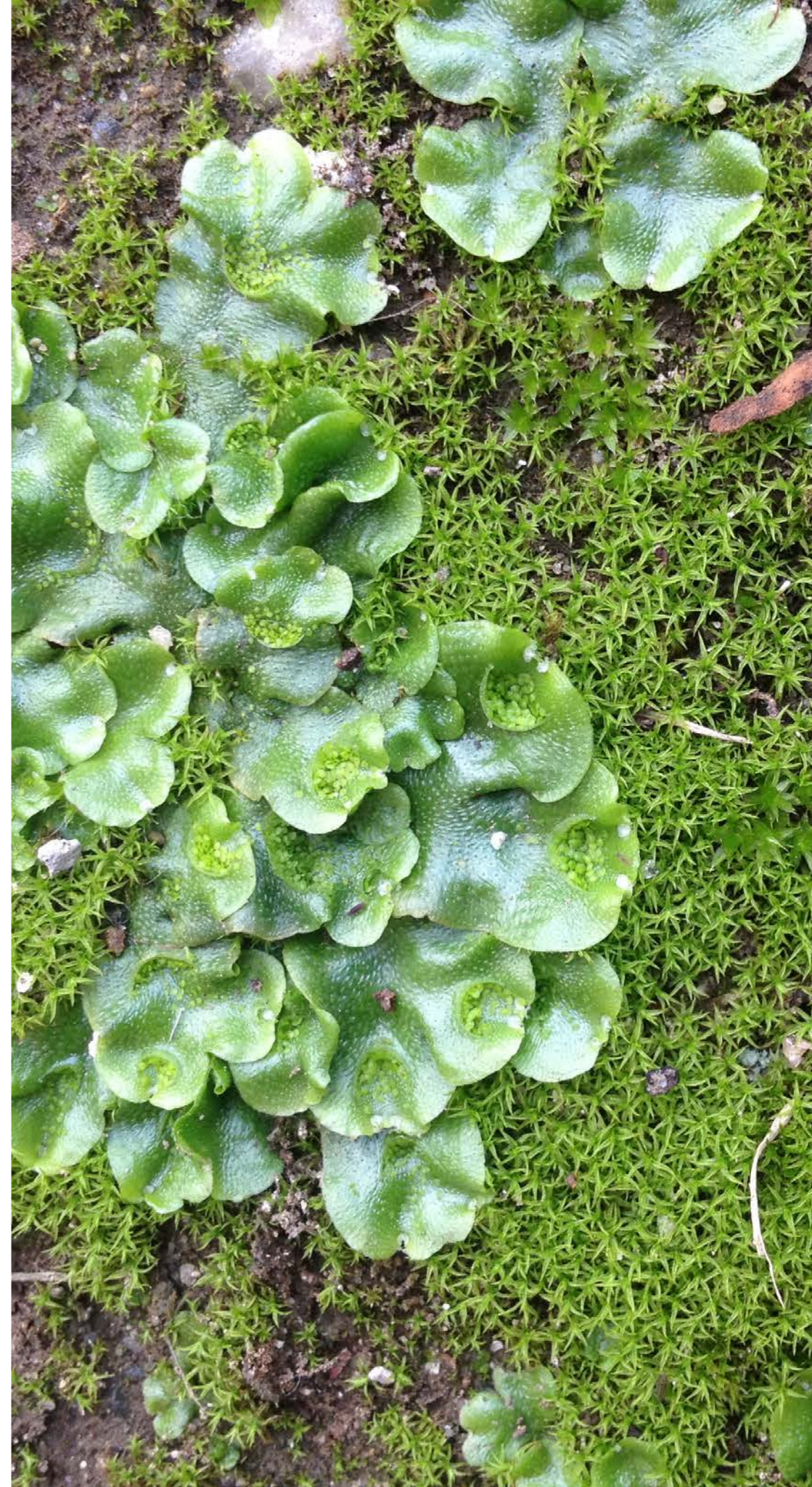


*Lunularia cruciata*- an arguably invasive liverwort in waterways around the Bay Area



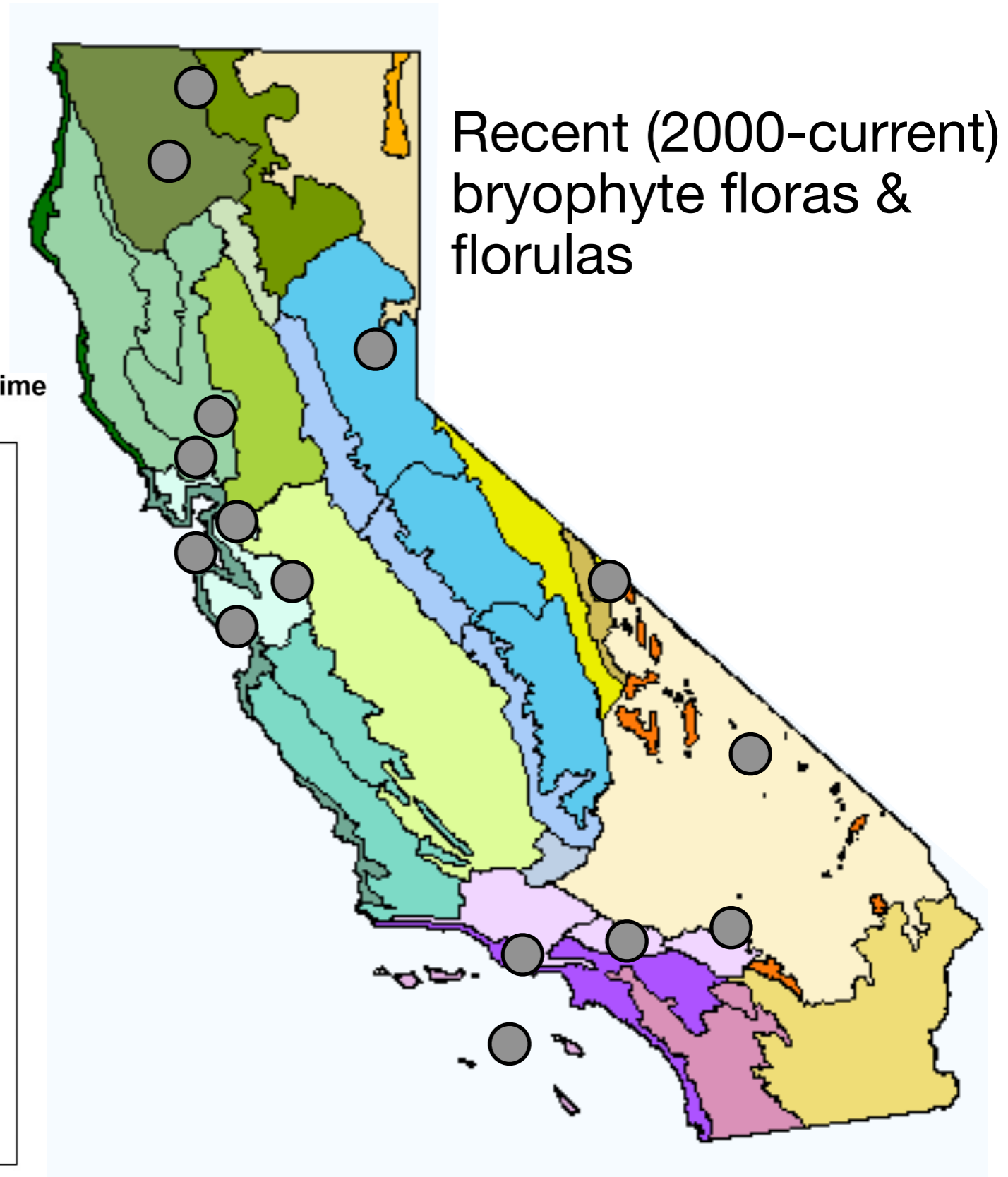
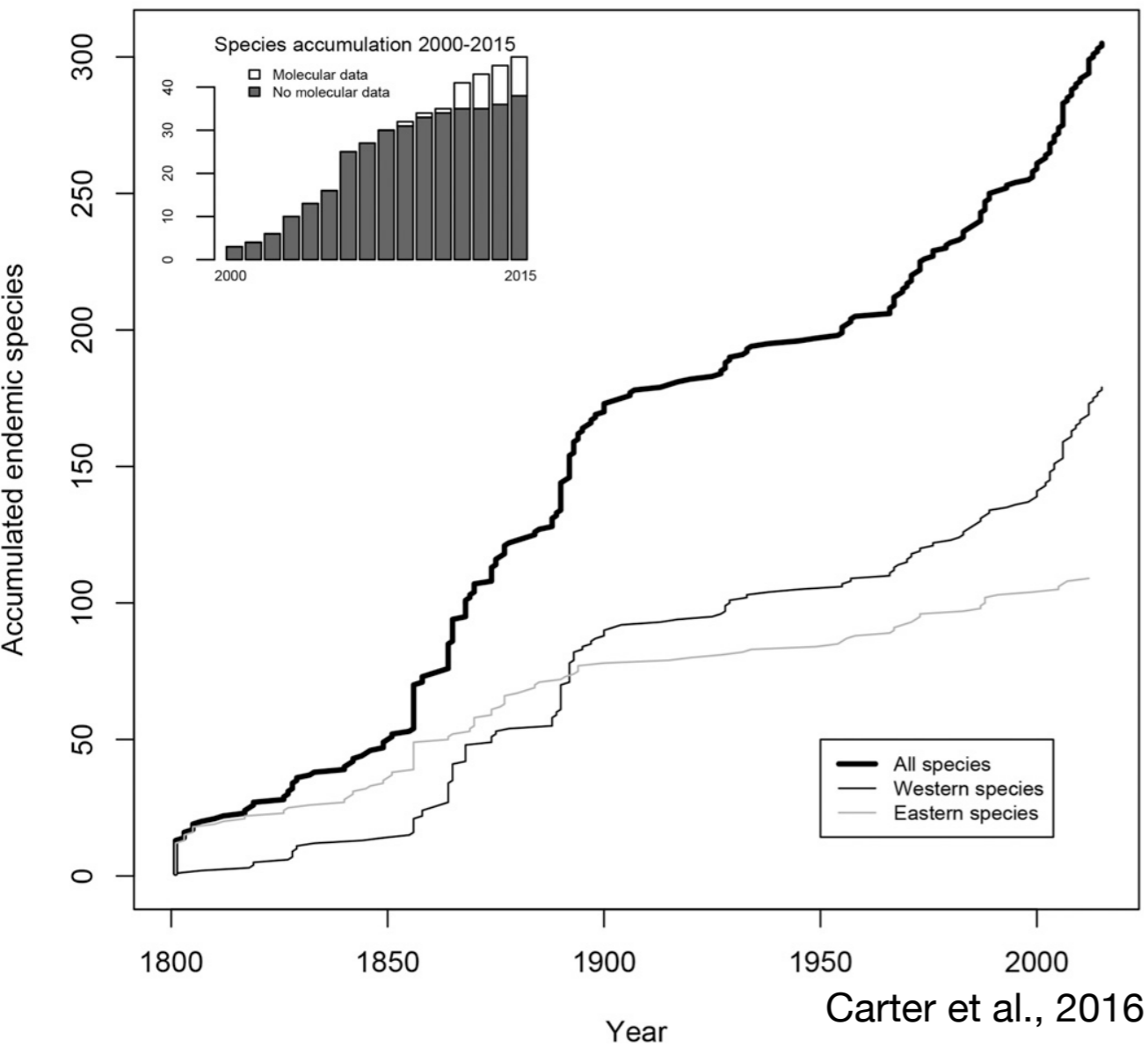
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# Updates to our knowledge of the flora

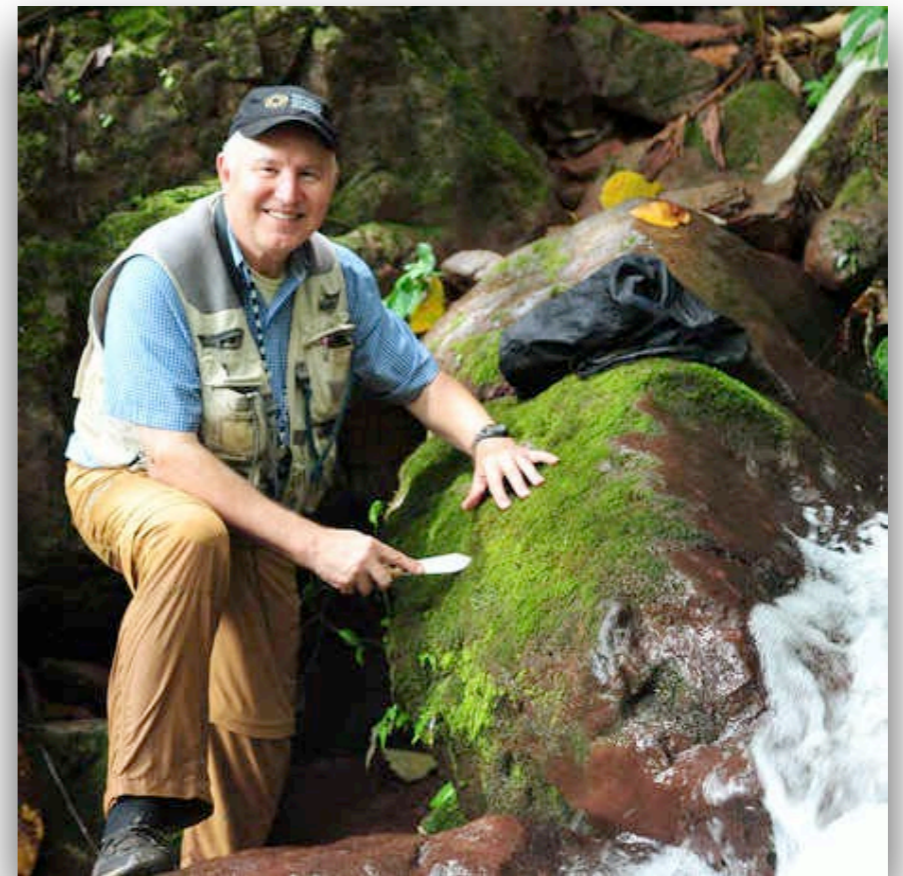
## Documentation of North American endemic species through time



## Updates to our knowledge of the flora

**Since Norris & Shevock's  
2004 catalog:**

- 104 taxa new for California**
- including 32 species new to science**
- 44 spp removed from the flora**



Jim Shevock, Cal Academy of Sciences

# Conservation

Historically, documenting the flora has been a higher priority than ranking rare species

With the recent introduction of a bryophyte chapter to CNPS, we're excited for more conservation action across the state

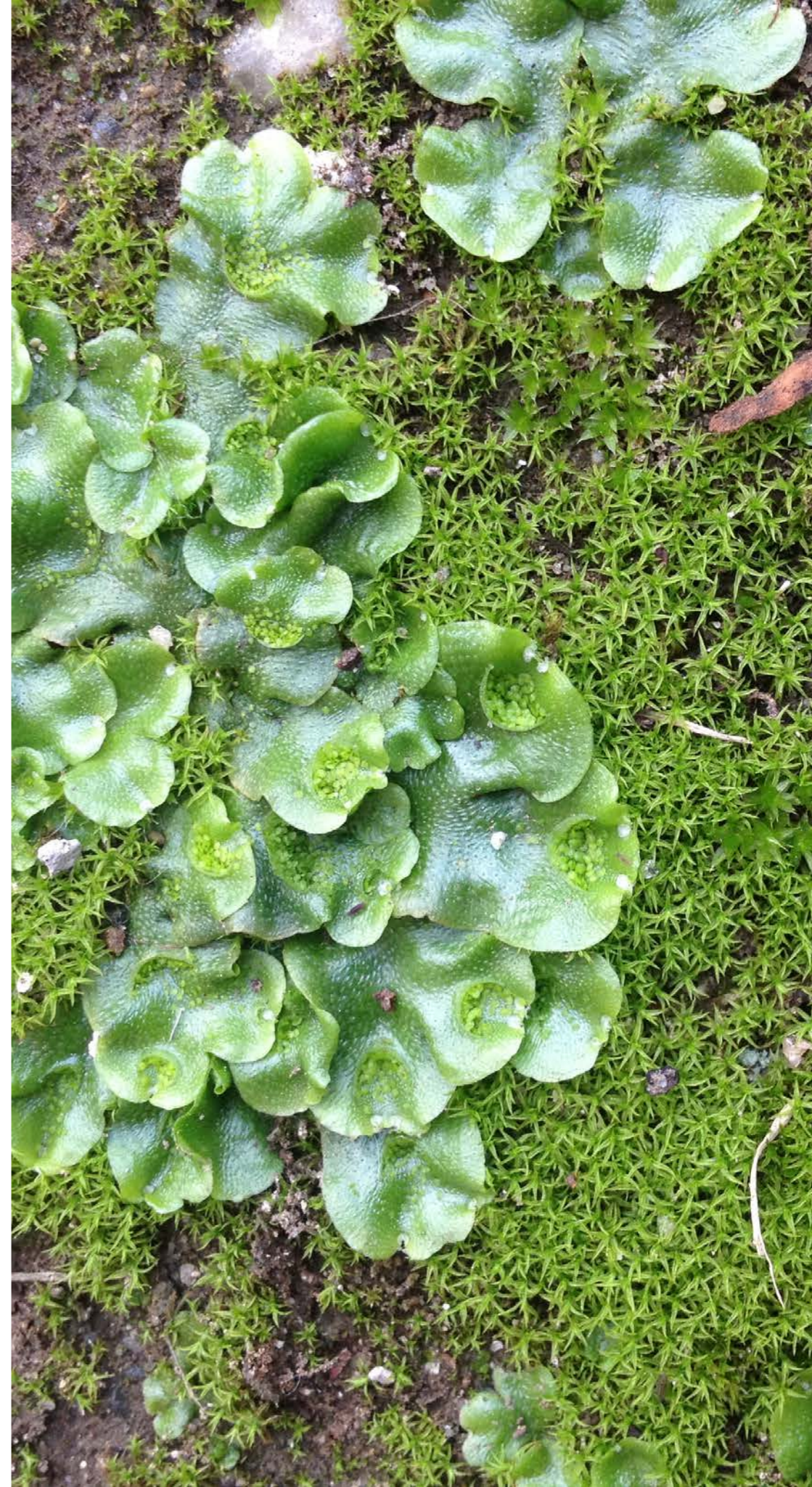
<b>CNPS rank</b>	<b>mosses</b>	<b>liverworts</b>
<b>4.2</b>	6	0
<b>4.3</b>	2	1
<b>1B.1</b>	1	2
<b>1B.2</b>	5	0
<b>1B.3</b>	6	0
<b>2B.1</b>	3	0
<b>2B.2</b>	7	1
<b>2B.3</b>	8	1
<b>Totals</b>	<b>38</b>	<b>5</b>

In Review: 12 mosses & 2 liverworts

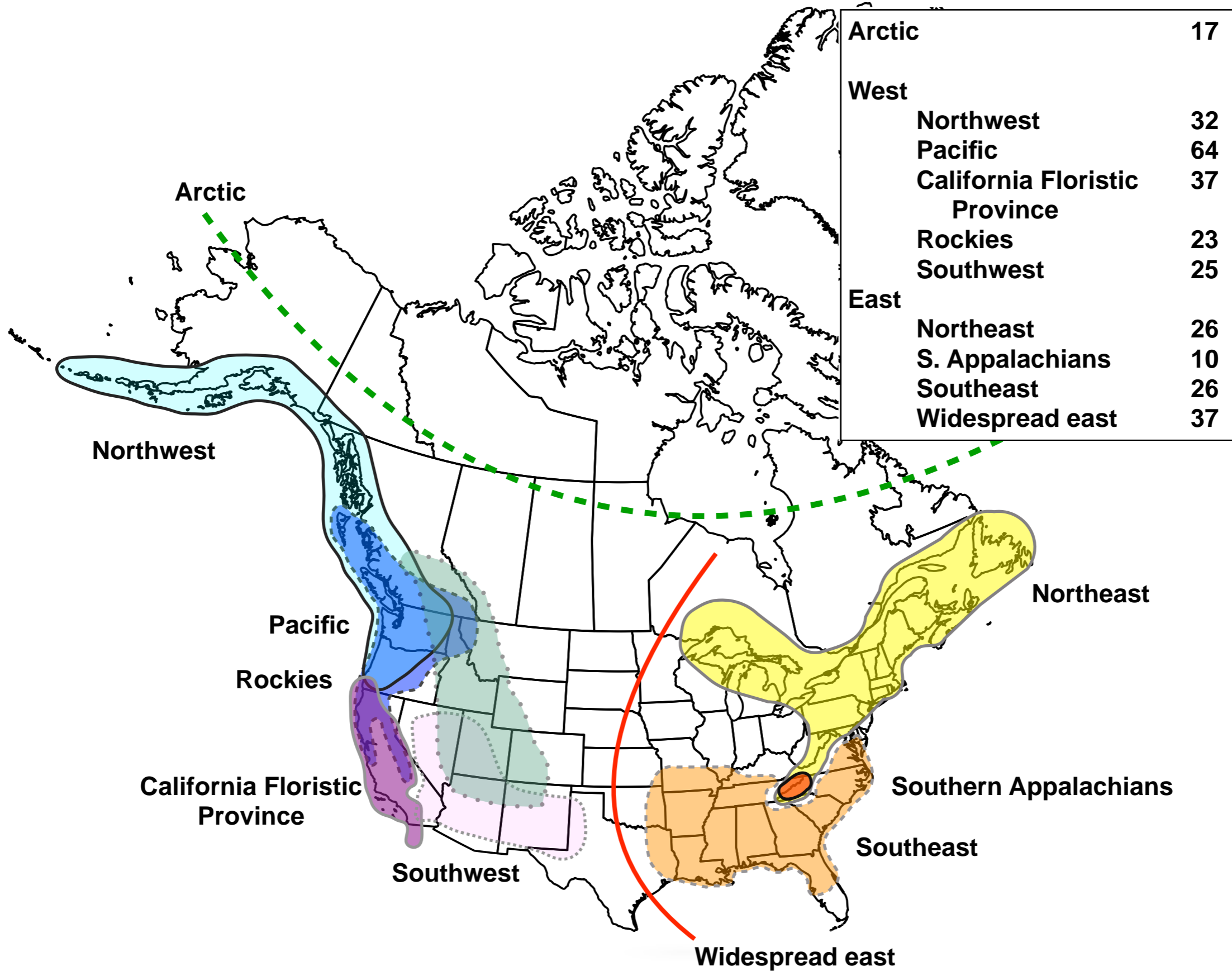
Thanks to **Ellen Dean & Doug Stone** from CNPS for these numbers!!

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# Regions of Endemism in North America

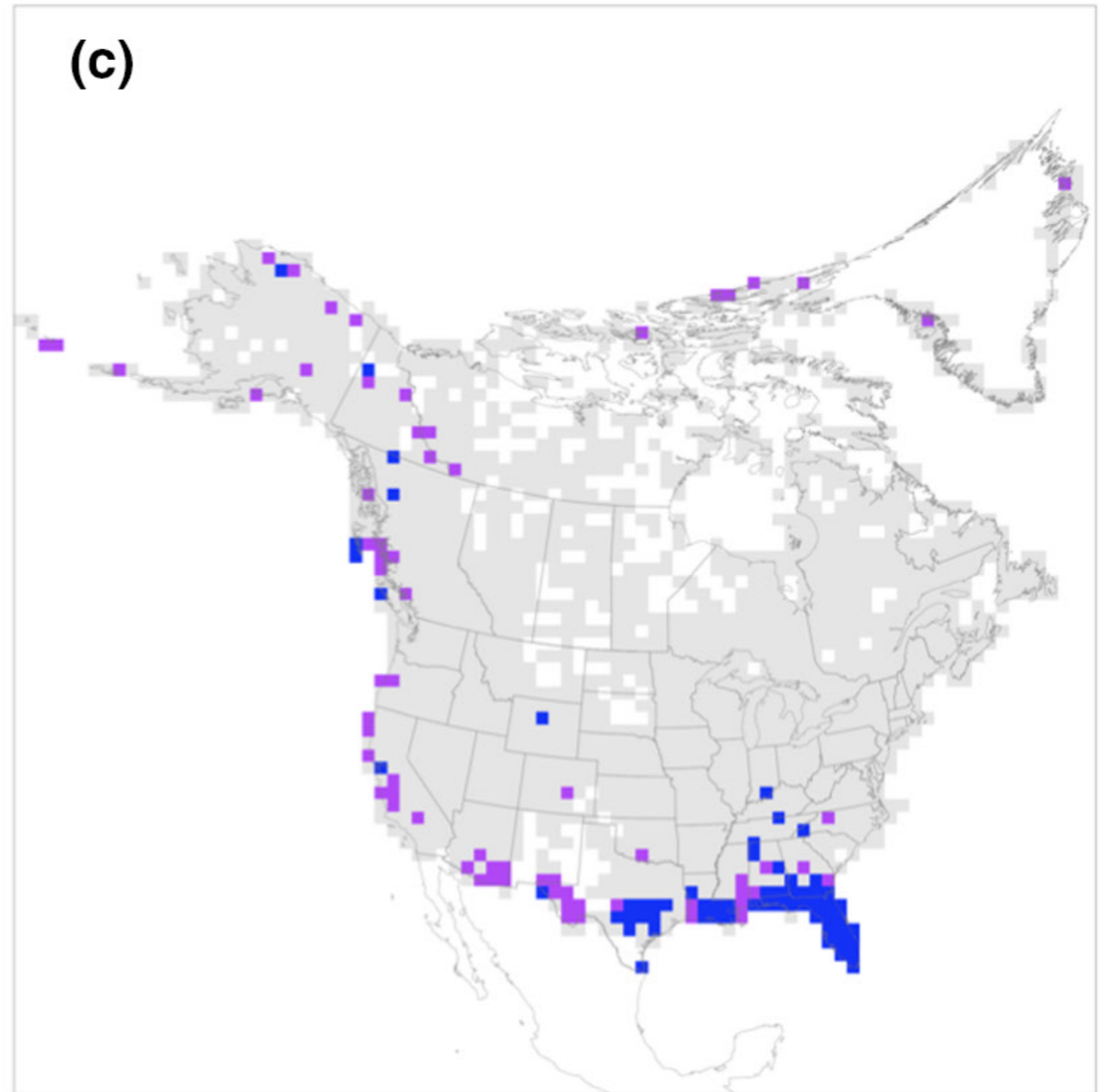




California has regions with high mixed endemism (more neo- and paleo-endemics than expected), but generally not areas with only high neo-endemism or paleo-endemism

\*These results are strongly tied to the continental scale of the analysis- a more geographically restricted analysis would likely yield very different patterns

Just like with vascular plants, there are examples of recent divergence, and of relict species



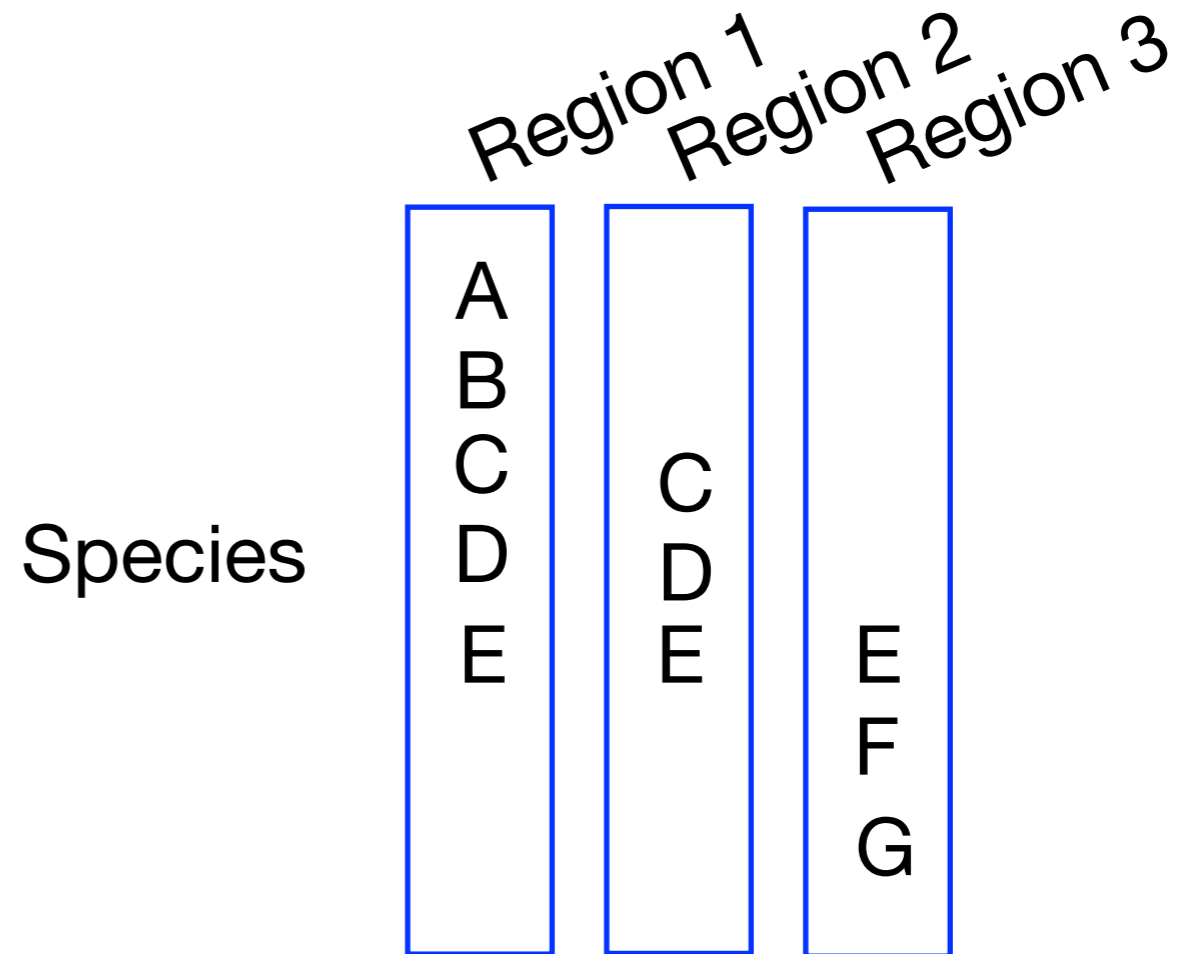
Carter et al. 2022

- Significantly high mixed endemism
- Significantly high paleo-endemism

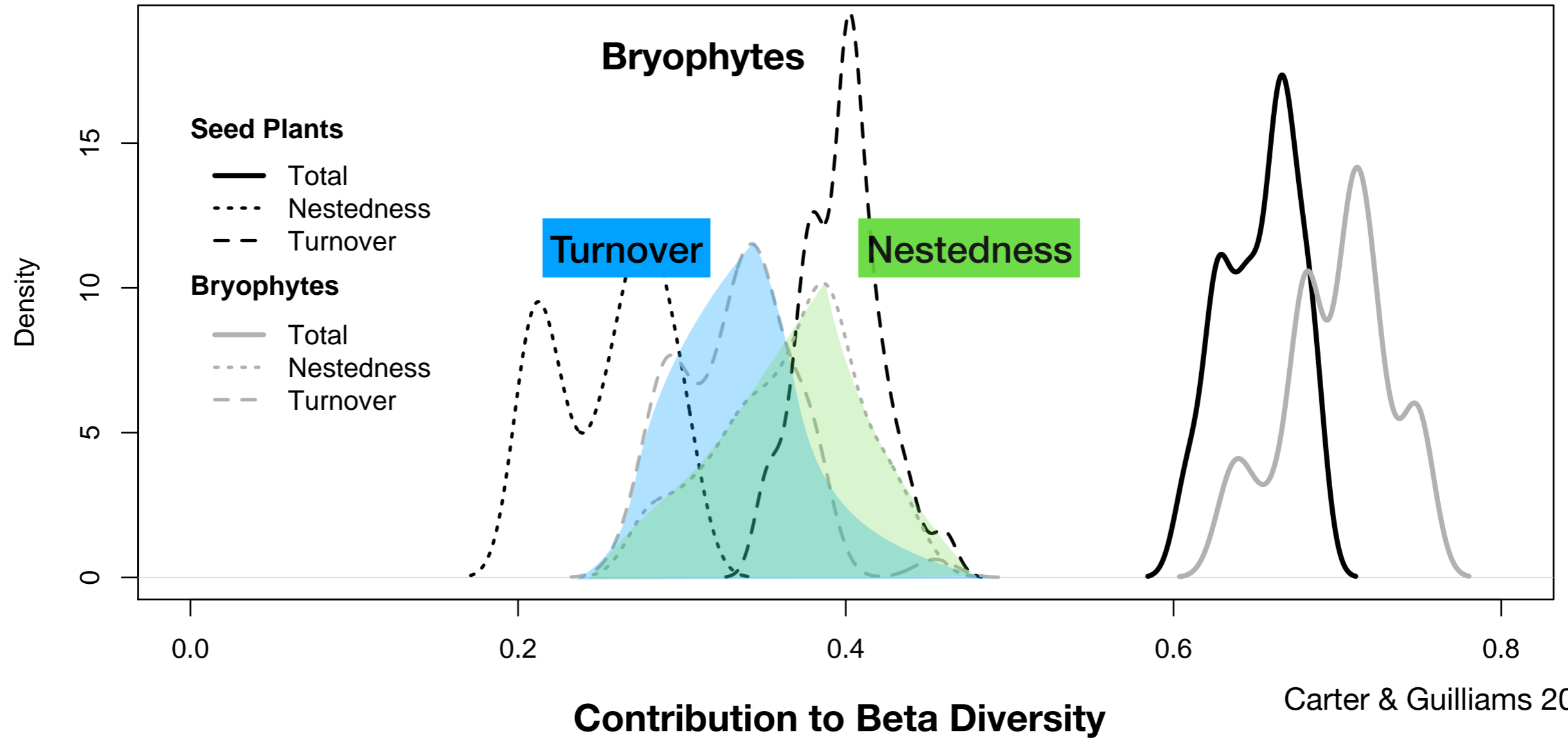
# Patterns of beta diversity- nestedness vs turnover

**Nestedness:** Region 2's flora is a subset of Region 1's flora

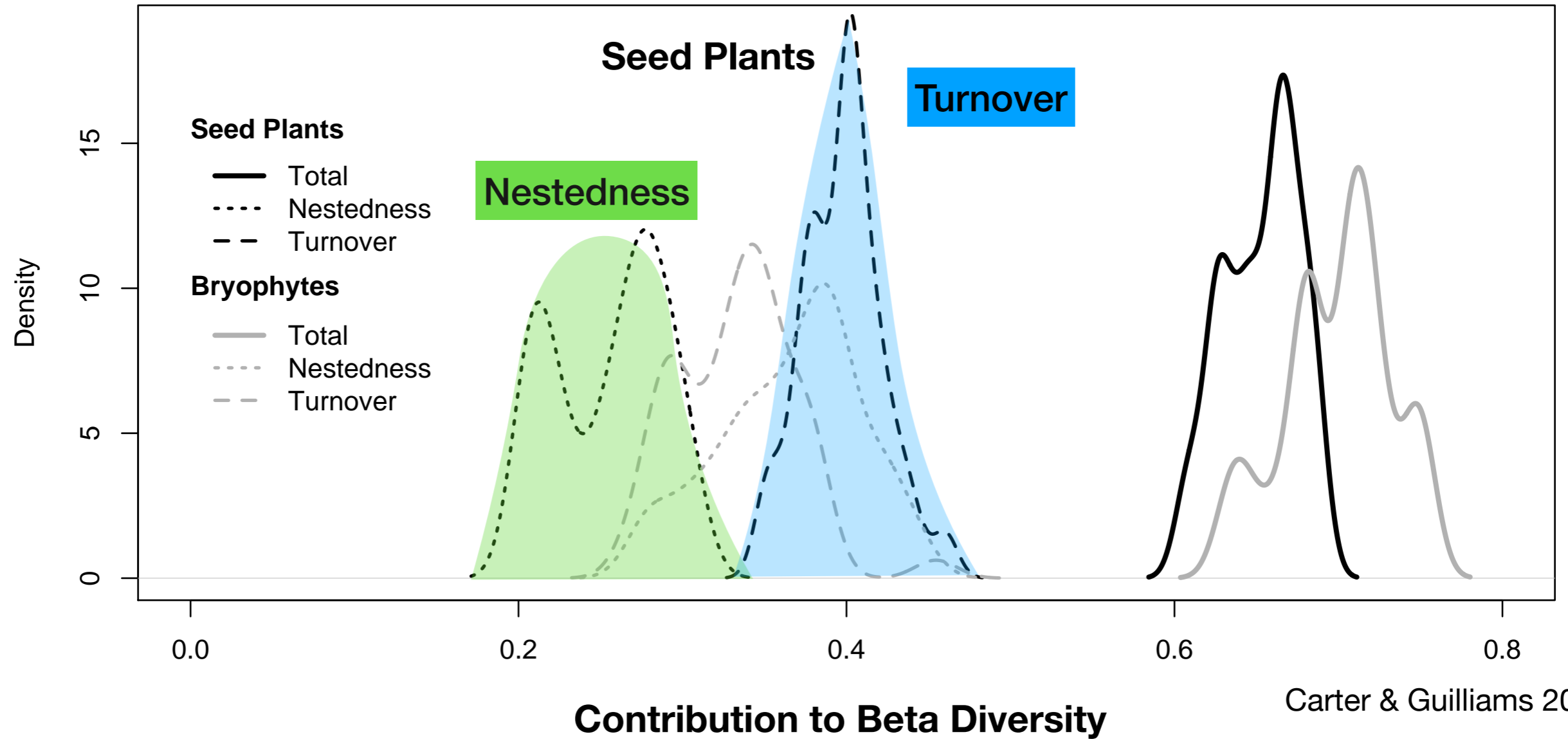
**Turnover:** Region 3's flora has a majority of species that are not found in Region 1



# Patterns of beta diversity- nestedness vs turnover

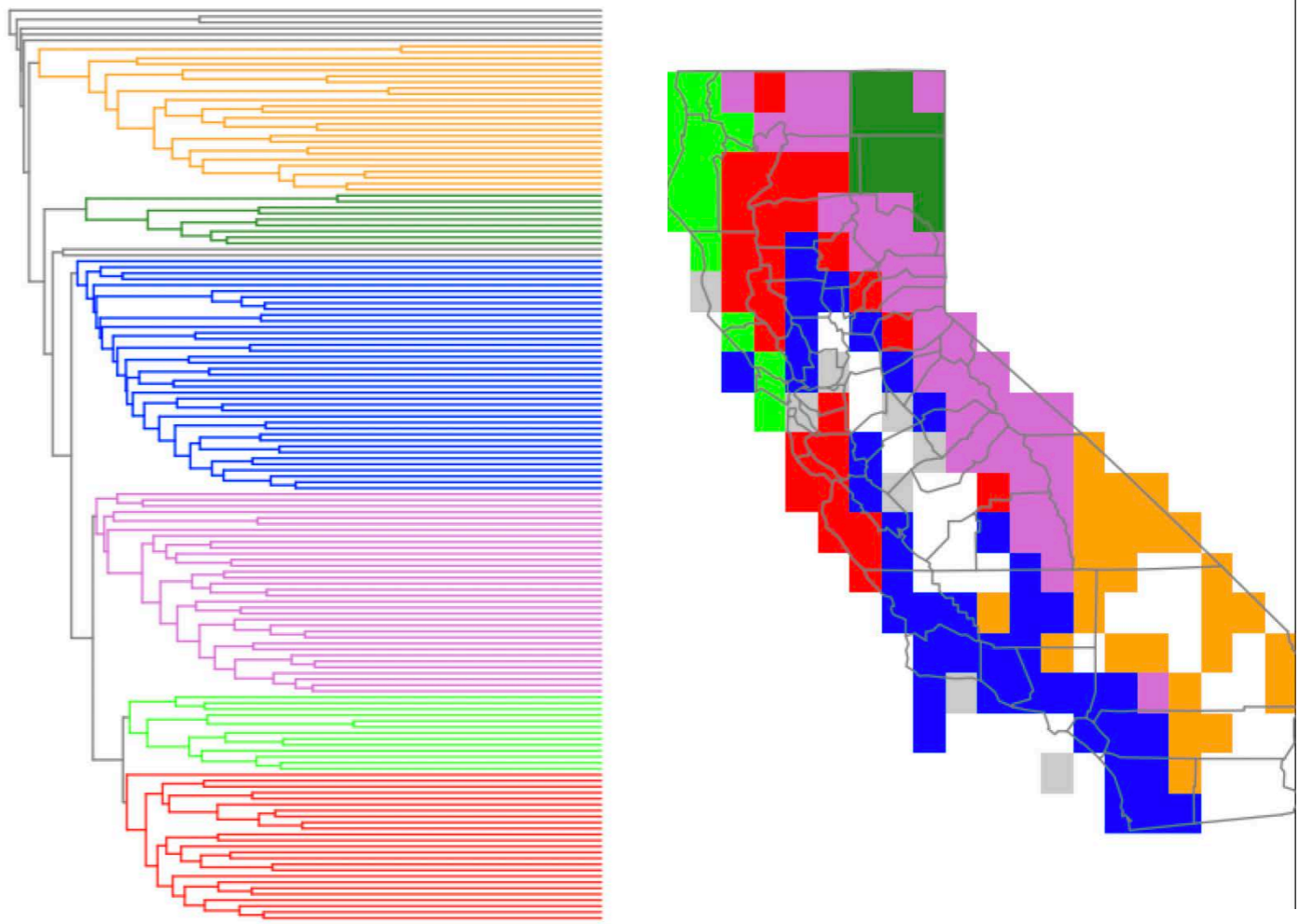


# Patterns of beta diversity- nestedness vs turnover



Patterns of beta diversity-  
nestedness vs turnover

The strength of nestedness  
in explaining beta-diversity  
holds in state-wide analysis  
of both pixels and eco-  
regions

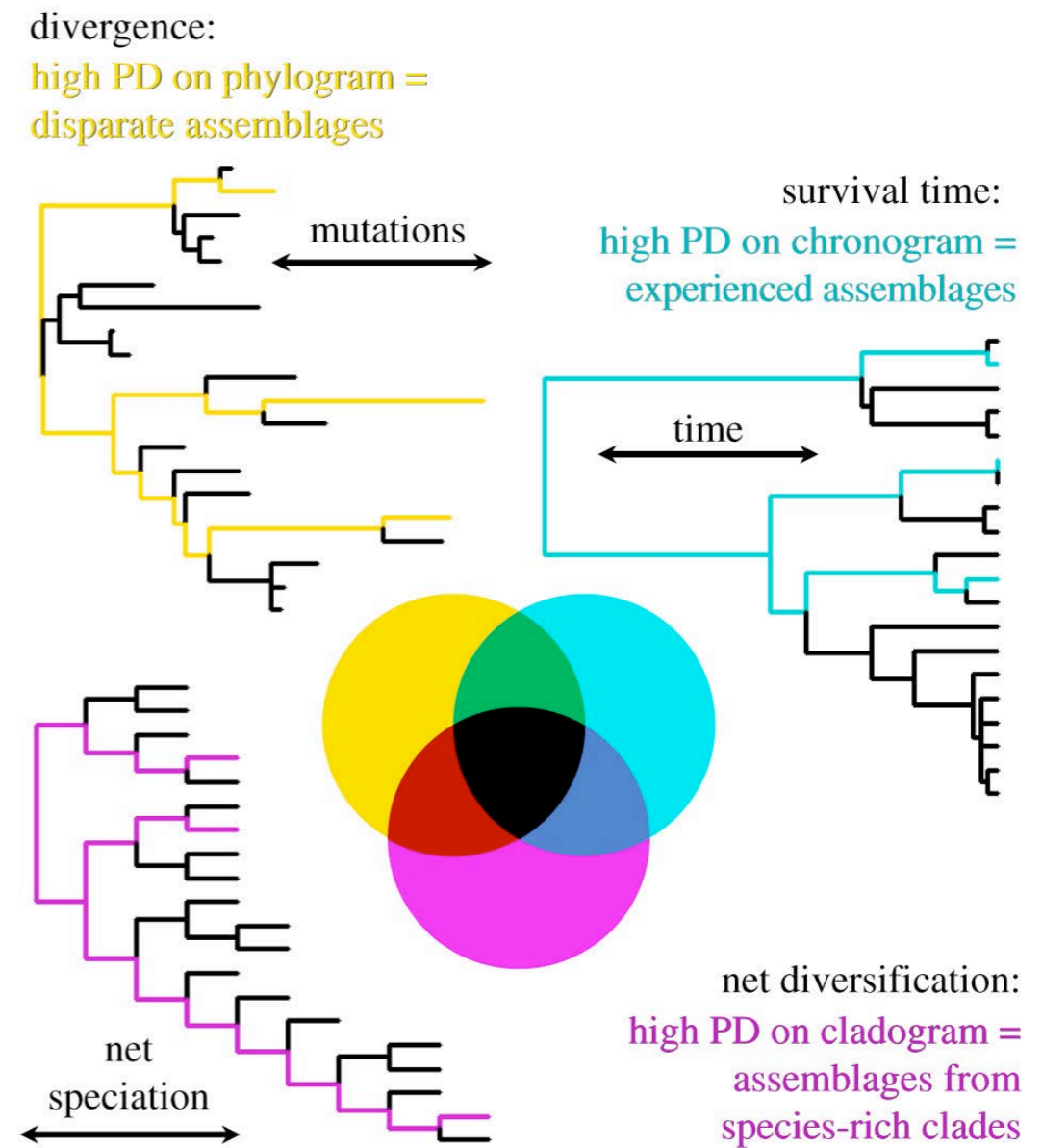


This highlights the importance of a very strong,  
ecological axis (water) that drives biogeographic  
patterns across the state, in contrast to more  
diverse drivers in seed plants

# Ongoing work: Facets of biodiversity approach (Kling et al. 2018)

What are the bryophyte hotspots across the state with respect to conserving different facets of evolutionary diversity?

with Brent Mishler, Israel Borokini, John McLaughlin and Ixchel González



**Interested in learning more  
about bryophytes?**

**CNPS bryophyte chapter website:**

<https://chapters.cnps.org/bryophyte/>

Forays  
workshops  
zoom chats  
ID help  
mentors  
and more!!

