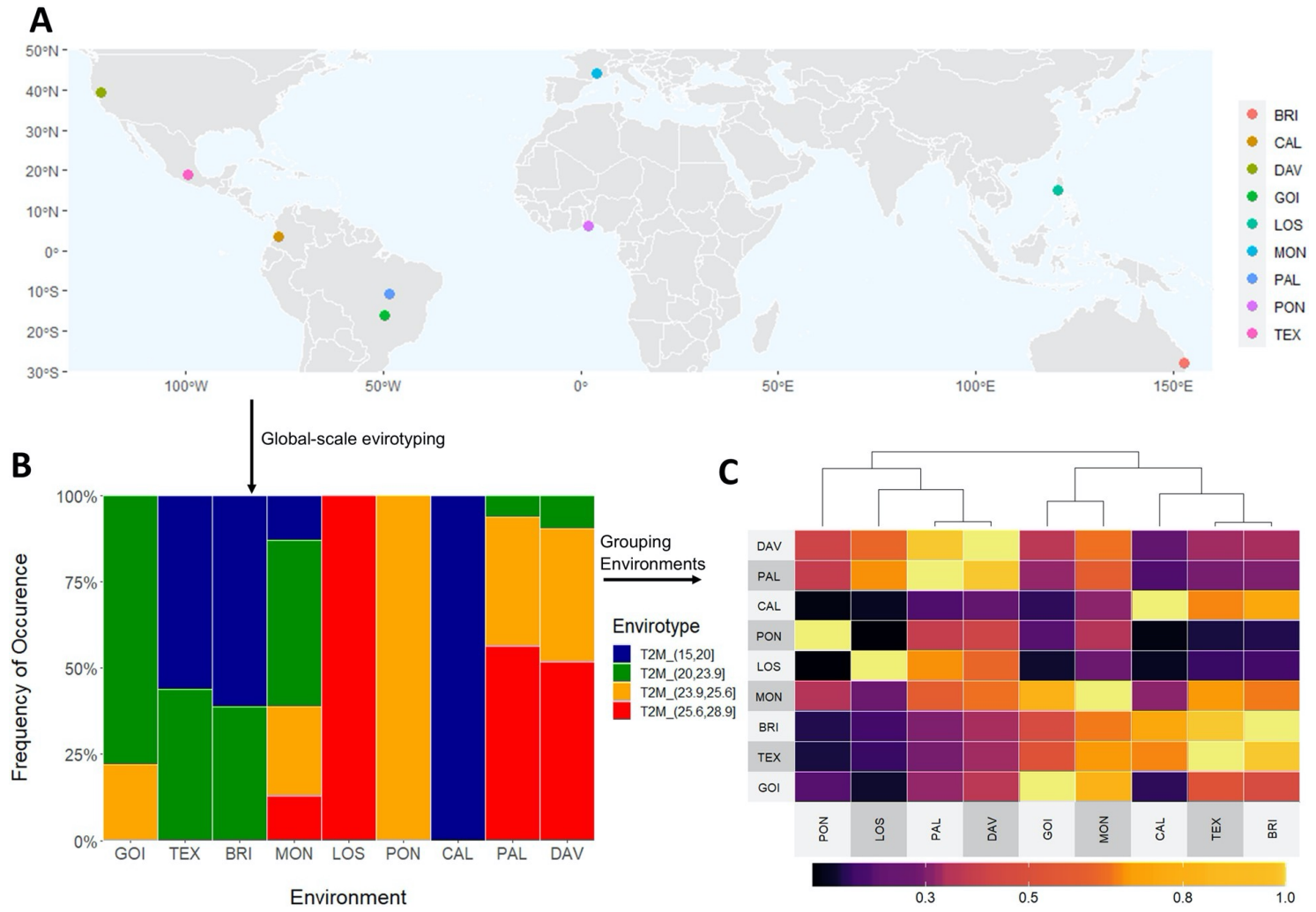
Global Envirotyping Networks

Example: Shared Temperature Typology for maize during summer season (for some years)

get_weather()

env_typing()

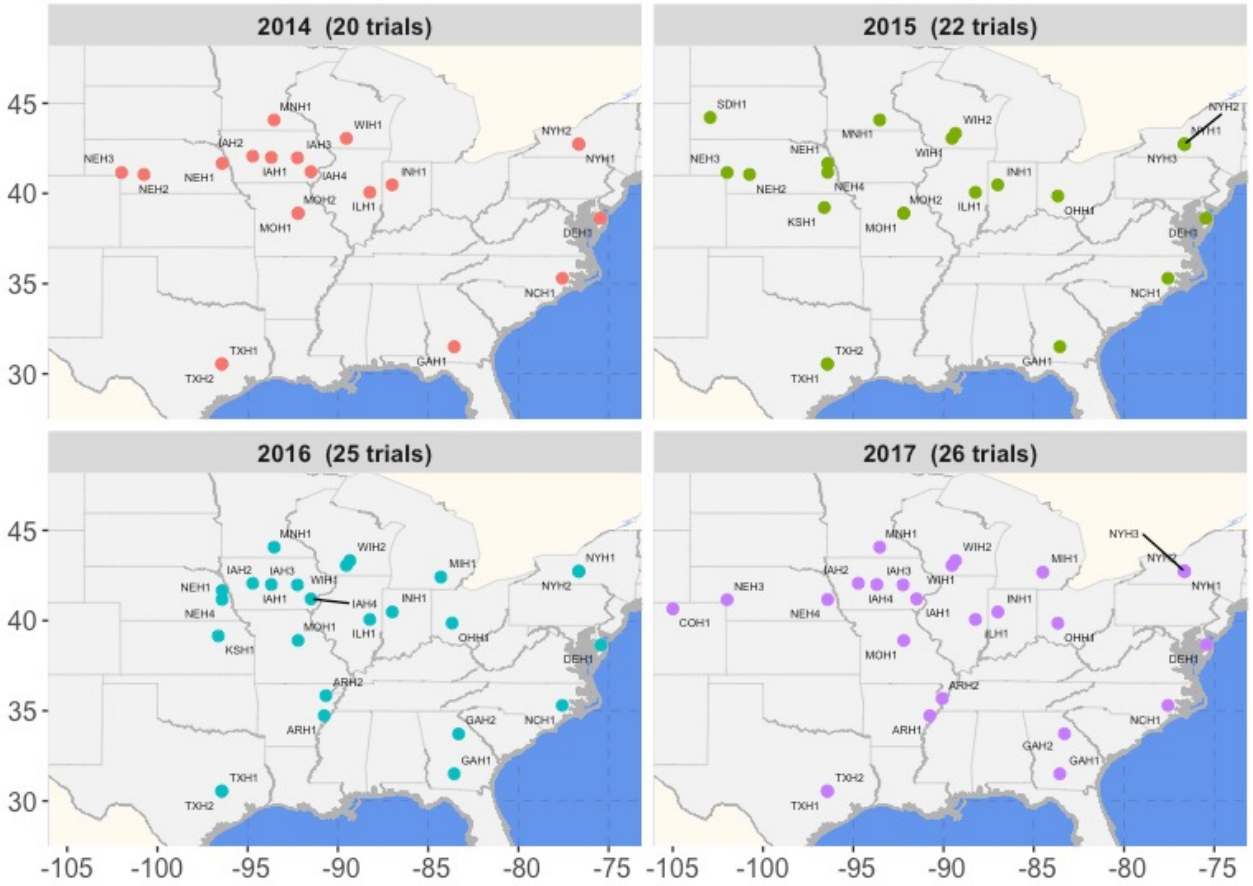


env_kernel(gaussian=TRUE)

Costa-Neto et al. (2021, G3)

Source	ID	Environmental Factor	Unit
Nasa Power[1]	ALLSKY_SFC_SW_DWN	All sky insolation incident on a horizontal surface	MJ m^{-2} d^{-1}
	ALLSKY_SFC_LW_DWN	Thermal infrared longwave radiative flux	MJ m^{-2} d^{-1}
	WS2M	Wind speed at 10 m above the surface of the earth	m s^{-1}
	T2M_MIN	Minimum air temperature at 2 m above the surface of the earth	°C d^{-1}
	T2M_MAX	Maximum air temperature at 2 m above the surface of the earth	°C d^{-1}
	T2MDEW	Dew-point temperature at 2 m above the surface of the earth	°C d^{-1}
	RH2M	Relative air humidity at 2 m above the surface of the earth	%
	PRECTOT	Rainfall precipitation (P)	mm d^{-1}
SRTM[2]	ALT	Elevation (above sea level)	m
Computed[3]	FRUE	Effect of Temperature on Radiation use Efficiency	-
	GDD	Growing Degree-days	C° d^{-1}
	ETP	Evapotranspiration (ETP)	mm d^{-1}
	PETP	Atmospheric water deficit P-ETP	mm d^{-1}
	DVP	Deficit of vapor pressure	kPa d^{-1}
	SVP	Slope of saturation vapor pressure curve	kPa C° d^{-1}
	T2M_RANGE	Temperature Range	°C d^{-1}
	RTA	Global Solar Radiation based on Latitude and Julian Day	MJ m^{-2} d^{-1}

Data Collection: G2F data (2014-2017)



McFarland et al (2020),
sample from Westhues et al (2021)

Requisites

- Time window (start / end), from 1981 - yesterday
- Geographic coordinates
- Basic R skills and Internet connection

14973 Daily observations in 2 min

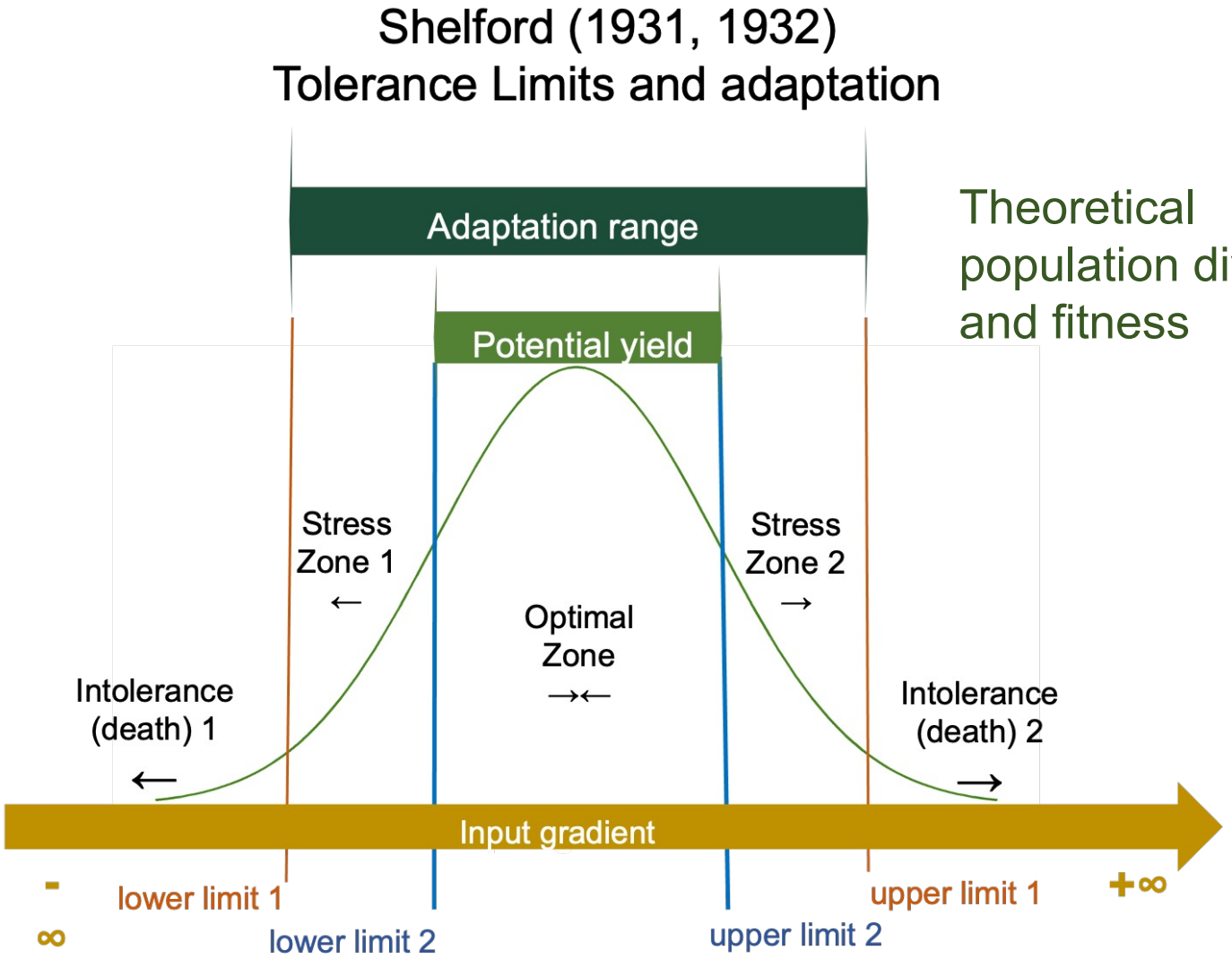
```
> env.data =
+   get_weather2(env.id = env,
+                lat = lat,
+                lon = lon,
+                start.day = start,
+                end.day = end,
+                country = country,
+                parallel = TRUE)
------------------------------------------------
ATTENTION: This function requires internet access
------------------------------------------------
Connecting to the NASA POWER API Client, Sparks et al 2018
https://docs.ropensci.org/nasapower
------------------------------------------------
Waiting 60s for a new query to the API.
Waiting 60s for a new query to the API.====                    | 25% 00:00:07
Waiting 60s for a new query to the API.=============           | 50% 00:01:12
Chunk 3/4 (29 points) downloaded |=========================   | 75% 00:02:18
NASA POWER: Done!
Connecting to https://biogeo.ucdavis.edu/data/ using Hijmans 2021--------------------
------------------------
trying URL 'https://biogeo.ucdavis.edu/data/diva/msk_alt/USA_msk_alt.zip'
Content type 'application/zip' length 20073726 bytes (19.1 MB)
==================================================
downloaded 19.1 MB


SRTM: Done!
```

Data Processing

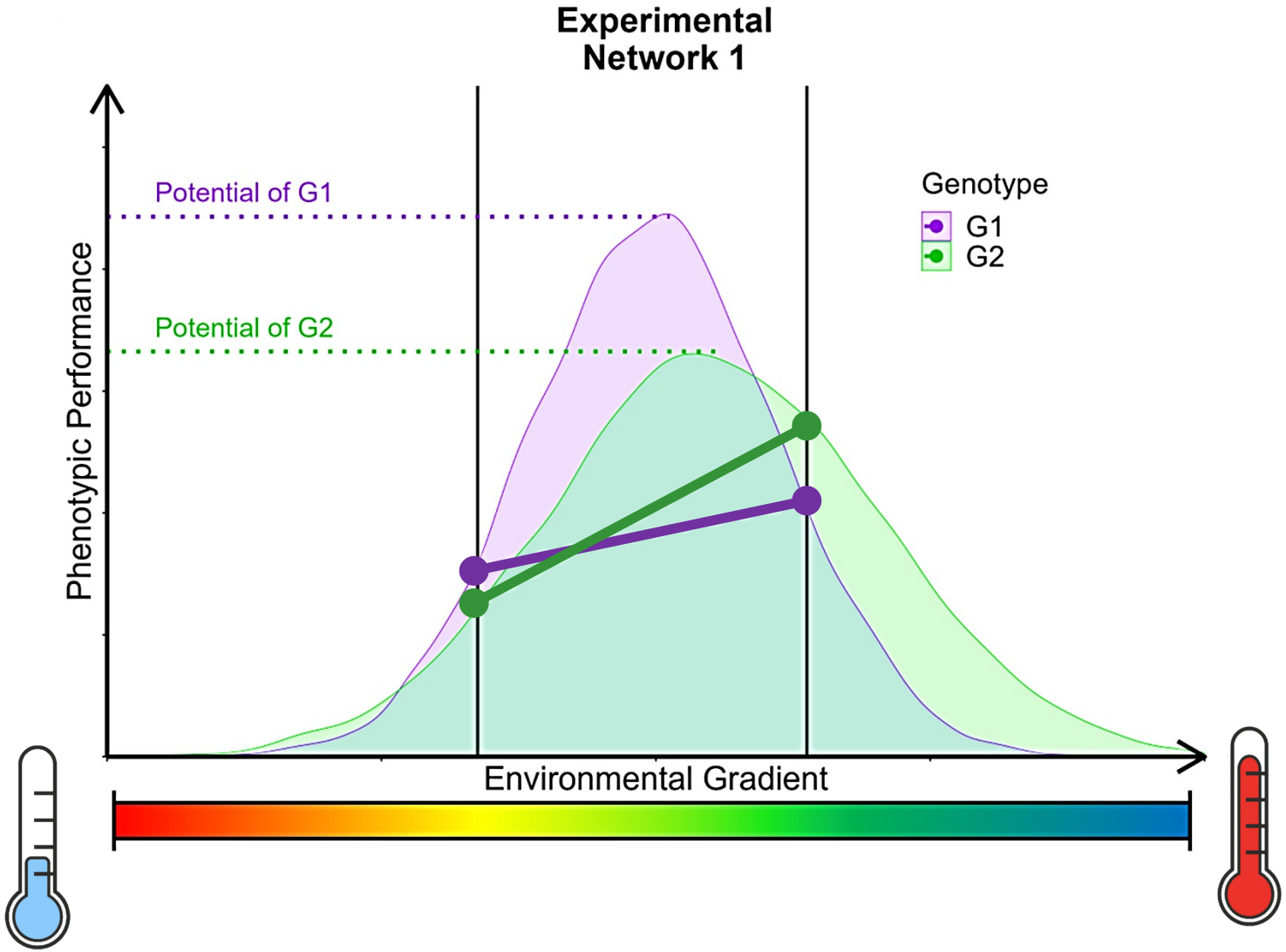
Ecology and **ecophysiology concepts** could help on the design of envirotyping pipelines

Theoretical gradient of some continuous environmental factor

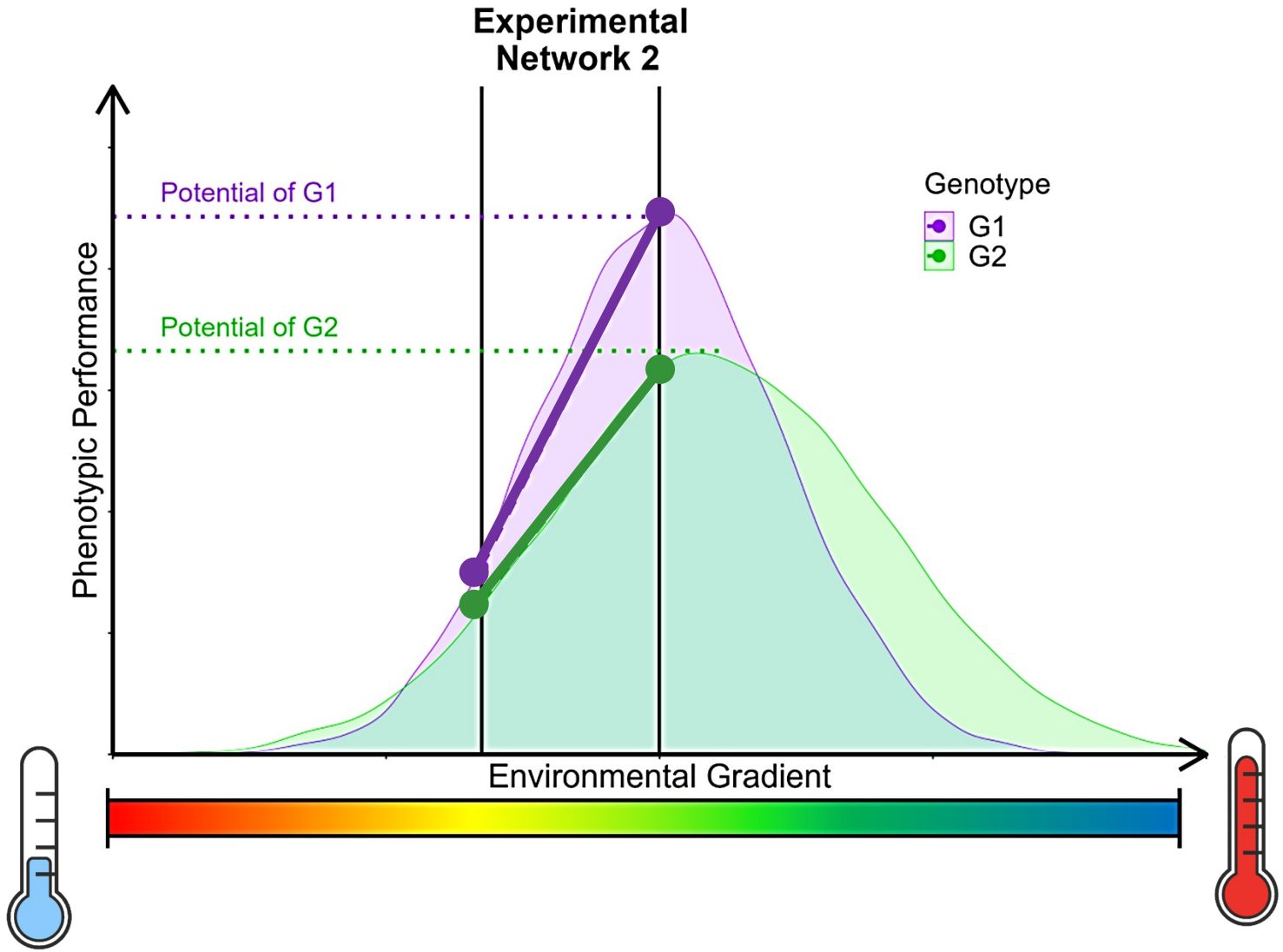


Theoretical population diversity and fitness

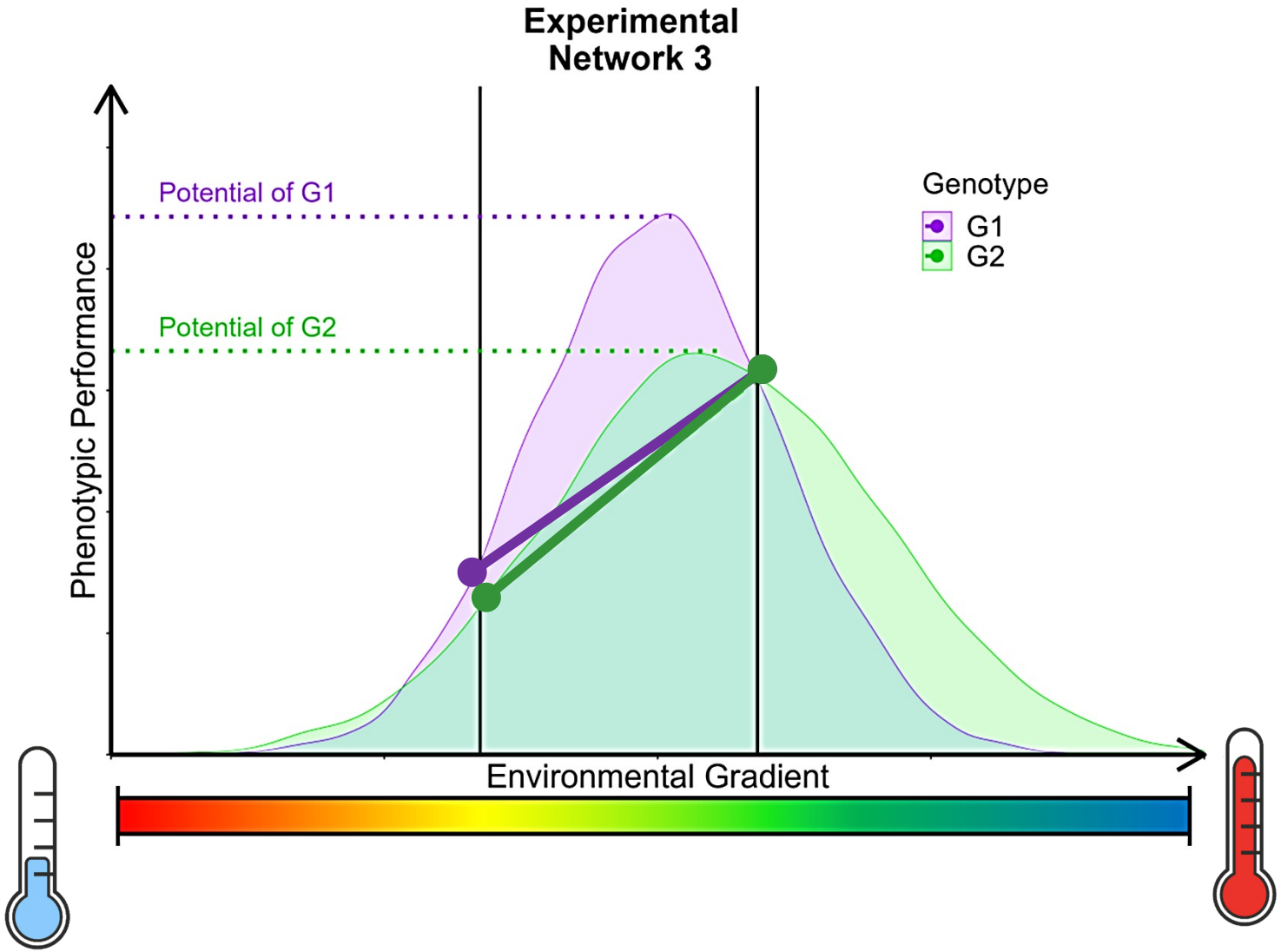
Environmental Diversity is key for GxE analysis



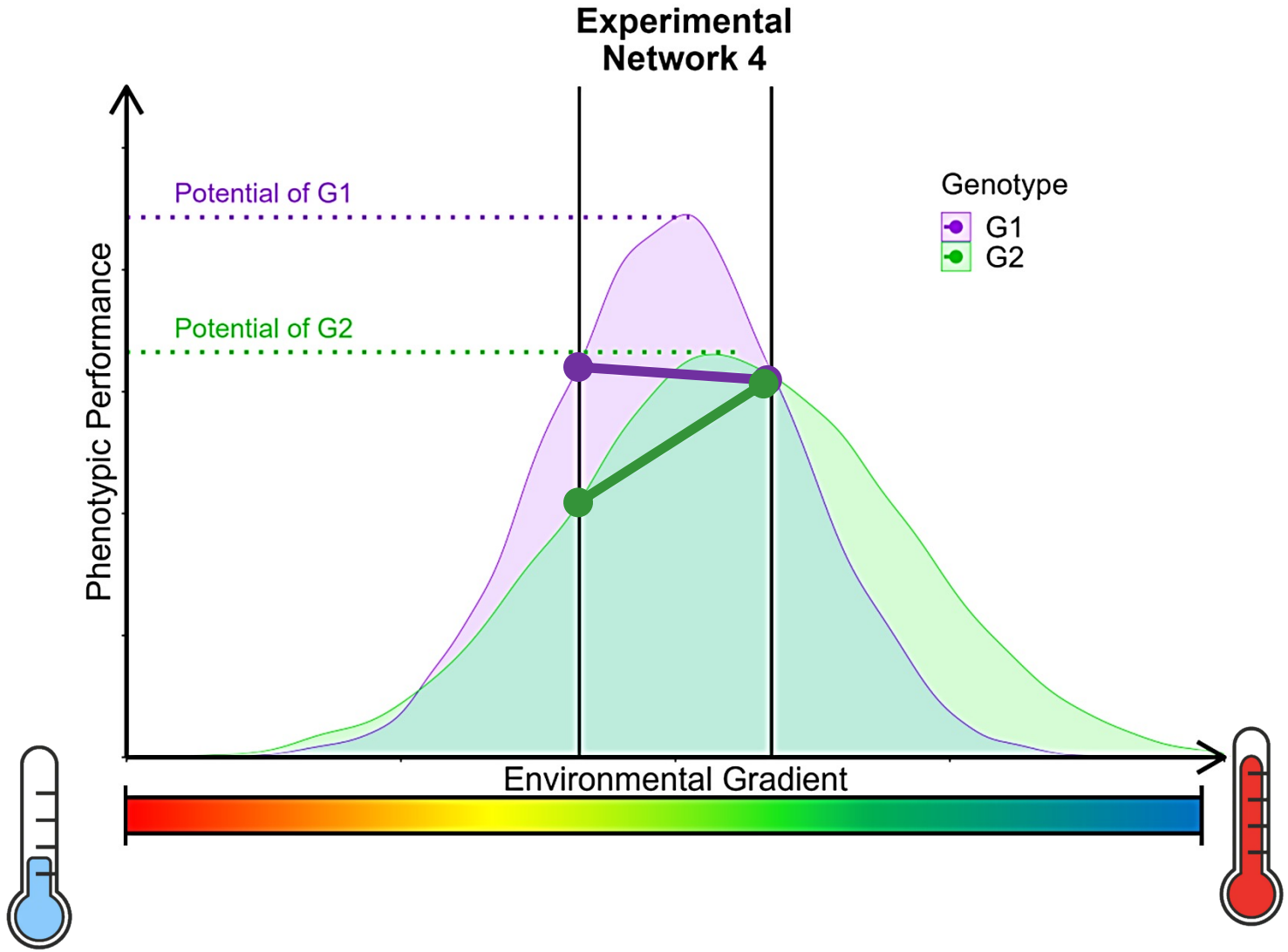
Environmental Diversity is key for GxE analysis



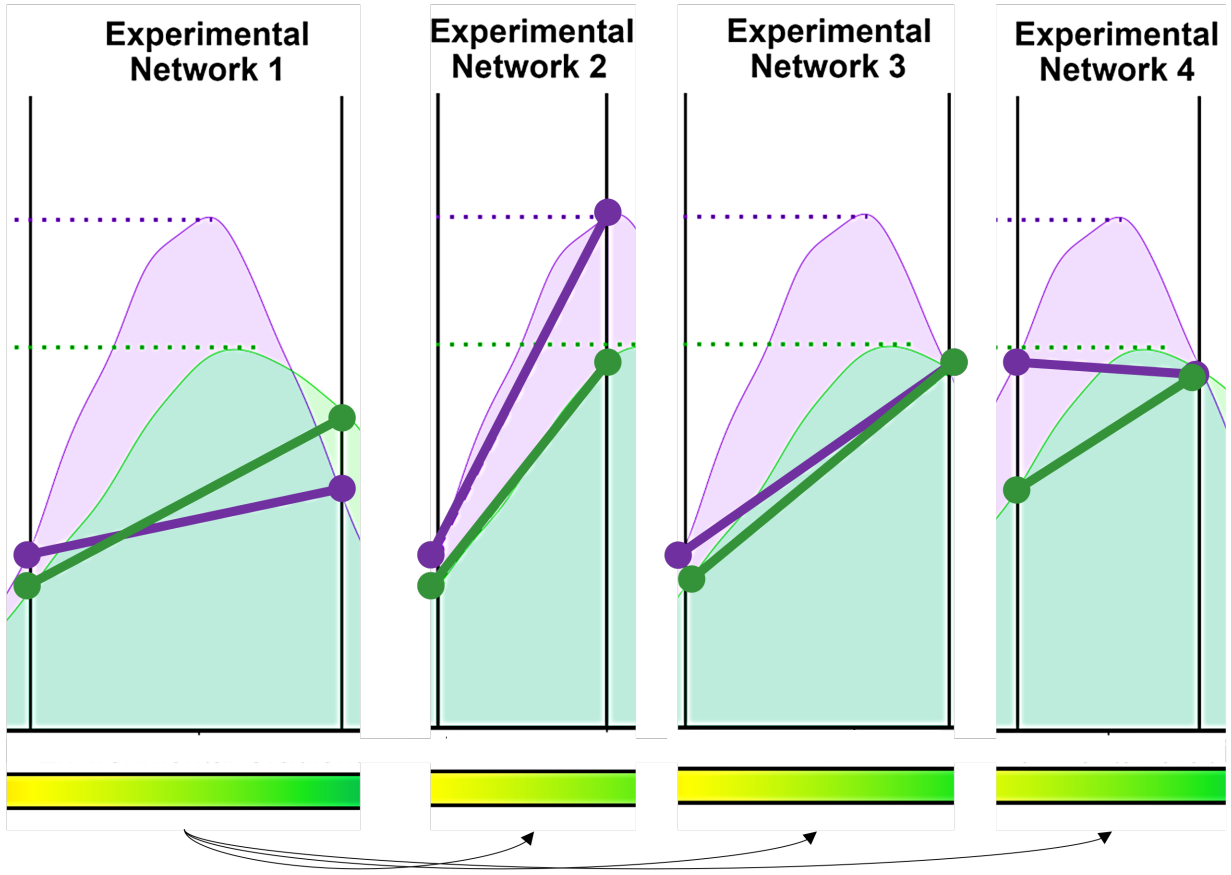
Environmental Diversity is key for GxE analysis



Environmental Diversity is key for GxE analysis



Transferability of GxE patterns across different experimental networks

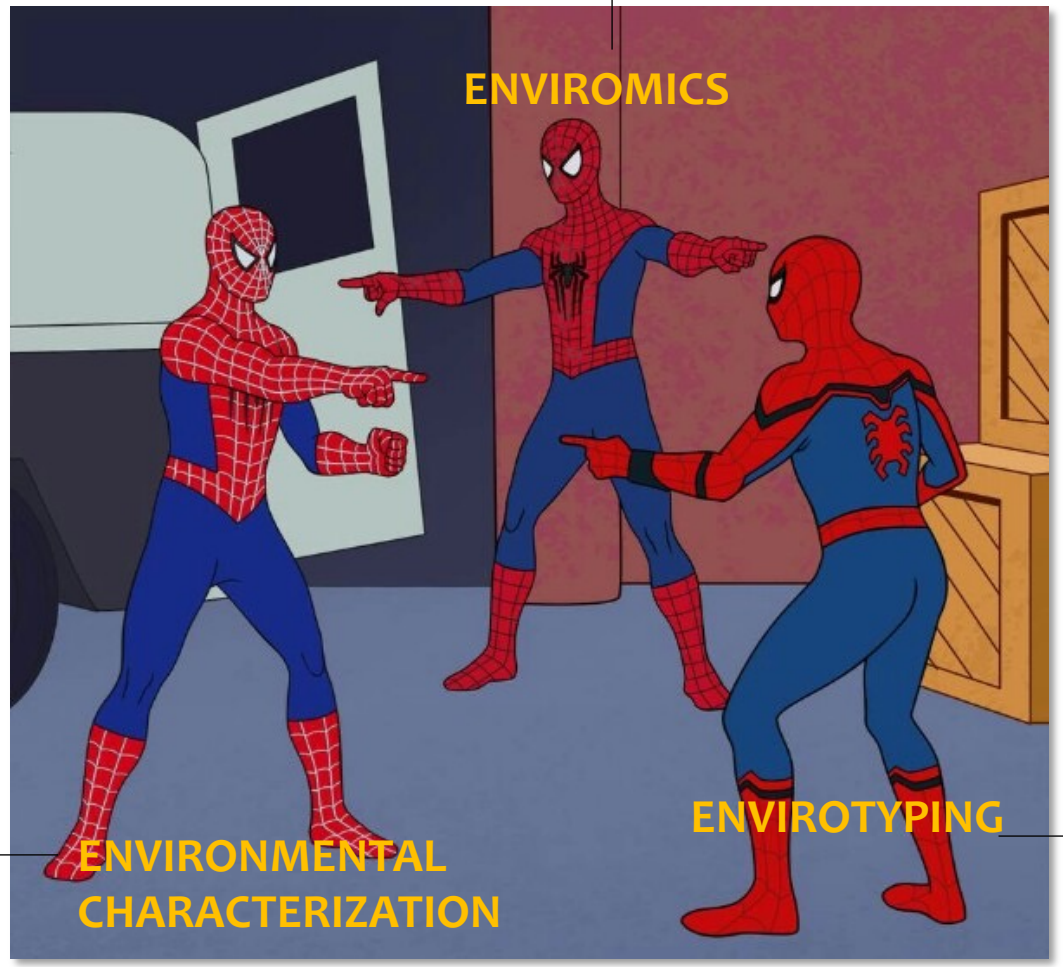


Can we predict 2, 3 and 4 using 1?
And 1,2,3 using 4?

Field trials / natural environments:

- Reaction-norms are consequence of the environmental diversity
- GxE is consequence of the reaction-norms
- GxE is MET-specific!
- But typologies are universal!
- Characterizing typologies is key

Environmental Characterization, Envirotyping & Enviromics



The Big-Picture

- Experimental network (breeding trials)
- Germplasm
- Specie
- Across Species

By Teixeira et al (2011), Resende et al (2020)

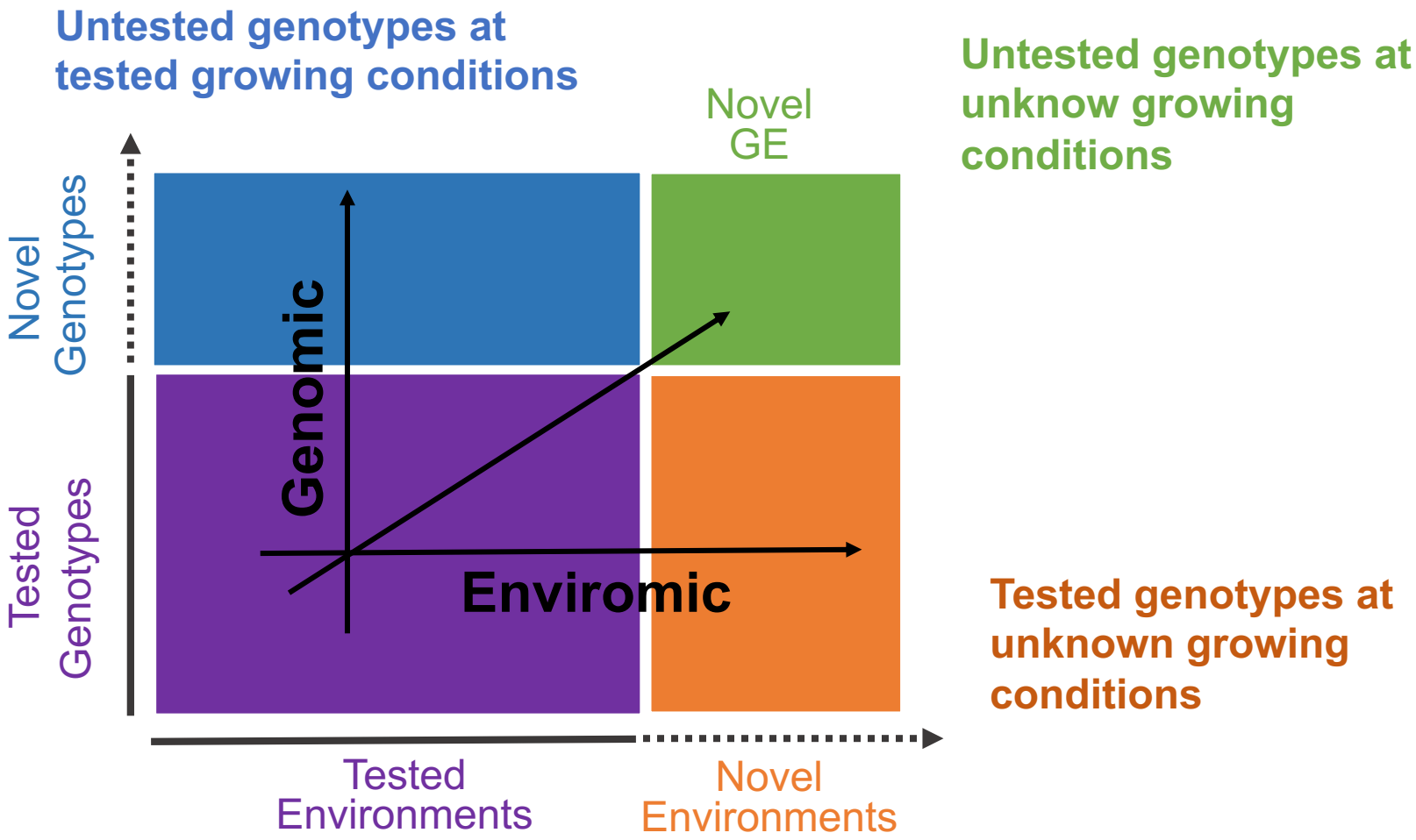
Back in the 90s-2000s

Terminology by Cooper et al 2014; Xu, 2016

Back in the 60s

Could involve or not the use of environmental data
E.g. trait-based characterizations of mega-environments (GGE biplot)

“Enviromic-aided” Genomic Prediction (E-GP)



Costa-Neto & Fritsche-Neto (2021), Adapted from Malosseti et al. (2013)

$$y = f(G, E, \dots) + \varepsilon$$