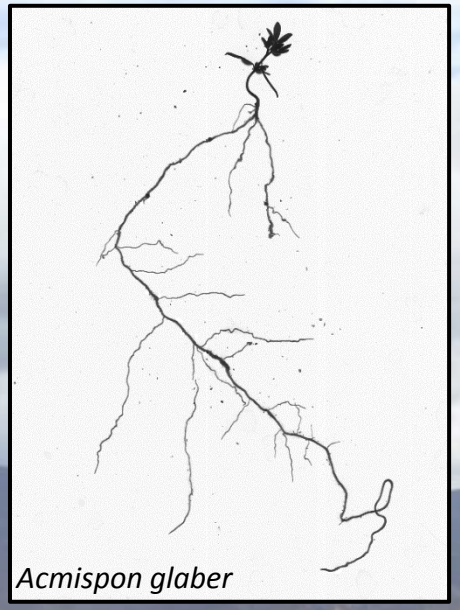
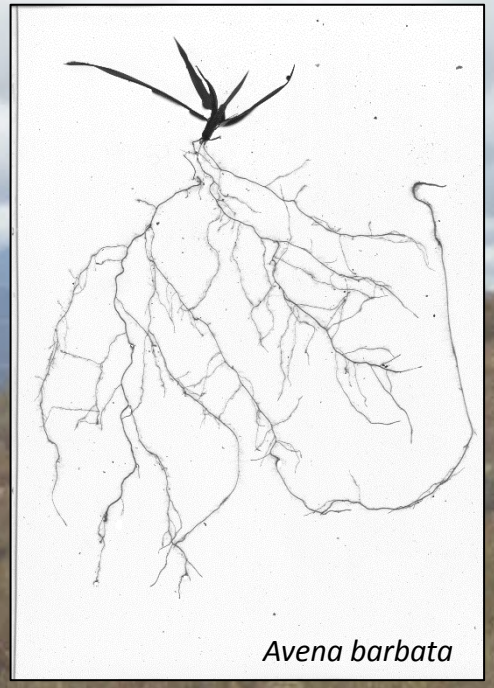
Root traits & seedling growth

across 18 native & invasive species exposed to drought



Acmispon glaber



Avena barbata

Coastal sage scrub

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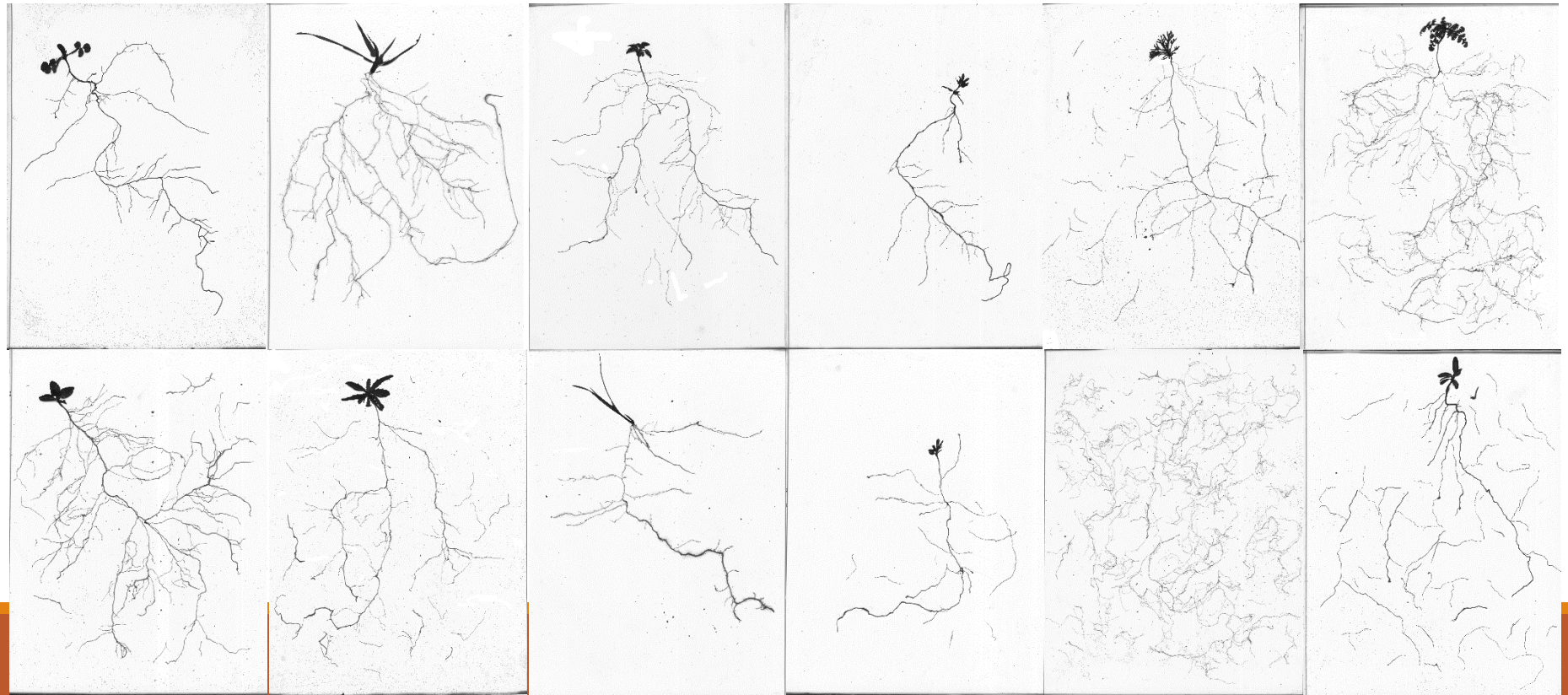
Functional traits

- Traits that influence an individual's fitness (growth, survival, reproduction)



Functional traits

- Traits that influence an individual's fitness (growth, survival, reproduction)

Perennial, shrubby

Slow growth

High leaf thickness
High water use efficiency
High leaf longevity

Annuals

Rapid growth

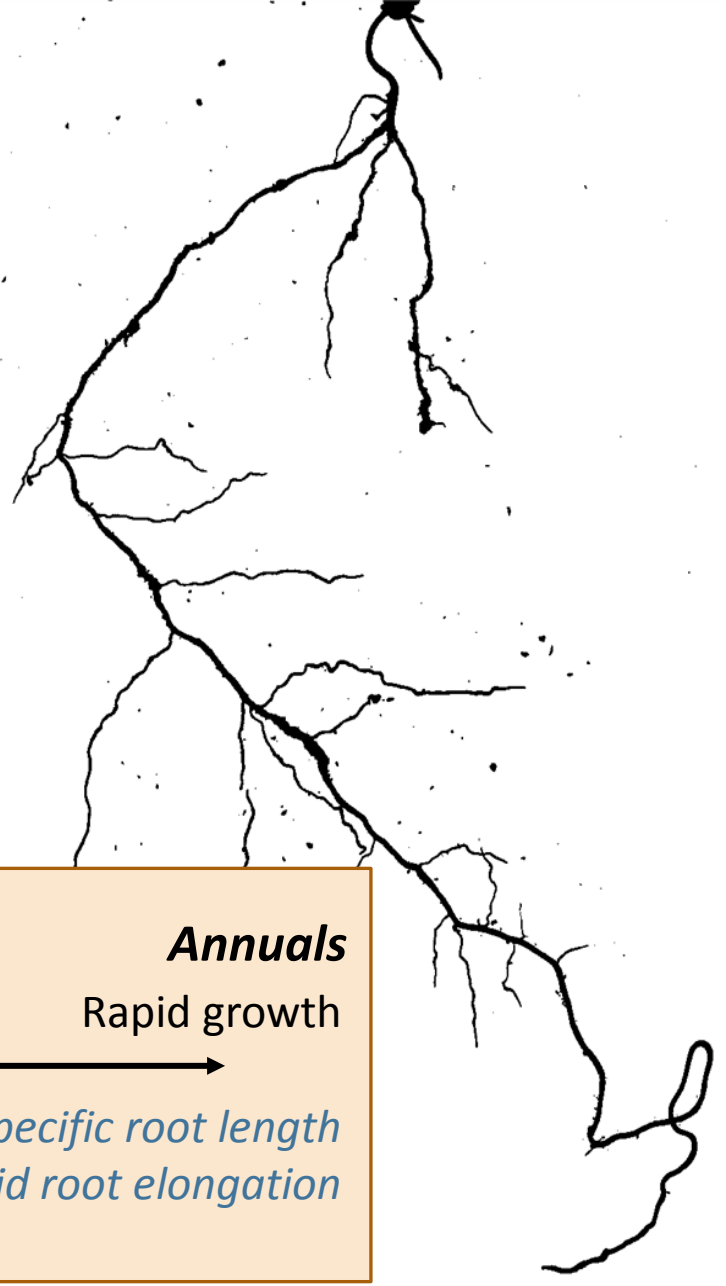
High specific leaf area
High photosynthetic capacity

Do **root traits** form a similar spectrum tied to seedling growth and life history?

Root functional traits

A number of traits may be tied to water uptake and growth

- -Root elongation rate (RER)
- -Specific root length (SRL)
- -Root diameter
- -Root mass fraction (RMF)

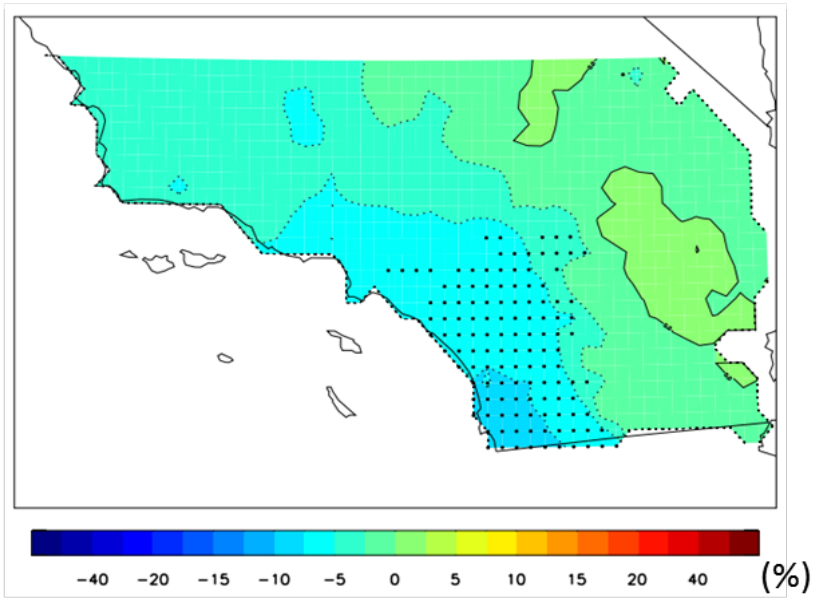


Perennial, shrubby	***Annuals***
Slow growth	Rapid growth
High root diameter	*High specific root length*
High root mass fraction	*Rapid root elongation*

Poorter & Markesteijn, 2008, Biotropica
Roumet et al. 2006, New Phytologist

How will root systems respond…

…to increasing drought?



…and during very young life stages?

Figure from R.J. Allen, 2013, Climate Change Scenarios in Southern California
UCANR Statewide Conference, Ontario, CA

Research questions

Across 18 native and invasive species:

1) How do root systems respond to drought? Do species and life history groups differ with respect to plasticity?
2) Do belowground “strategies” of coordinated root traits exist? Do life history groups or invasive species differ broadly with respect to these strategies?

Methods

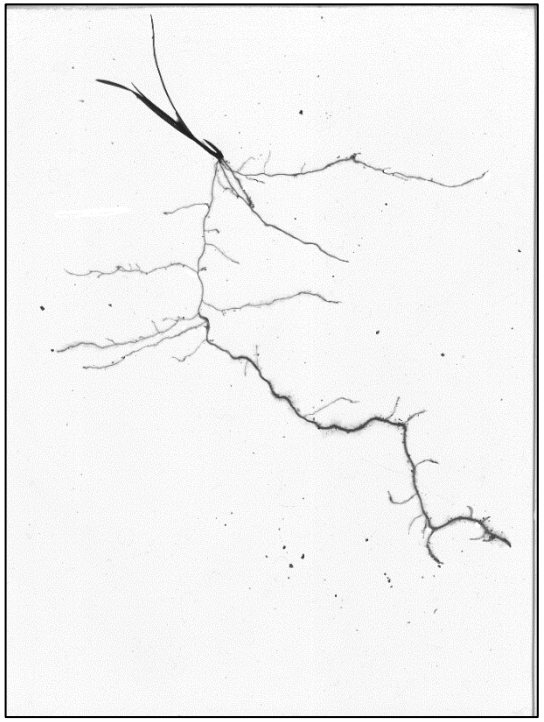
18 species * 3 watering treatments * 5 reps = 270 seedlings

Species	Code	Origin	Life history group
Brassica nigra	BRNI	I	Annual forb
Medicago polymorpha	MEPO	I	Annual forb
Deinandra fasciculata	DEFA	N	Annual forb
Phacelia cicutaria	PHCI	N	Annual forb
Salvia columbariae	SACO	N	Annual forb
Eschscholzia californica	ESCA	N	Perennial forb
Malacothrix saxatilis	MASA	N	Perennial forb
Avena barbata	AVBA	I	Annual grass
Bromus madritensis	BRMA	I	Annual grass
Leymus condensatus	LECO	N	Perennial grass
Nassella pulchra	NAPU	N	Perennial grass
Artemisia californica	ARCA	N	Perennial shrub
Encelia californica	ENCA	N	Perennial shrub
Eriogonum fasciculatum	ERFA	N	Perennial shrub
Salvia apiana	SAAP	N	Perennial shrub
Salvia mellifera	SAME	N	Perennial shrub
Acmispon glaber	ACGL	N	Perennial subshrub
Isocoma menziesii	ISME	N	Perennial subshrub

Water treatment	Volumetric water content
L	11%
M	18%
H	25%

Methods

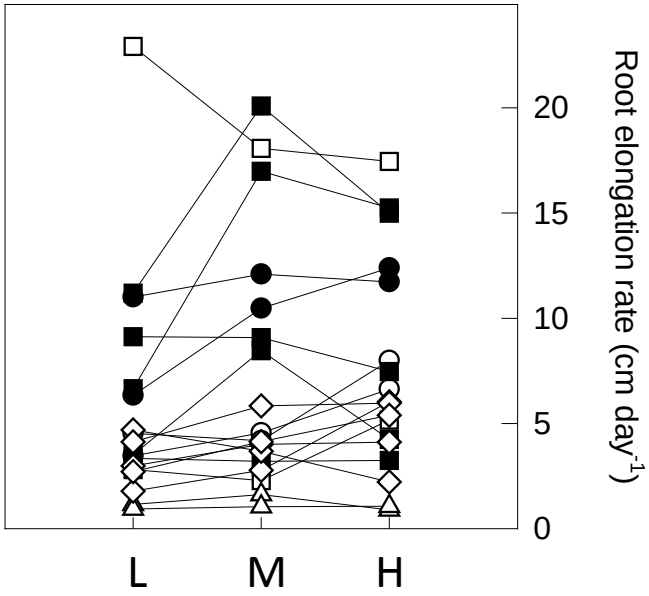
- Seedlings grown for 4-6 weeks
- Scanned and weighed for root and growth traits



1) How do root systems respond to drought?

- ANOVA: **For all traits**, there was a significant effect of species, water treatment, and their interaction ($p<0.05$)

Trait	Effect of drought (H to L)	% Change (H to L)
Plant growth rate	Decrease	32%
Root mass growth rate	Decrease	25%
Root elongation rate	Decrease	24%
Plant N uptake	Decrease	44%
Specific root length	Decrease	5%
Root diameter	Increase	8%
Root mass fraction	Increase	12%



- **Root traits can be highly plastic, but the extent varies by species**

1) Do life history groups differ with respect to plasticity?

ANOVA: Only two plasticity indices differed between life history groups

Plasticity Index	Life History
Plant growth rate	NS
Root mass growth rate	NS
Root elongation rate	NS
Plant N uptake	NS
Specific root length	$p < 0.10$
Root mass fraction	$P < 0.05$
Root diameter	NS

- **Life history group is not a good predictor of root trait plasticity**

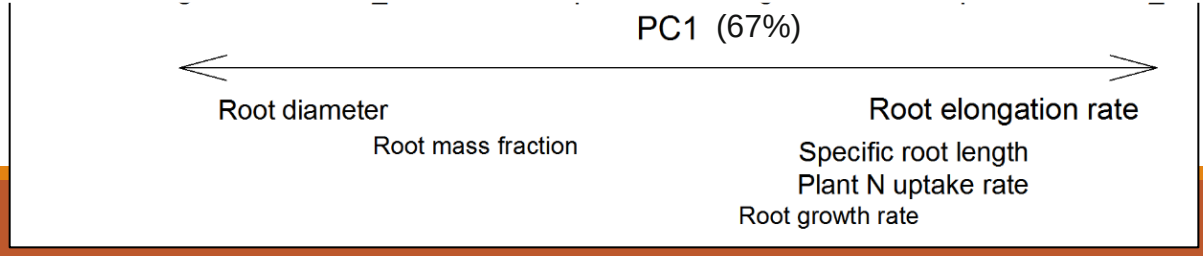
2) Do belowground “strategies” of coordinated root traits exist?

PCA of root traits:

-One axis (PC1) explained most of the variation in root traits

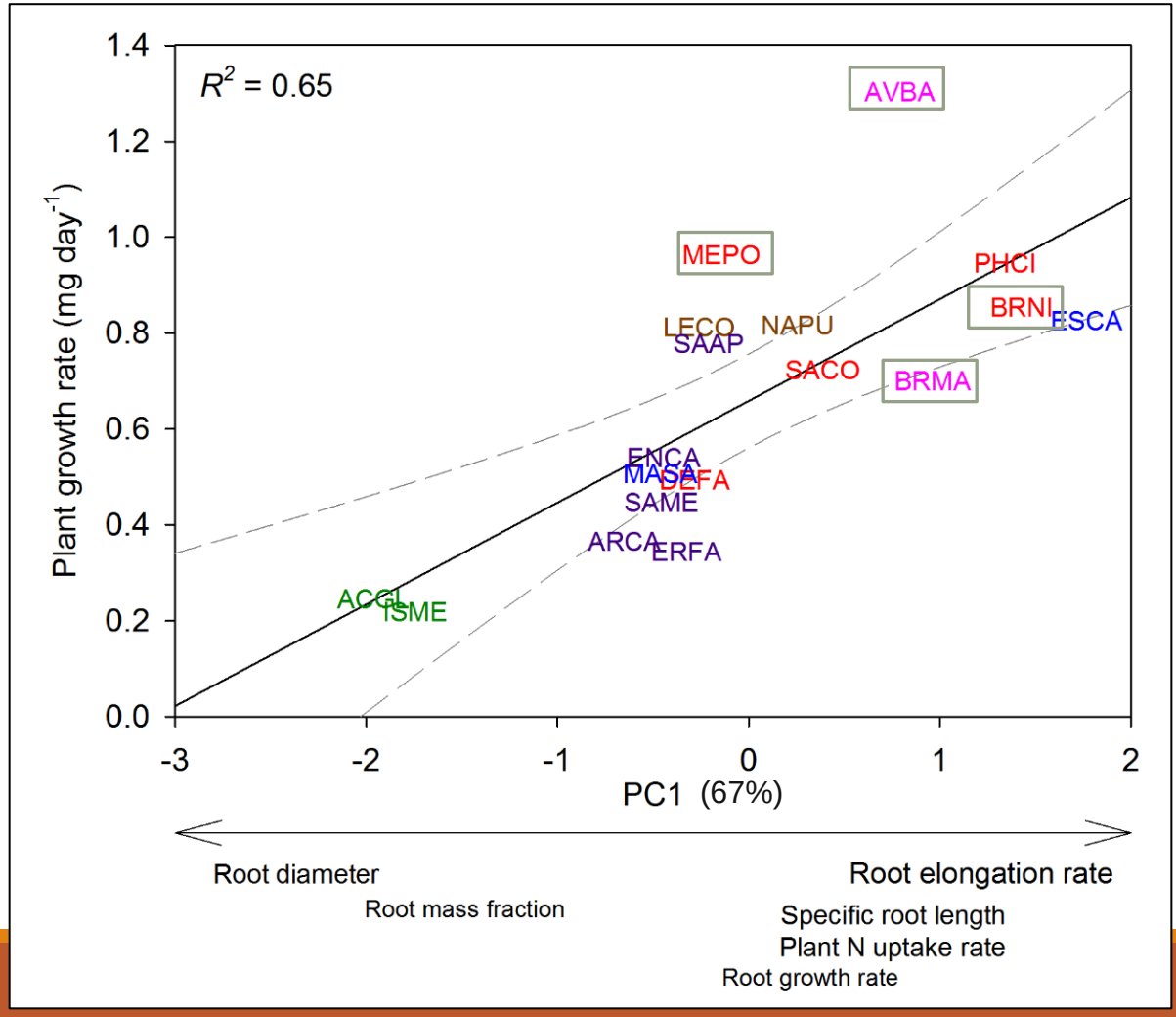
- PC1 correlated strongly with whole plant growth

Across watering treatments, correlated root traits do suggest a belowground trait spectrum related to growth rate



2) Do life history groups or invasive species differ broadly with respect to these strategies?

Annual forb
Perennial forb
Annual grass
Perennial grass
Perennial shrub
Perennial subshrub



Invasive annuals display more rapid belowground growth, but some natives appear to be very similar

Conclusions

- Root traits AND plasticity differed substantially across species, with some link to life history
- A few key root traits could capture broad differences in belowground strategy (root elongation rate)
  - Should consider additional traits (e.g., architecture, root depth)
  - Should link traits to water uptake, survival
- Management implications
  - Native species displayed a variety of belowground strategies relative to invasive annuals
  - Identifying functionally similar and different natives could be useful to either suppress invasives or promote coexistence

Acknowledgements

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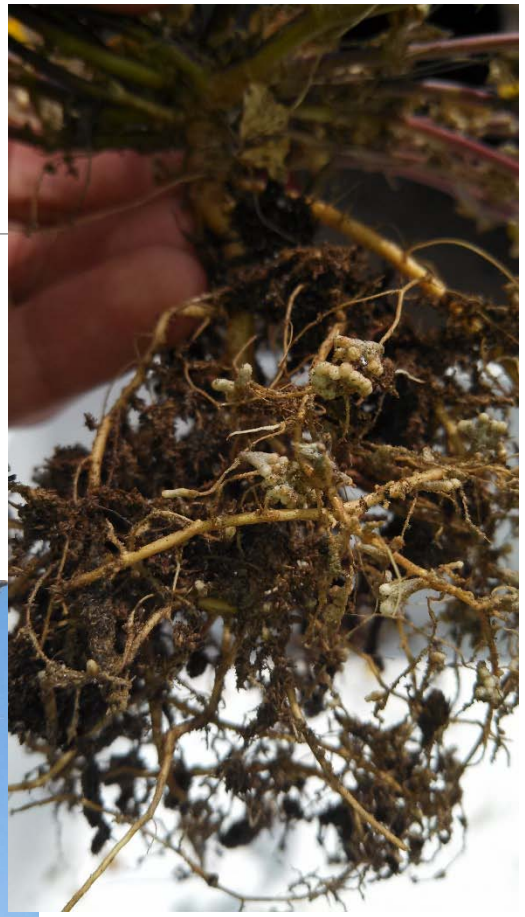


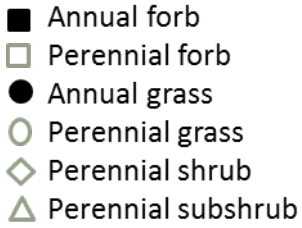
Table 2 Pearson correlations (r) and percent variance (h2) explained for the first PCA axis (PC1). The h2 metric estimates the percent variance of an observed trait which is accounted for by the retained components.

Trait	*r*	h^2
Root mass fraction	-0.64	0.41
Root diameter	-0.83	0.69
Root growth rate	0.69	0.48
Root elongation rate	0.98	0.96
Specific root length	0.84	0.71
Plant N uptake rate	0.89	0.79
Total % variance	0.67	

Table 3 Pearson correlation matrix of root traits and plant growth rate (a) across water treatments and within (b) low, (c) moderate, and (d) high water treatments. Trait abbreviations are root diameter (RD), root mass fraction (RMF), root growth rate (root GR), root elongation rate (RER), specific root length (SRL), plant N uptake rate (N uptake), and plant growth rate (plant GR).

		RD	RMF	Root GR	RER	SRL	N uptake	Plant GR
(a) *Across treatments*								
	RD	1						
	RMF	0.43^{+}	1					
	Root GR	-0.32	-0.2	1				
	RER	**-0.81***	**-0.49***	**0.74***	1			
	SRL	**-0.91***	**-0.55***	0.24	**0.83***	1		
	N uptake	**-0.53***	**-0.58***	**0.88***	**0.87***	**0.53***	1	
	Plant GR	-0.4	-0.46^{+}	**0.96***	**0.81***	0.37	**0.96***	1
(b) *Low*								
	RD	1						
	RMF	0.45^{+}	1					
	Root GR	-0.19	-0.19	1				
	RER	**-0.81***	**-0.53***	**0.65***	1			
	SRL	**-0.92***	**-0.55***	0.11	**0.83***	1		
	N uptake	**-0.53***	**-0.69***	**0.79***	**0.86***	**0.54***	1	
	Plant GR	-0.31	**-0.5***	**0.95***	**0.75***	0.28	**0.92***	1
(c) *Moderate*								
	RD	1						
	RMF	**0.55***	1					
	Root GR	-0.33	-0.18	1				
	RER	**-0.78***	**-0.54***	**0.77***	1			
	SRL	**-0.9***	**-0.65***	0.33	**0.85***	1		
	N uptake	**-0.6***	**-0.61***	**0.84***	**0.91***	**0.65***	1	
	Plant GR	-0.46^{+}	-0.46^{+}	**0.96***	**0.86***	**0.49***	**0.95***	1
(d) *High*								
	RD	1						
	RMF	0.24	1					
	Root GR	-0.2	-0.02	1				
	RER	**-0.68***	-0.25	**0.8***	1			
	SRL	**-0.9***	-0.4^{+}	0.13	**0.69***	1		
	N uptake	-0.32	-0.32	**0.93***	**0.86***	0.31	1	
	Plant GR	-0.24	-0.23	**0.98***	**0.83***	0.21	**0.97***	1

***<0.05** *+<0.10*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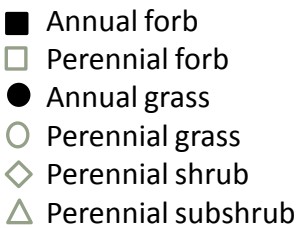
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BCSD-CMIP3 SoCal Precipitation Change
Medium Emissions Scenario, 2041-2070