

A close-up photograph of a plant branch with numerous small, fuzzy, light brown seed heads. The seeds are attached to thin, reddish-brown stems. Some green, pointed leaves are visible at the base of the branches.

Using climate niche modeling to map areas at risk of invasion by Stinkwort (*Dittrichia graveolens*)

Nicky Lustenhouwer & Ingrid M. Parker

University of California, Santa Cruz

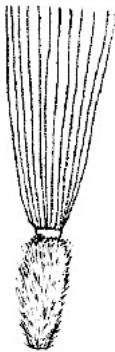
Cal-IPC Symposium 2020



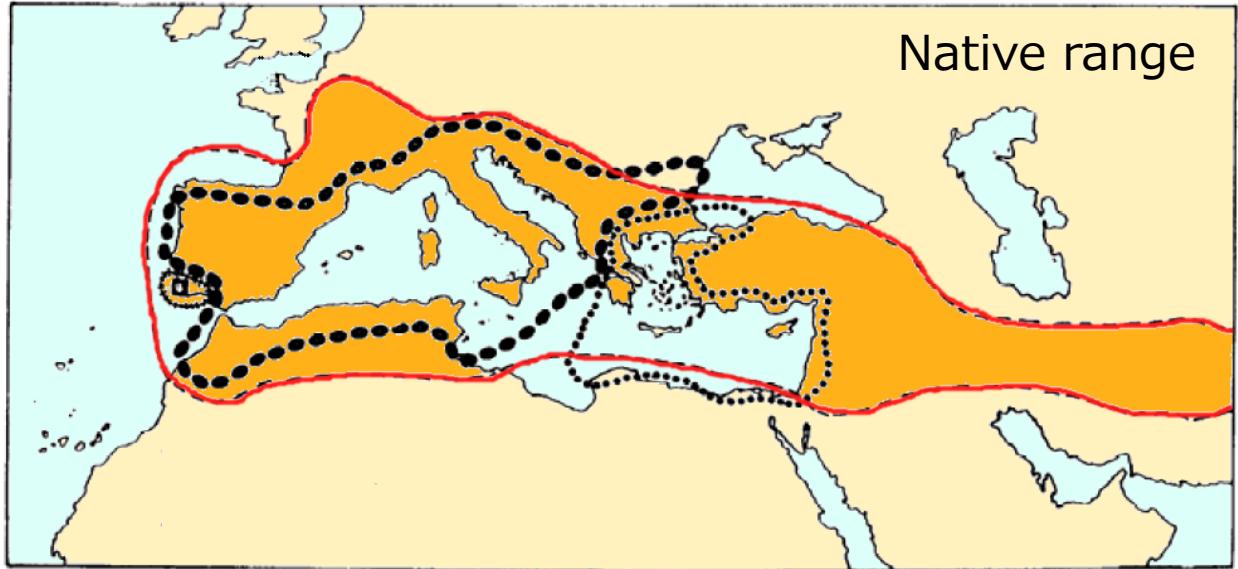
UNIVERSITY OF CALIFORNIA
SANTA CRUZ



Stinkwort

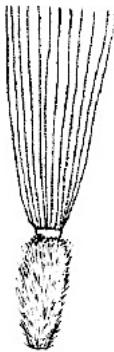


*Dittrichia
graveolens*

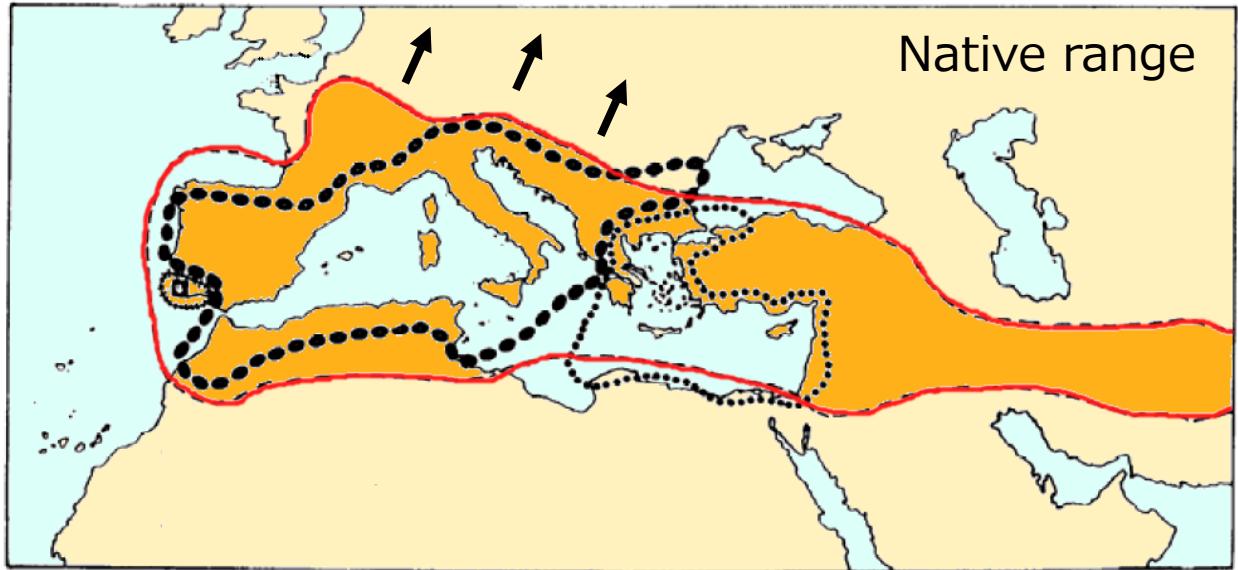


Map adapted from Brullo & De Marco 2000 Port Acta Biol

Stinkwort

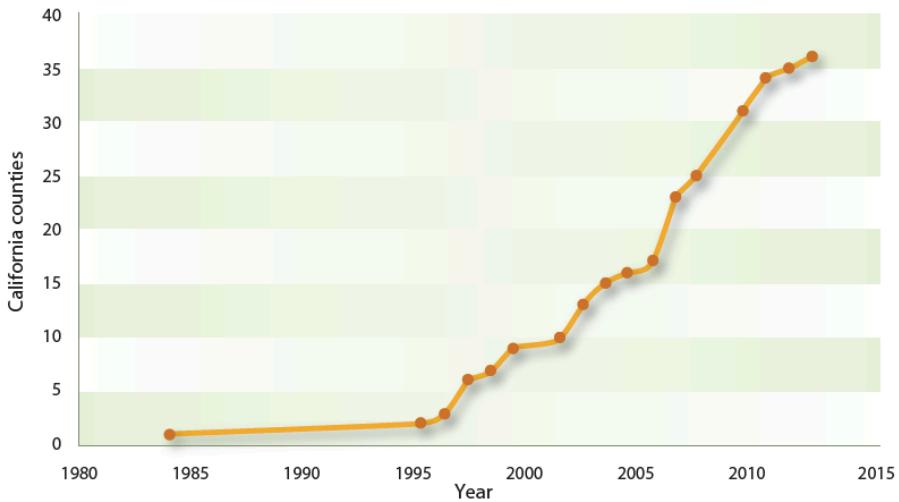


*Dittrichia
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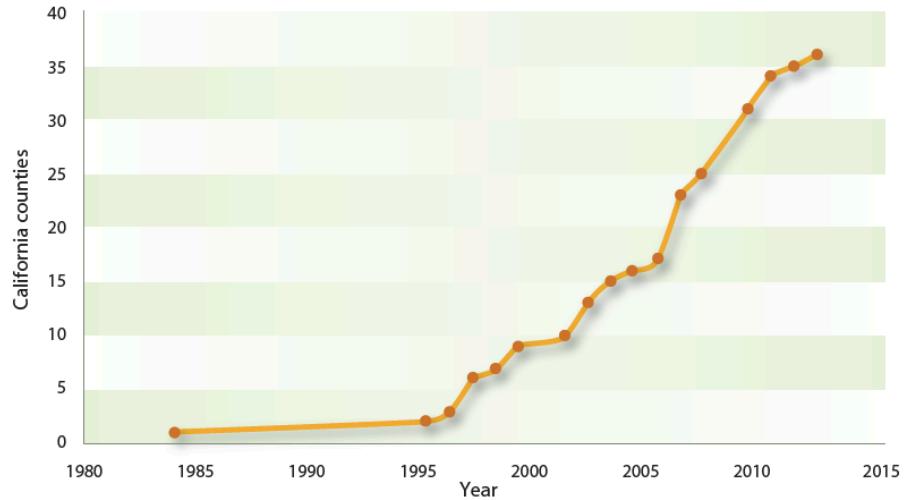
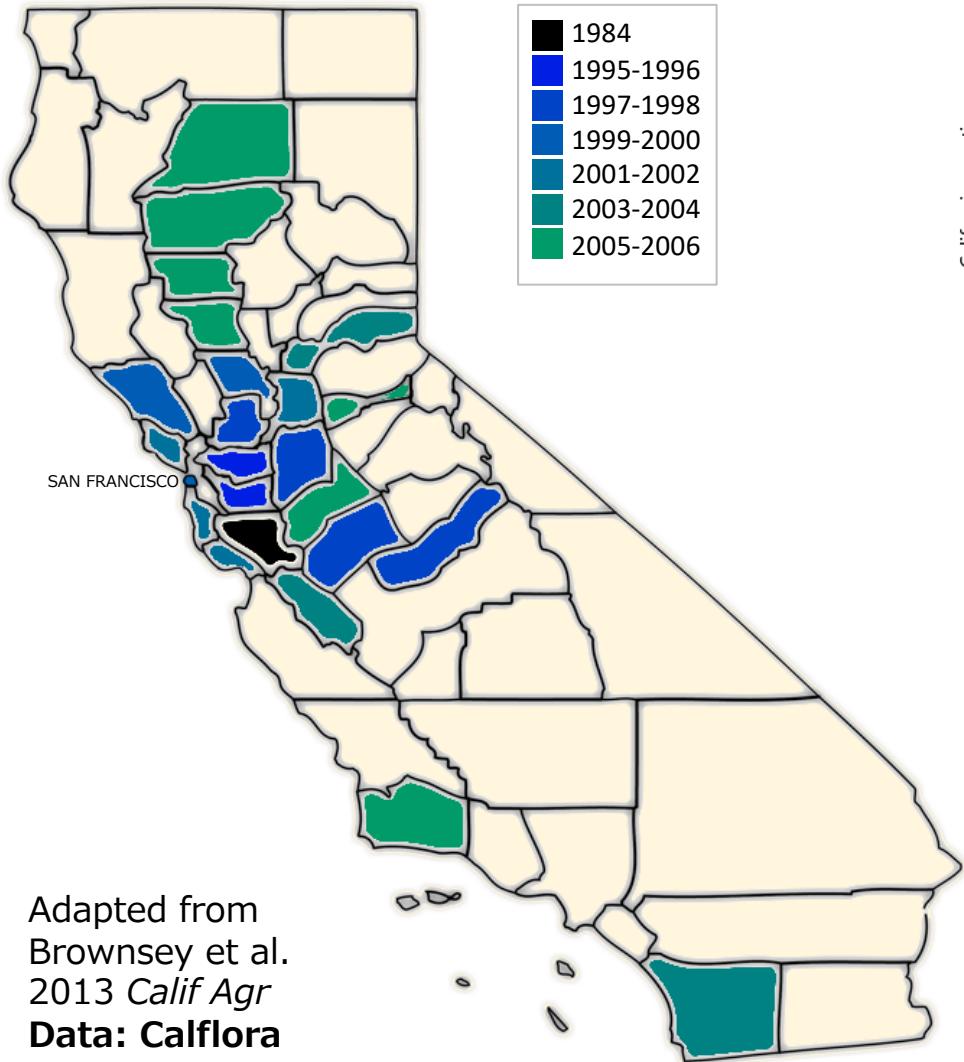


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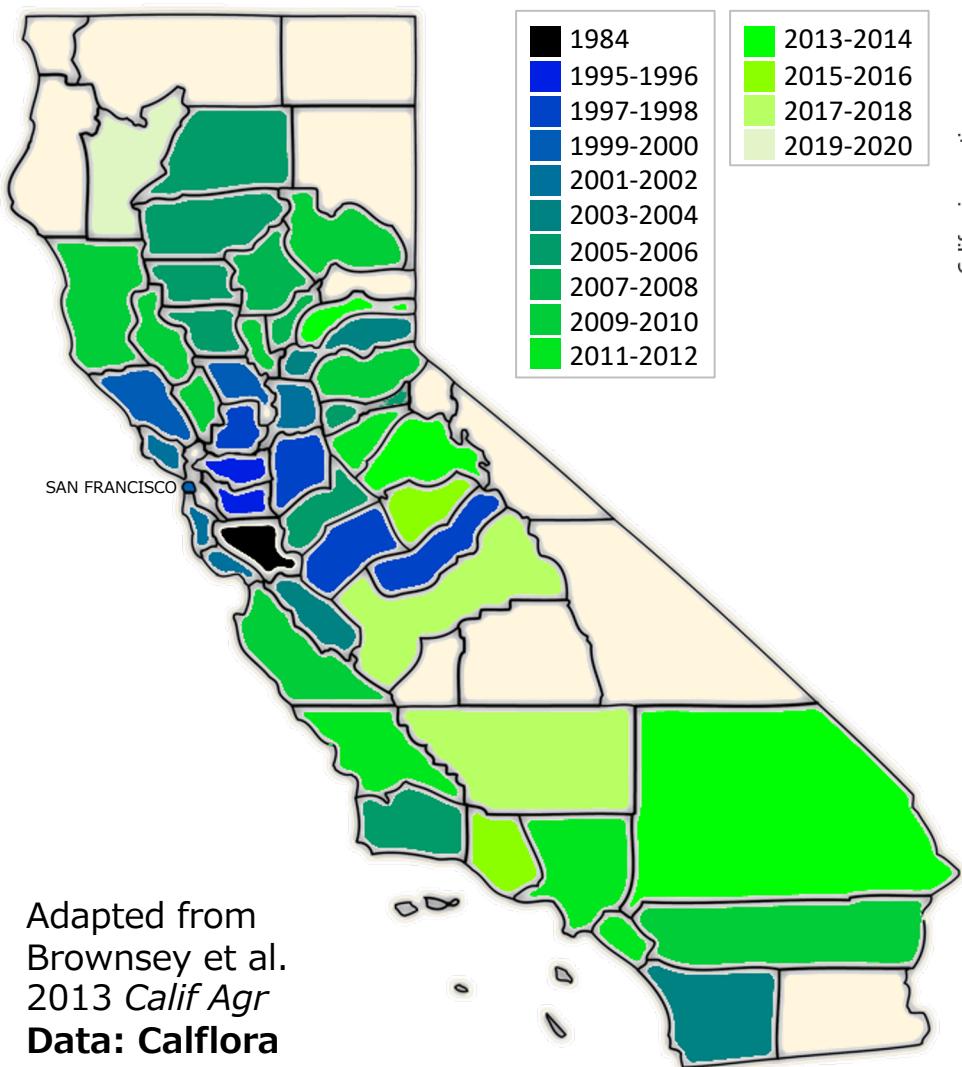
Stinkwort invasion in California



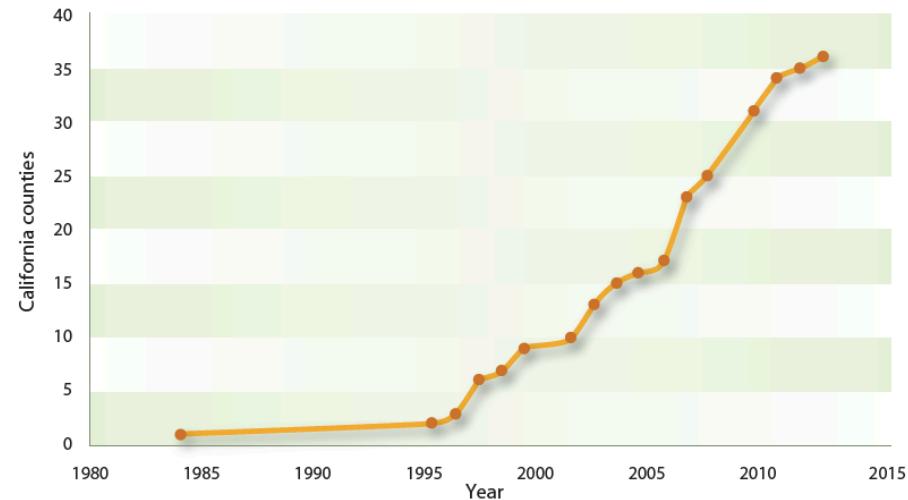
Stinkwort invasion in California



Stinkwort invasion in California



Adapted from
Brownsey et al.
2013 *Calif Agr*
Data: Calflora

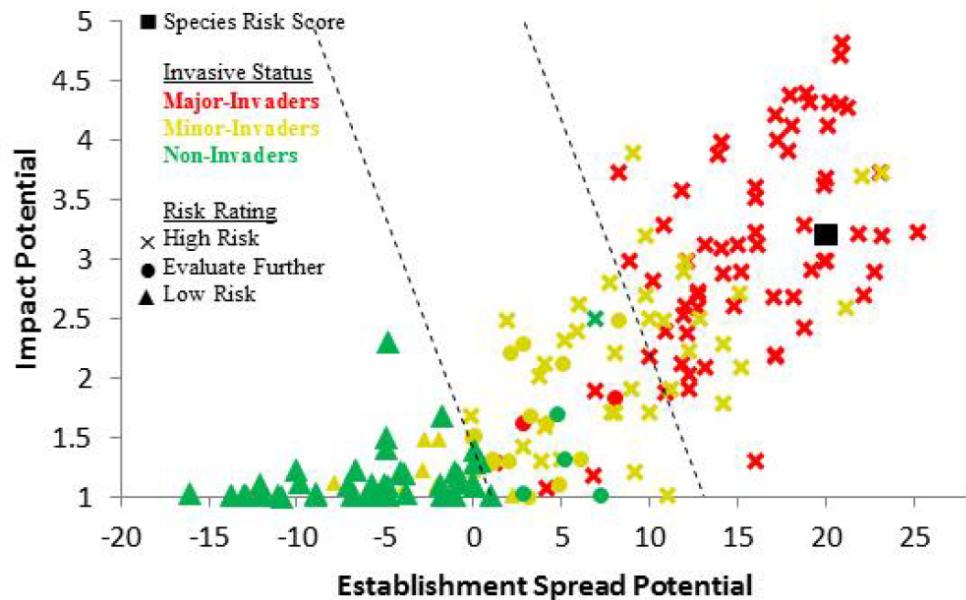


Risk assessment

Reported risks

- Contact dermatitis
- Toxicity to livestock
- Vineyards
- Restoration

USDA Weed Risk Assessment

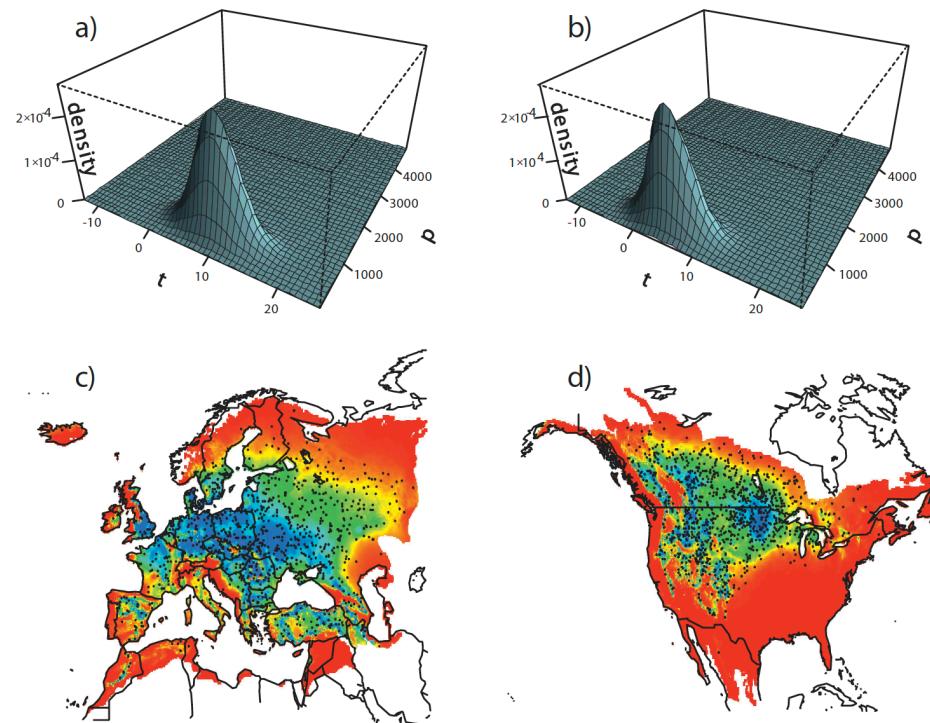


- Early Detection and Rapid Response:
Where is *Dittrichia graveolens* located and likely to spread?



Climate niche modeling approach

- Niche models, habitat suitability models, climate envelope models...

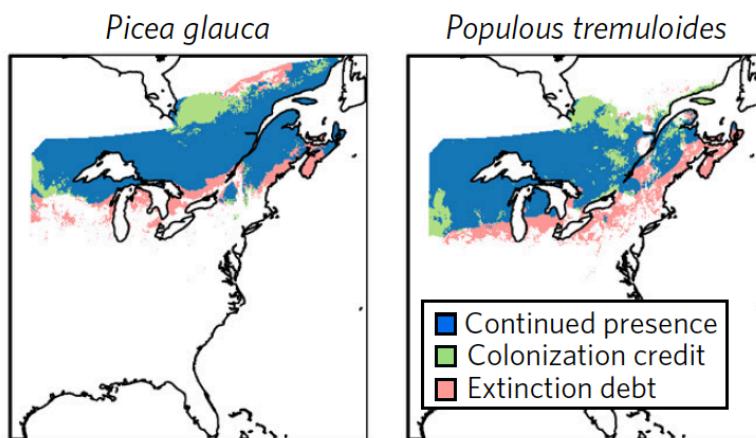


Broennimann et al. 2012

Climate niche modeling approach

Models can help quantify:

- the **preferred climate conditions** of a species (its niche);
- whether the niche has **evolved over time**;
- and where we expect to find suitable climate conditions in **other locations** or **time periods**

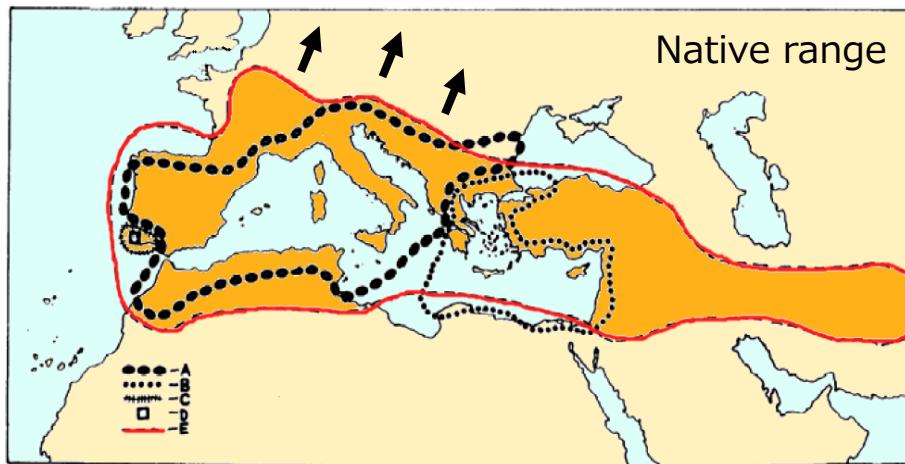


Talluto et al. 2017



Research questions

- Where is *Dittrichia graveolens* present now?
- Did *Dittrichia* expand its niche during its native range expansion in Europe?
- How does including the native range expansion affect invasion risk assessment in California?



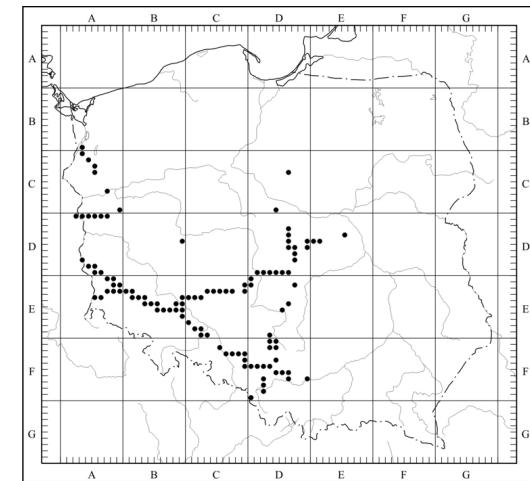
Key steps and decisions

- Data collection and processing
 - Collect species occurrence data
 - Define native range
 - Get environmental data
 - Choose resolution
 - Define background area
- Choose a modeling approach
- Project suitable climate in California
- Model validation



Collecting occurrences

- Eurasia: 10,889
- California: 8,048



1410. *I. graveolens* (L.) Desf. — I. à odeur forte.

① Plante à tige entièrement herbacée de 30-70 cm, pubescente-glanduleuse, visqueuse, à odeur forte. Feuilles lancolées-linéaires entières, souvent d'un vert sombre, les inférieures atténues en pétiole, les supérieures sessiles, jamais embrassantes. Capitules bien plus petits que chez *I. viscosa* (8-10 mm). Bractées externes de l'involucre herbacées, les internes scarieuses sur le bord. Inflorescence en grande panicule pyramidale lâche de petits capitules (8-10 mm). Fleurs jaunes, les ligules ne dépassant pas l'involucre. Aigrette à soies soudées en anneau à la base. — VIII-X. — Champs cultivés, jachères. K : Tabarka; NE : Carthage (Cd.), la Goulette, Hammam-Lif; CB : Zembla; TC : Enfida (L.H.). Aire géographique : Algérie, Maroc, Europe méridionale, Syrie, Palestine.

Hladnikia 24: 35-43 (2009)

Dittrichia graveolens, nova tujerodna vrsta slovenske flore

Dittrichia graveolens, a new alien species of the Slovenian flora

Collecting occurrences: GBIF data only



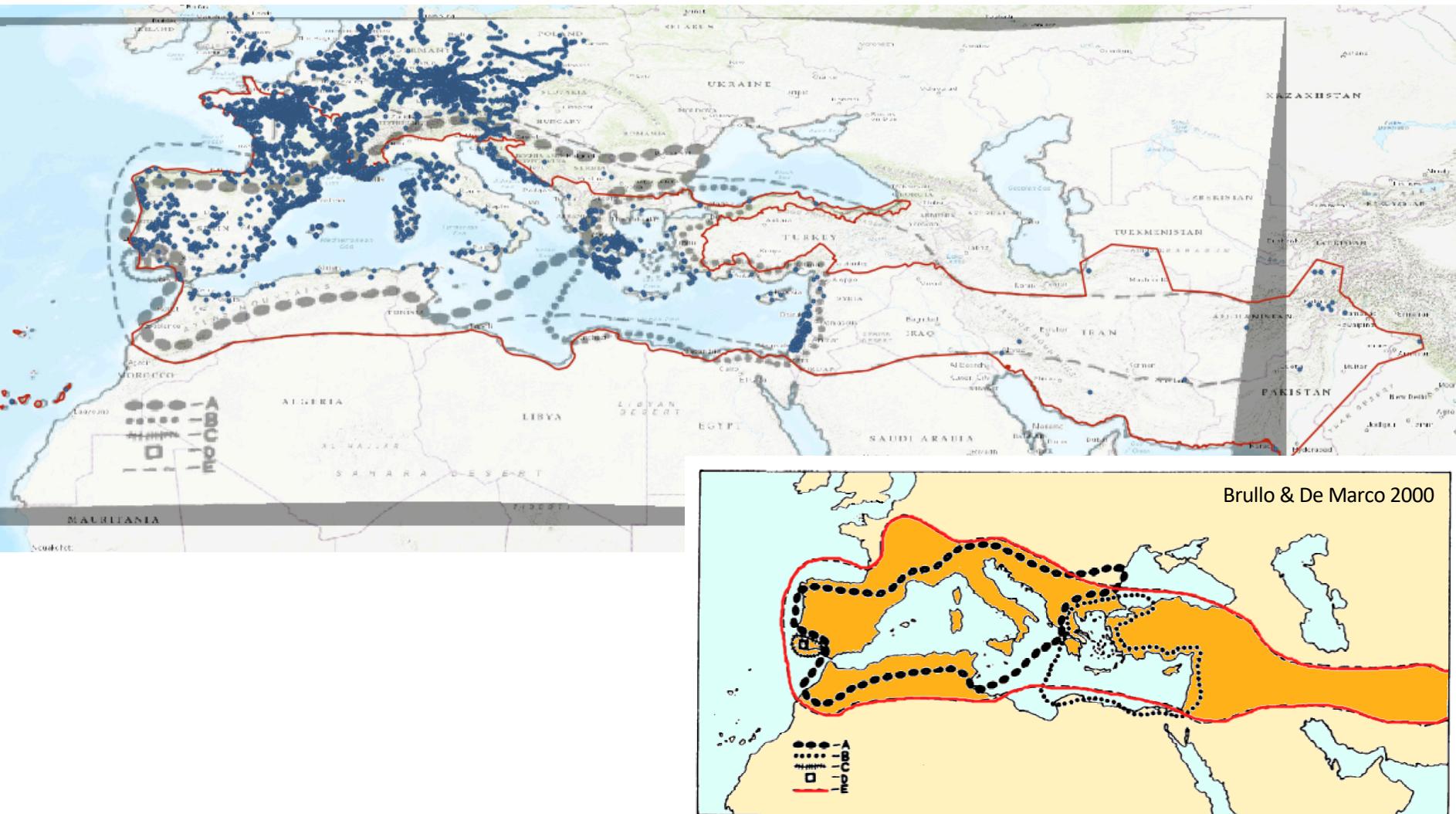
Collecting occurrences: all data



Defining the original native range boundary



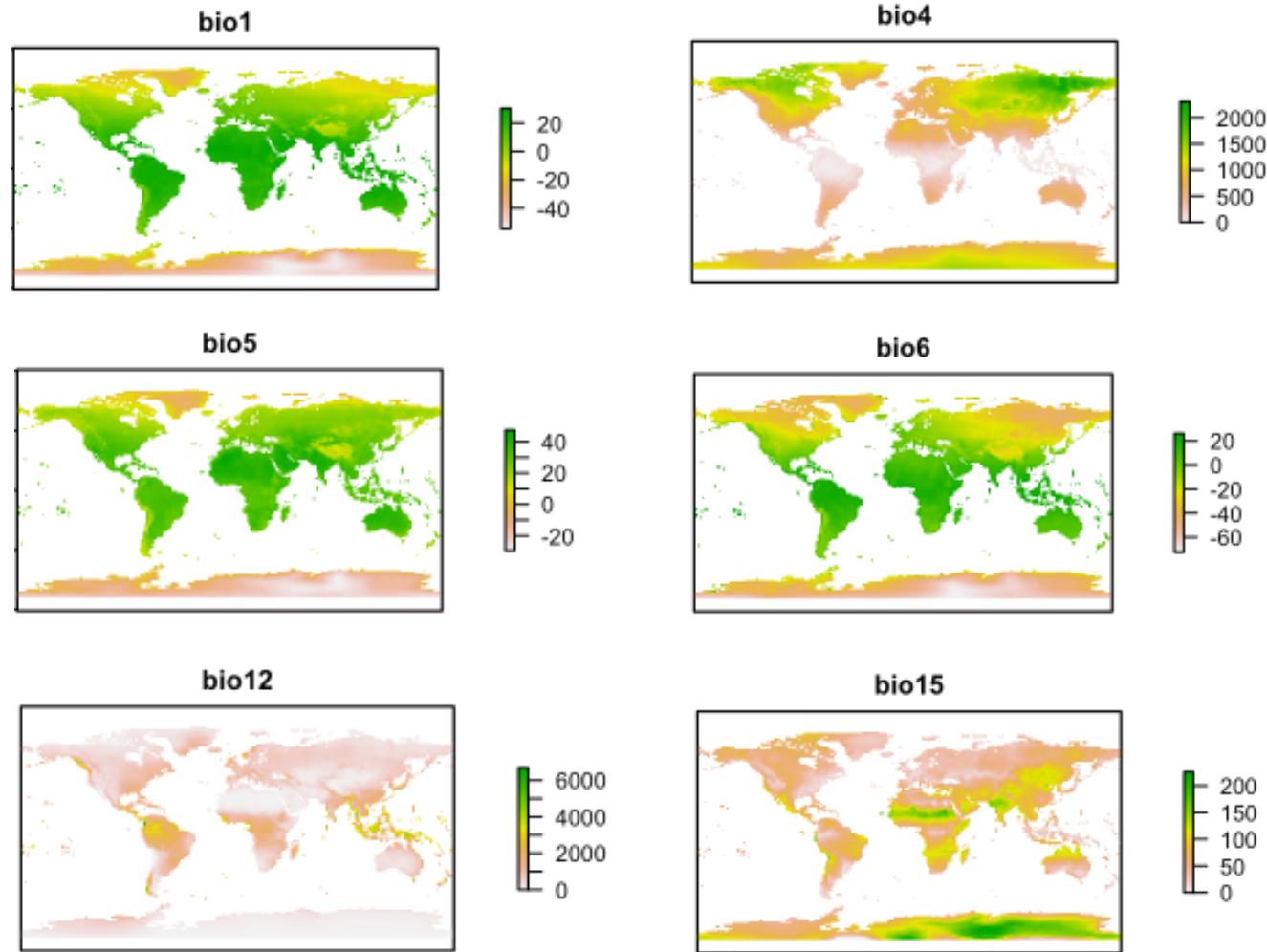
Defining the original native range boundary



Final native range map

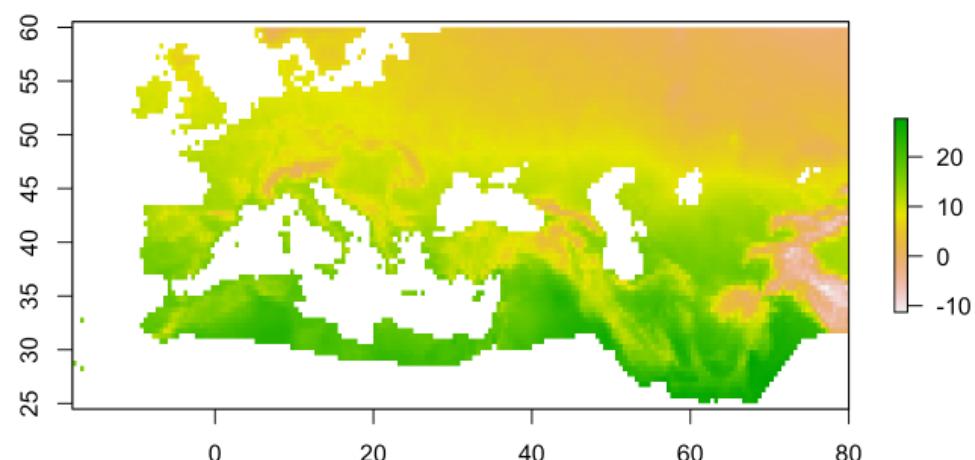
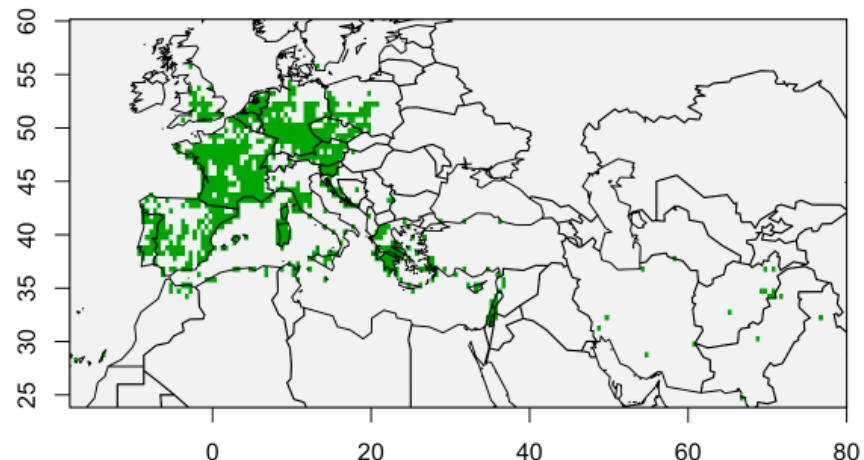


Get environmental data



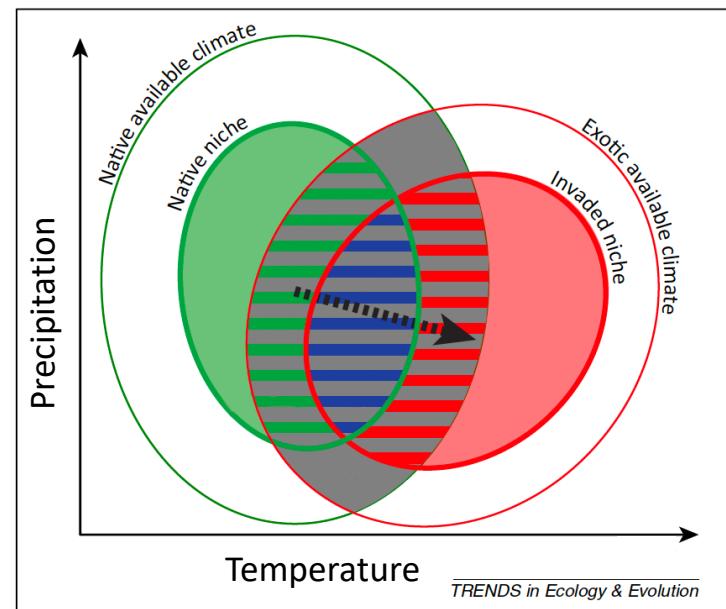
Choose resolution

- 0.5 degrees grid = 30 minutes ~ 35 by 35 miles
- This is a relatively coarse resolution but helpful on this large scale



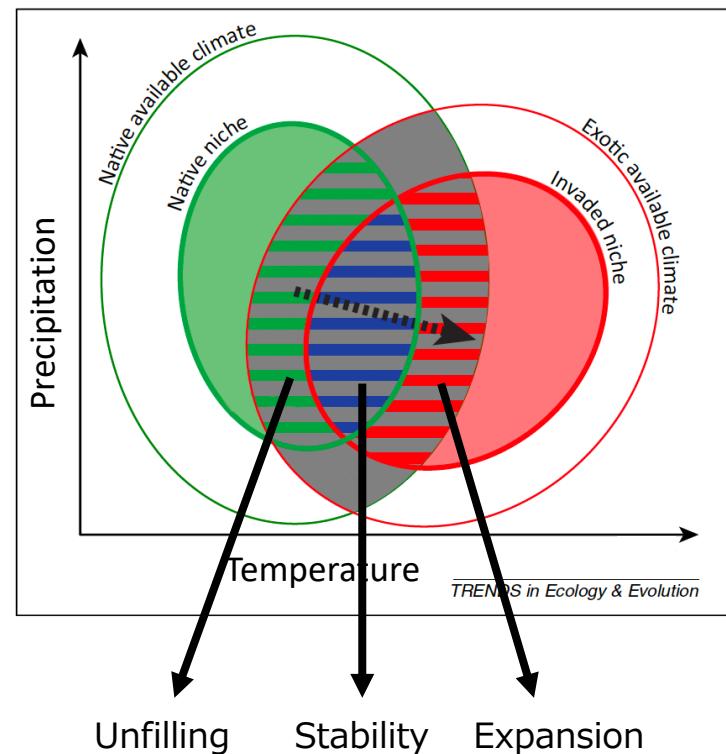
Did *Dittrichia* shift its climate niche during range expansion?

- Framework to calculate niche shifts based on recent papers and software
 - Petitpierre et al. 2012 *Science*
 - Guisan et al. 2014 *TREE*
 - Di Cola et al. 2017 *Ecography*
 - ecospat R package



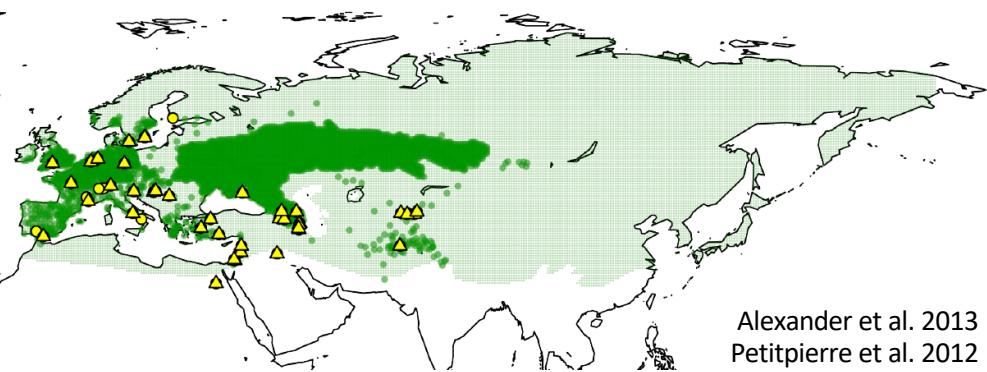
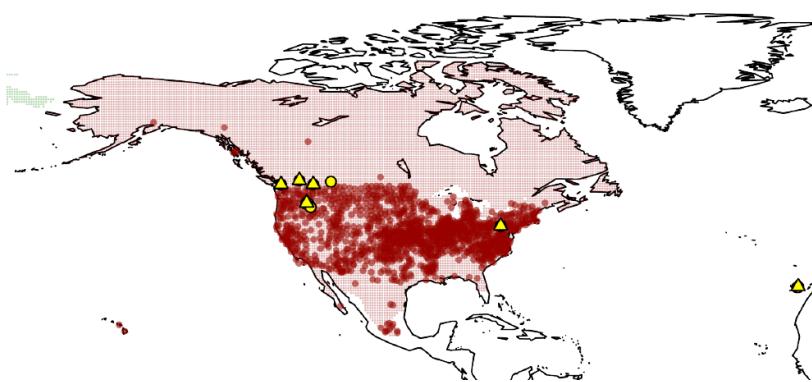
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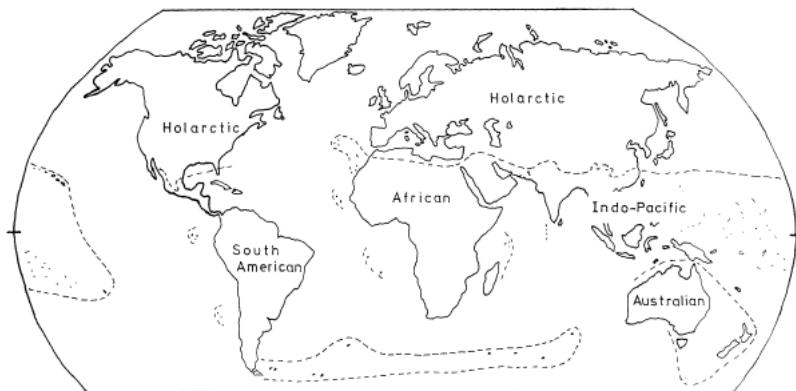


Defining the “available climate”

- Example study of *Lactuca serriola*

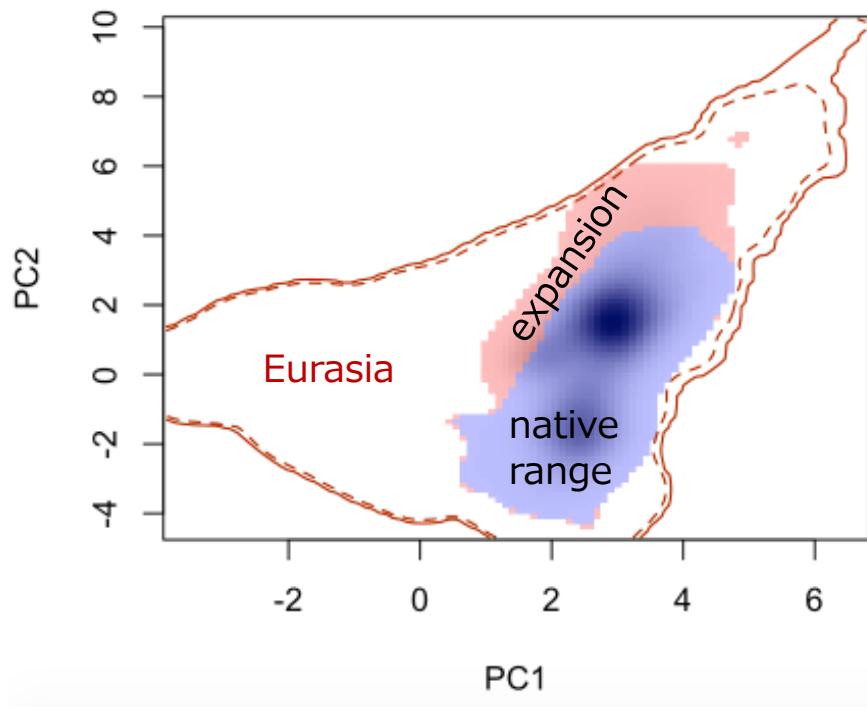


Alexander et al. 2013
Petitpierre et al. 2012

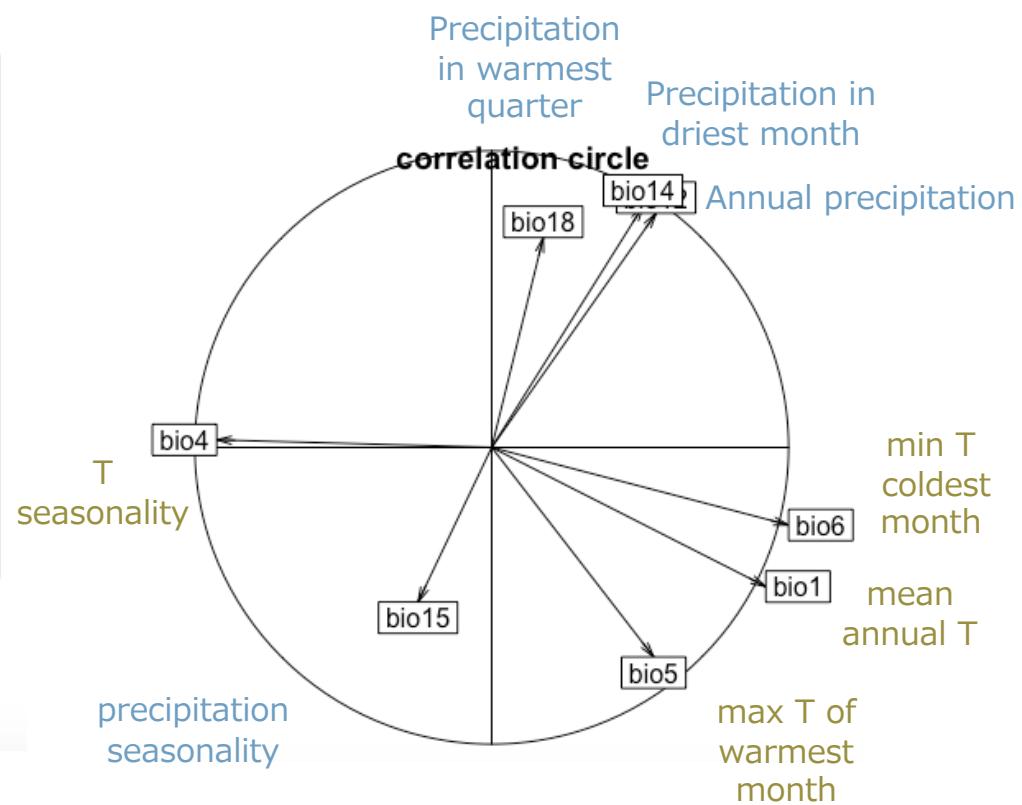


- Available climate:
Holarctic Floral Kingdom (Cox 2001)

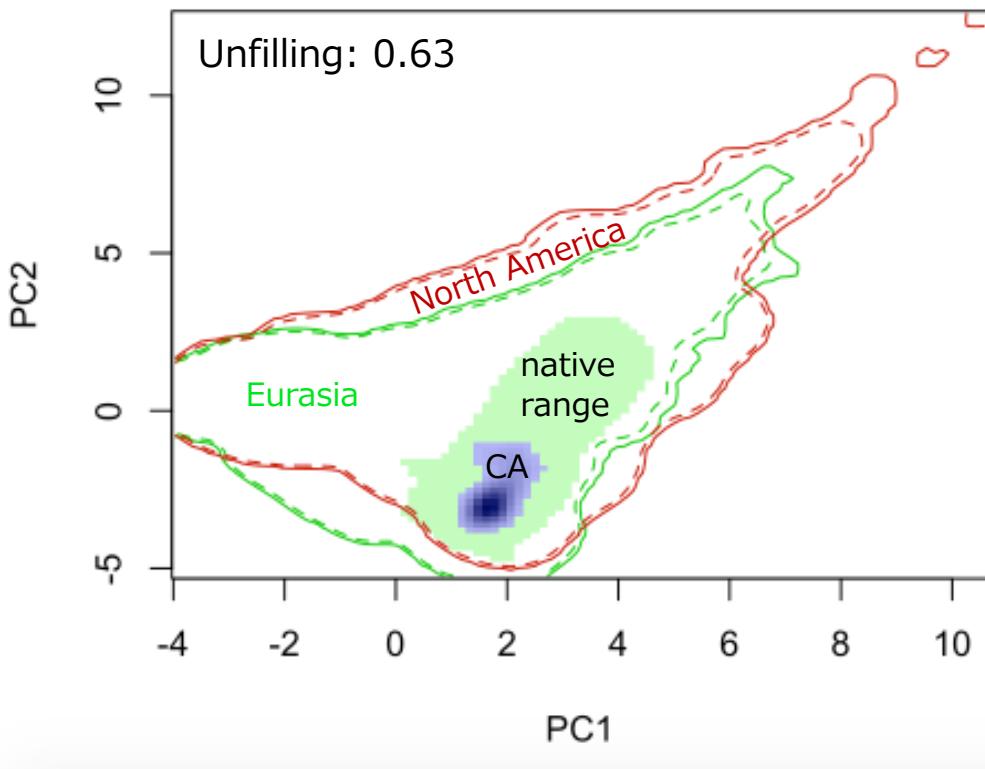
Climate niche shift during native range expansion



Blue shading: original native range
Red shading: native range expansion
Red line: climate of all of Eurasia



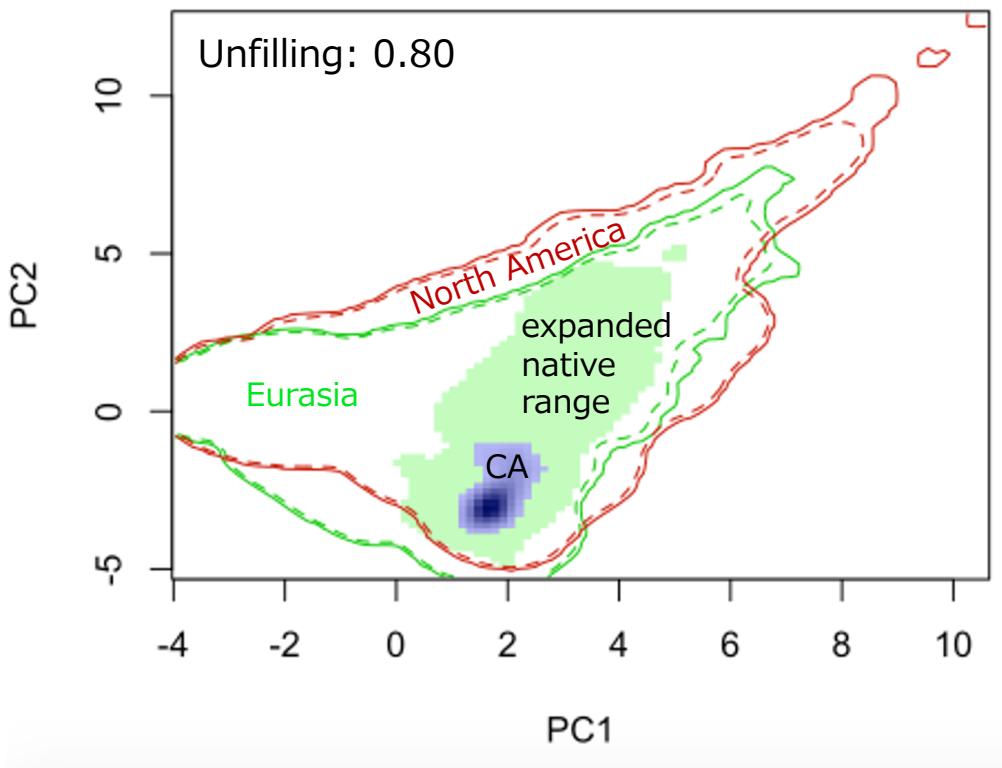
How much suitable habitat has *Dittrichia* already filled in California?



Green shading: **original native range**
Blue shading: overlap (California)

Green line: climate of Eurasia
Red line: climate of North America

How much suitable habitat has *Dittrichia* already filled in California?

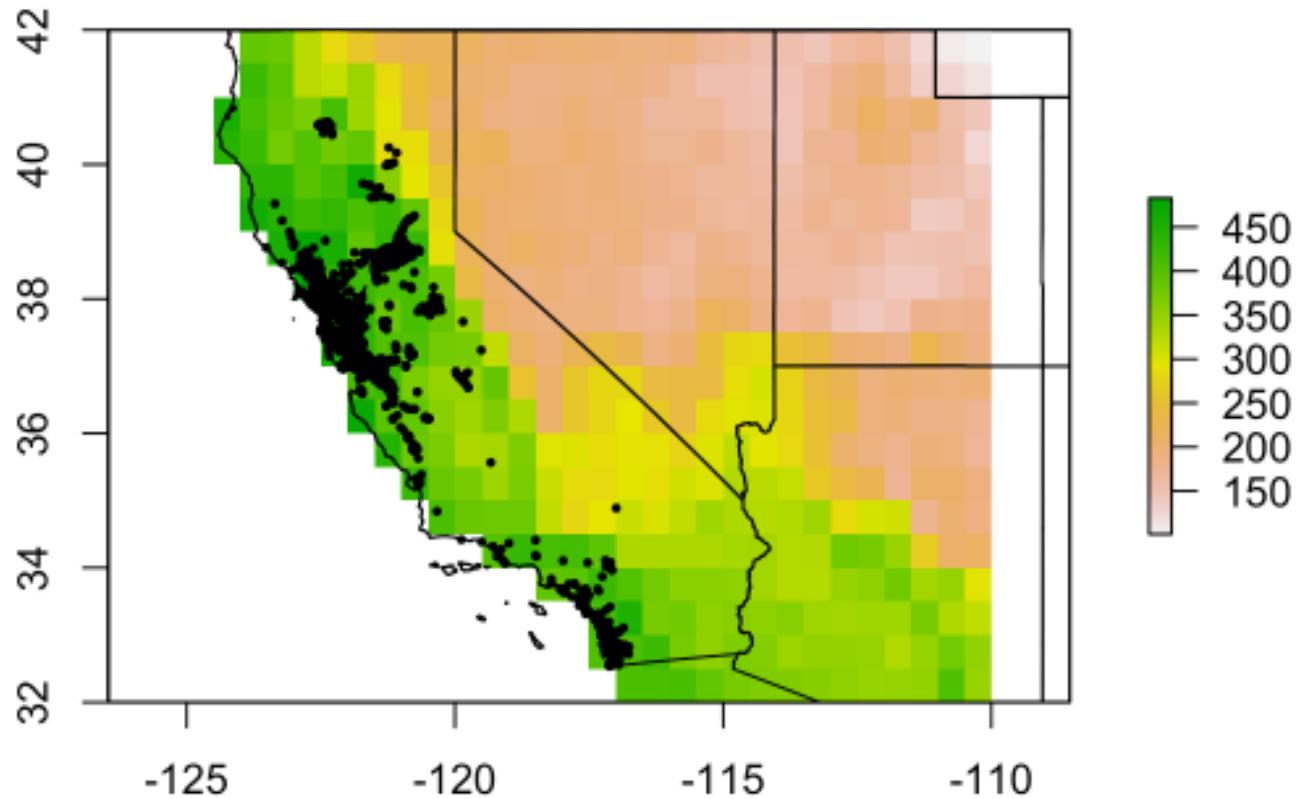


Green shading: **expanded native range**
Blue shading: overlap (California)

Green line: climate of Eurasia
Red line: climate of North America

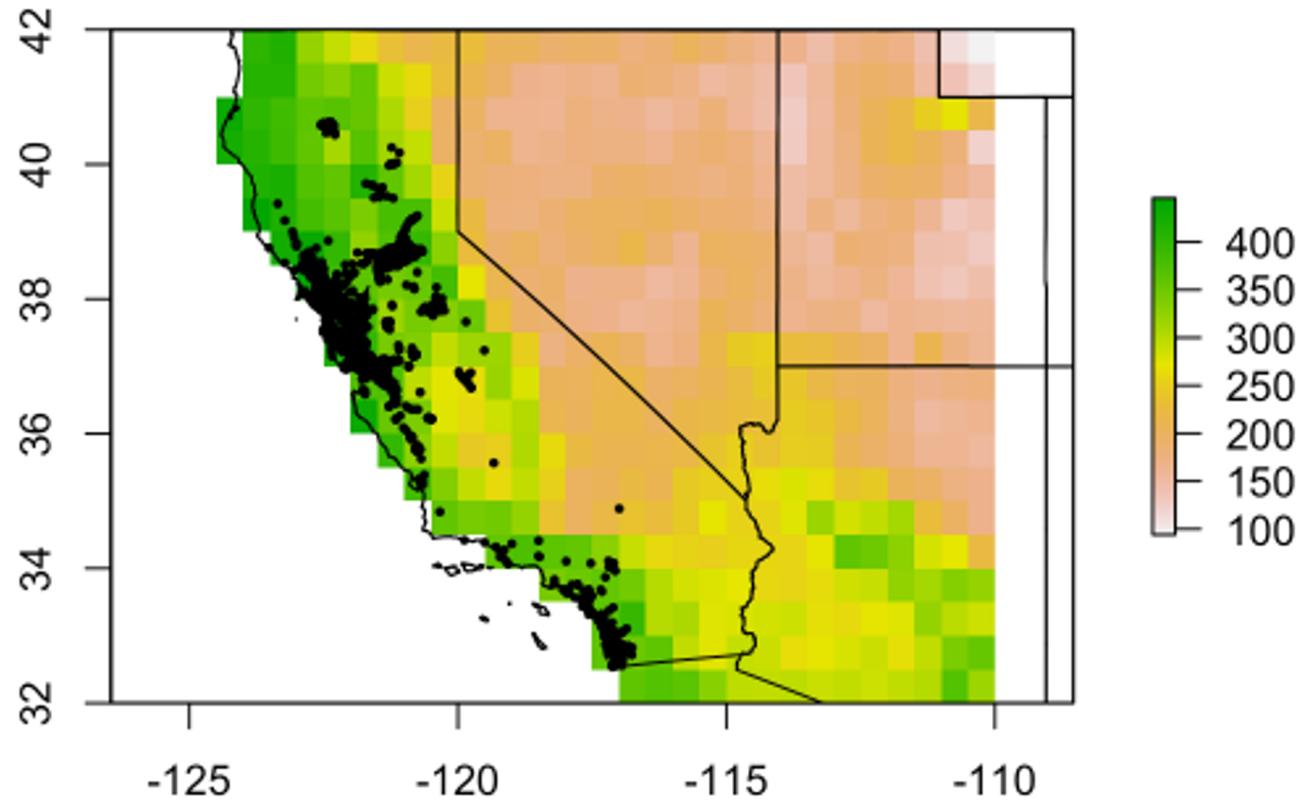
California projection based on **original** native range

- Ensemble forecast model
(preliminary – not ready for use in risk assessment)



California projection based on **expanded** native range

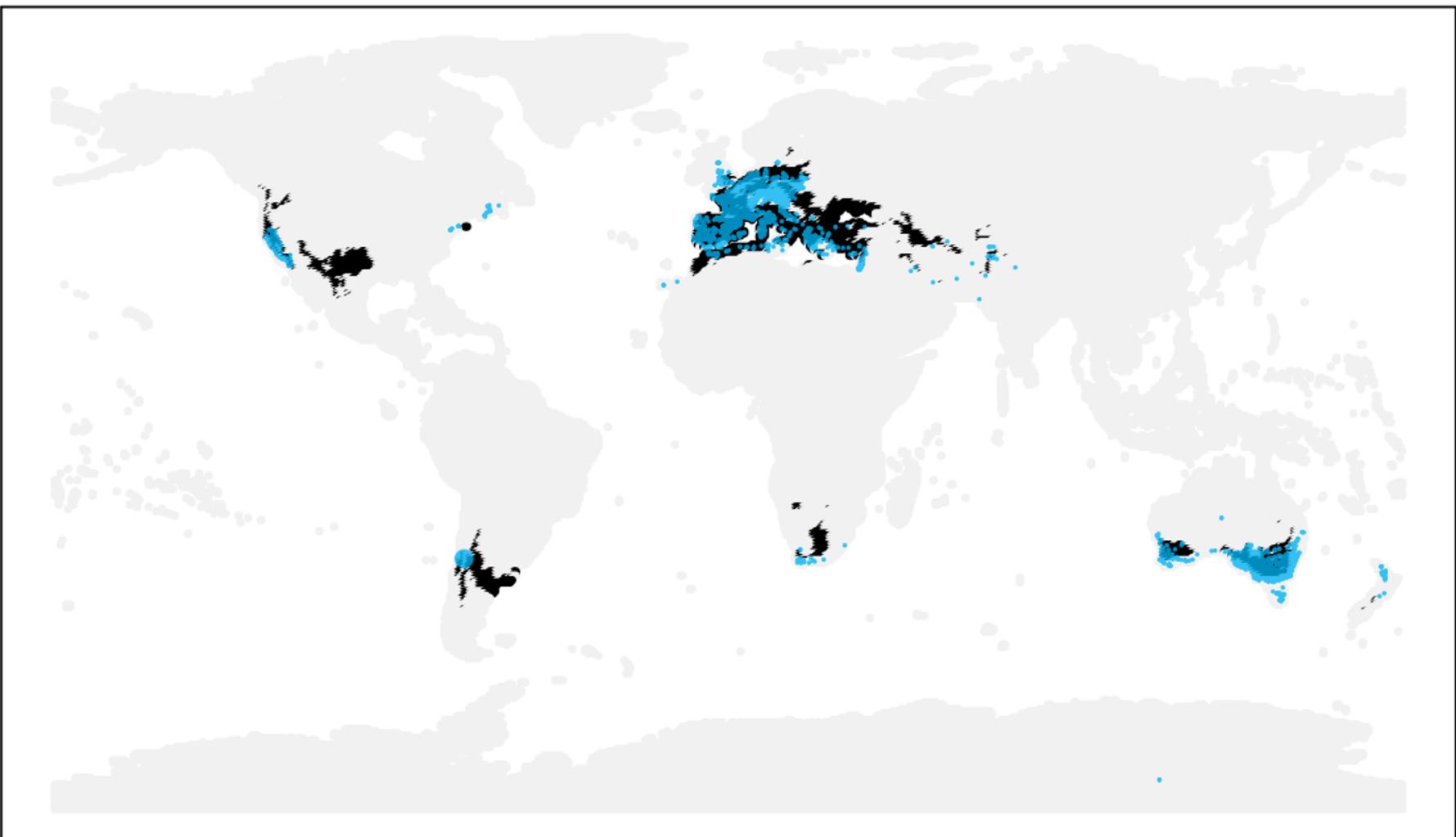
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What about the rest of the world? An envelope model:



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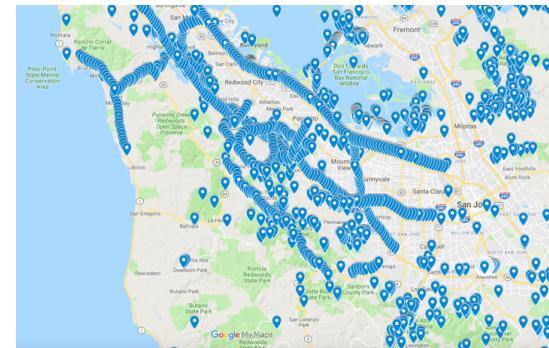


Take-aways

- Exact predictions highly depend on your modeling method
 - However, it is clear that:
 - 1) *Dittrichia* is still actively spreading and has not yet reached all suitable habitat in California
- Early detection efforts seem worthwhile!



Roadways are important corridors to reach new areas



Roadways are important corridors to reach new areas



Dittrichia is starting to invade off-road habitat in California



Characteristics of plant communities invaded by *Dittrichia graveolens* (Asteraceae), as it spreads away from roadsides in Santa Clara County

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Introduction

Biological invasion occurs when an exotic species thrives and spreads in a new region¹. Invasions often impose consequences on native species, communities, and ecosystems, and it is expected that the severity of these impacts will increase as more exotic species become established.

Dittrichia graveolens (stinkwort) is an annual plant in the Asteraceae family native to the Mediterranean Basin. It was first introduced to North America in the 1930s, where it grows along roadsides and in disturbed areas². More recently, *Dittrichia* has been observed invading natural sites away from roads³, representing a common pattern for invasive plants. To best direct resources for management and prevention, it is important that we understand which communities are most vulnerable to invasion.



Methods

- Plant community surveys were conducted at 15 locations in Santa Clara County
- Each location had 2 paired sites
 - Roadside and off-road
 - ~ 30 sites total
- Roadside site is presumed source for off-road population
- Population size was estimated using categories (10; 50; 100; 500; 1,000; 10,000)

Roadside Population



Offroad Population

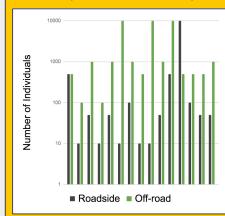


Andrew Lopez 2020

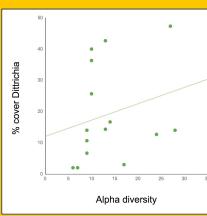


Quadrat example:
Dittrichia graveolens
Other vegetation

Off-road sites are larger in population size (number of individuals)



Dittrichia cover was higher, not lower, at more diverse off-road sites



Discussion

Our research shows that *Dittrichia graveolens* is invading away from roadsides. Off-road populations were often larger than roadside populations, demonstrating that *Dittrichia* can successfully take hold in vegetated communities. Even though there may be more species diversity in off-road populations, these communities are not immune to *Dittrichia* invading.

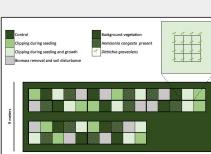
Large populations of *Dittrichia* were found across a broad range of disturbance levels (bare ground). In addition, the most invaded communities were comprised of Asteraceae species and other forbs. Exotic grasses such as *Avena barbata* may create a biological boundary that limits the ability of *Dittrichia* to invade.

Take Home Messages for Management

1. Potential for invasion away from roads.
2. We need to pay attention to controlling off-road populations.
3. More diverse sites, and less disturbed sites, are not necessarily protected from *Dittrichia* invasion.
4. Grassland sites strongly dominated by European annuals seem to be less invasible.

Next Steps

Data presented are correlational. Next we will conduct an experiment where disturbance and biodiversity are manipulated.



We hope to present findings of this grassland competition and disturbance study next year!

Acknowledgements

- United States Department of Agriculture, National Institute of Food and Agriculture
- UC Santa Cruz, Department of Ecology and Evolutionary Biology
- The Center to Advance Mentored, Inquiry-Based Opportunities (CAMINO)

References

1. Gallo, A., Almendariz, F. W., Holt, J. S., Lodge, D. M., Meléndez, J., Woh, K. A., ... Weller, S. G. (2001). The Population Biology of Invasive Species. *Annual Review of Ecology and Systematics*, 32(1), 305–332. doi:10.1146/annurev.ecolsys.32.081501.114037
2. Preston, R. B. 1991. *Dittrichia graveolens* (Asteraceae), New to the California Weed Flora. *Madroño*.
3. Brooker, R., G. B. Kyer, and I. M. DiTomaso. 2013b. Stinkwort is rapidly expanding its range in California. *California Agriculture* 67:110–115.



Andrew Lopez



Miranda Melen

Take-aways

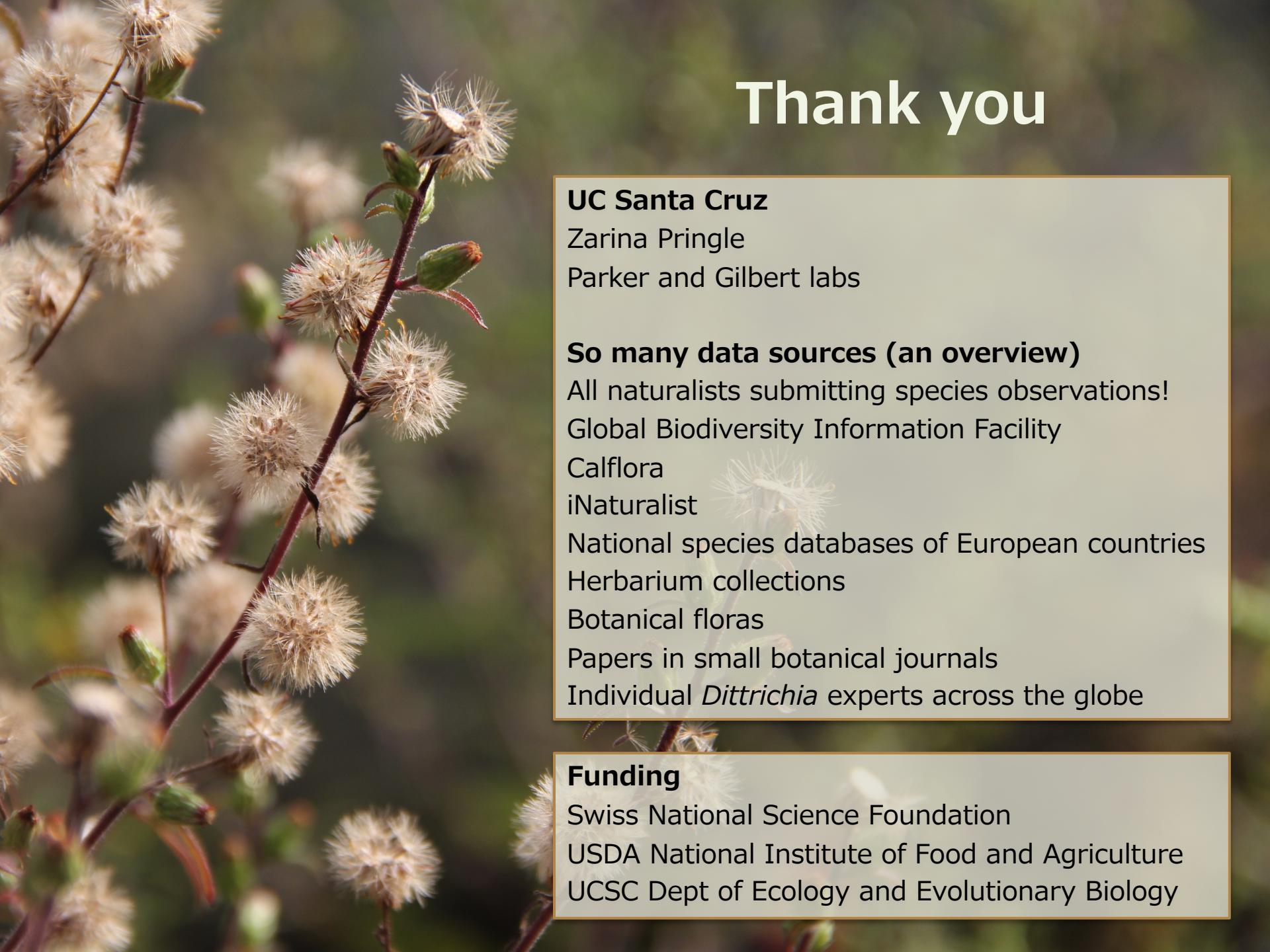
- Exact predictions highly depend on your modeling method
- However, it is clear that:
 - 1) *Dittrichia* is still actively spreading and has not yet reached all suitable habitat in California

Early detection efforts seem worthwhile!
 - 2) If similar niche evolution would happen like in Europe, cooler, moister areas are at risk of invasion



Work in progress





Thank you

UC Santa Cruz

Zarina Pringle

Parker and Gilbert labs

So many data sources (an overview)

All naturalists submitting species observations!

Global Biodiversity Information Facility

Calflora

iNaturalist

National species databases of European countries

Herbarium collections

Botanical floras

Papers in small botanical journals

Individual *Dittrichia* experts across the globe

Funding

Swiss National Science Foundation

USDA National Institute of Food and Agriculture

UCSC Dept of Ecology and Evolutionary Biology

How do *Dittrichia* in California compare to European plants?

