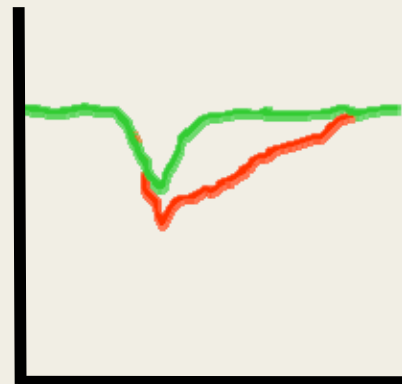
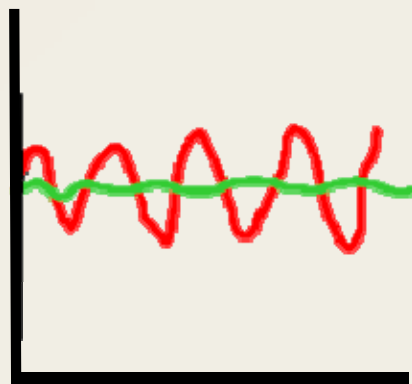
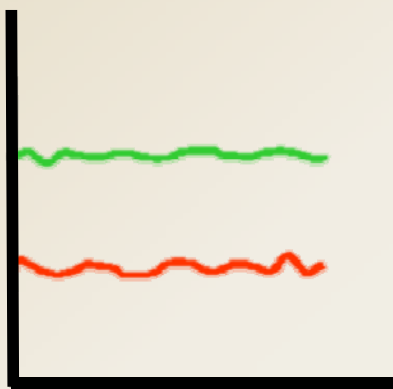


Resilience, Stability, and Productivity of Alfalfa in North America



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Casler, and Dan Undersander
Agronomy Department
University of Wisconsin – Madison

NAAIC, Logan, UT, USA
June 6th 2018





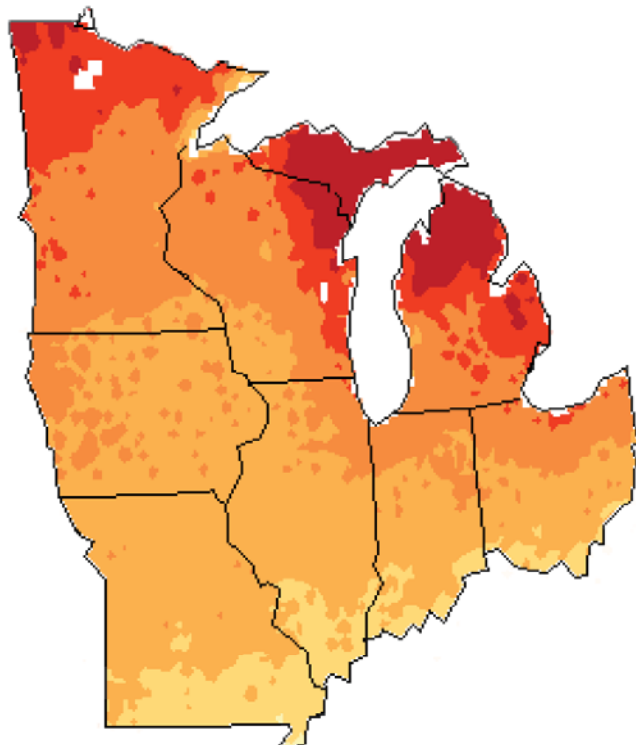
Outline

- Why resilience?
- Practical definitions
- Are there more resilient cultivars?
- Is resilience associated with productivity or stability?
- Is resilience associated with stress tolerance traits?
- Future work

Climate change in US Midwest



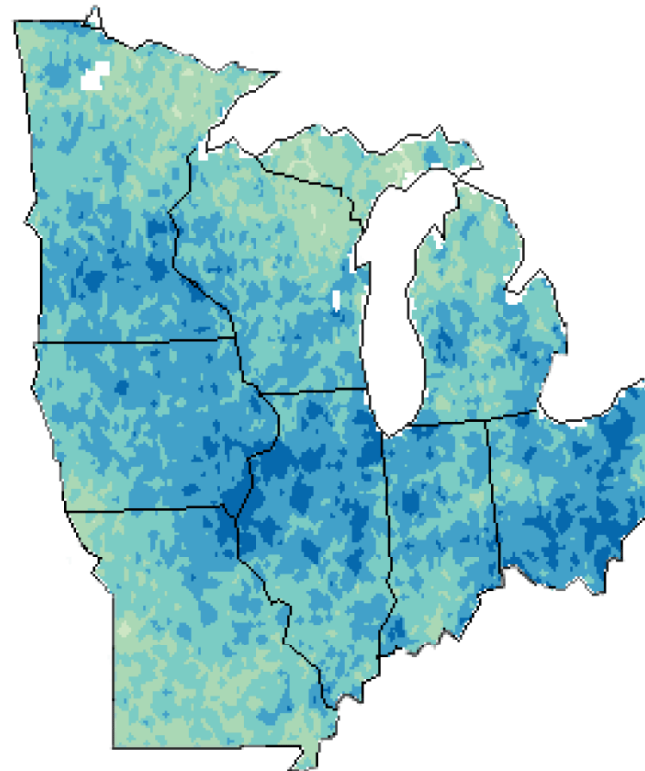
Temperature



Temperature Difference (°F)



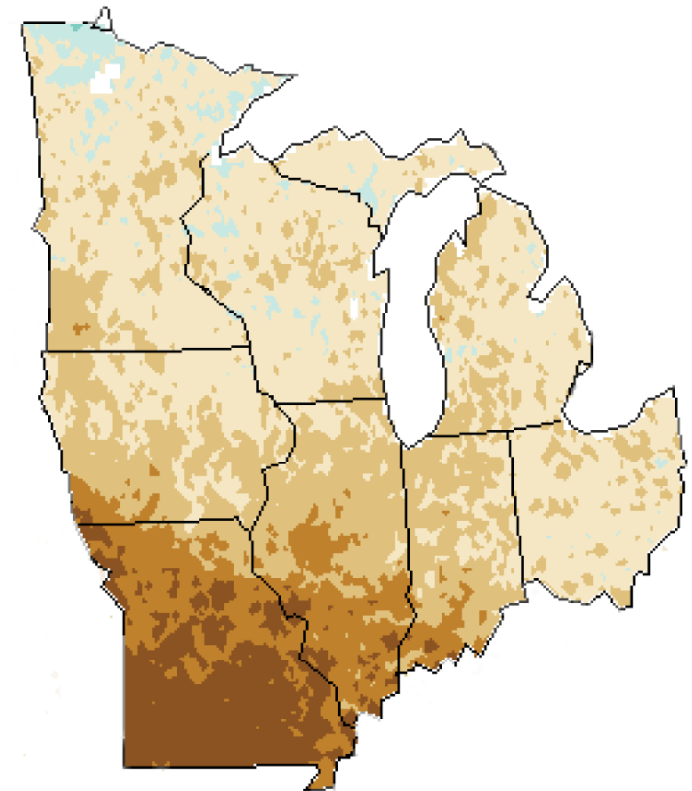
Rainfall



Precipitation Difference (Inches)



Dry days

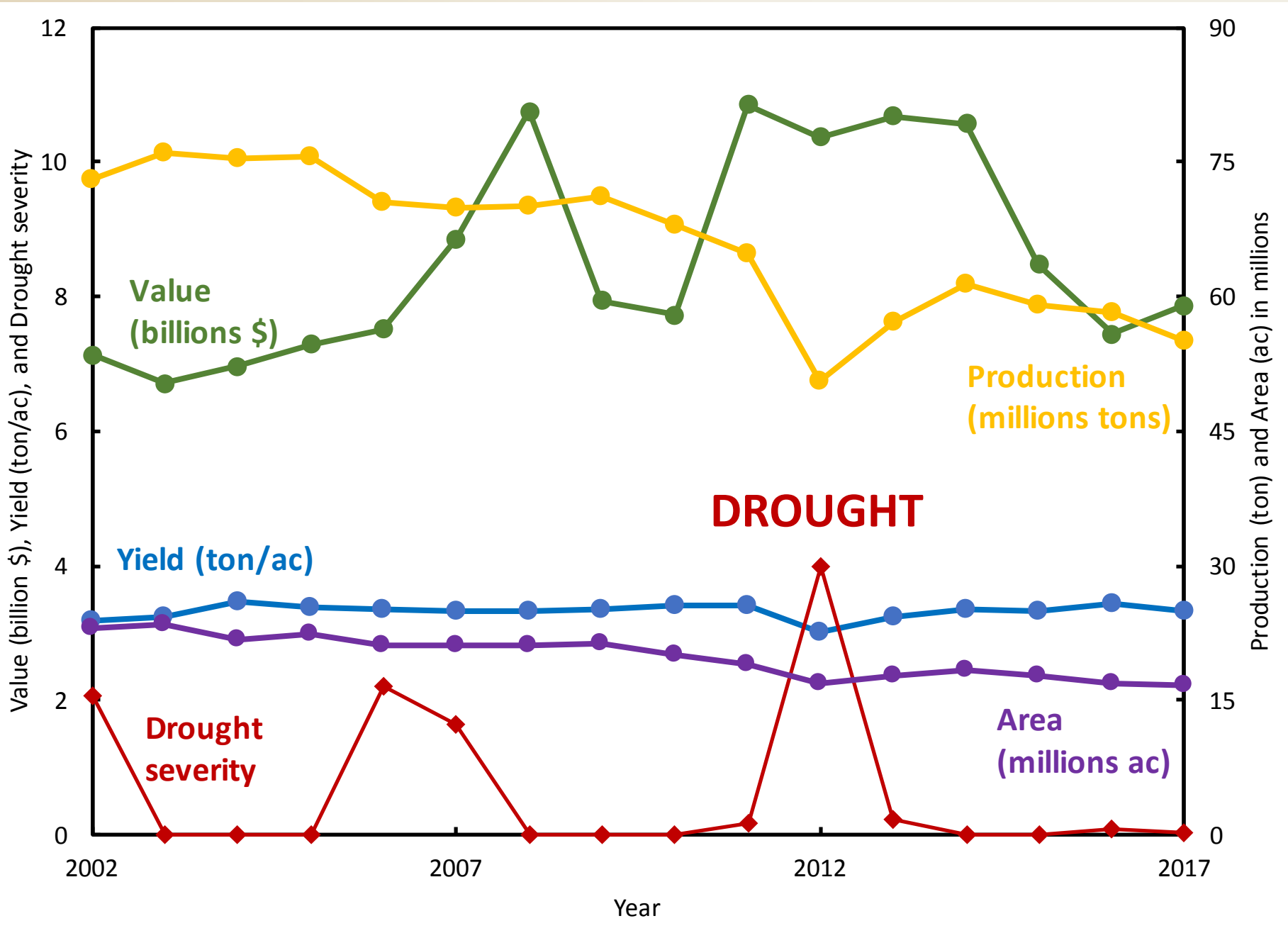


Difference in Number of Days



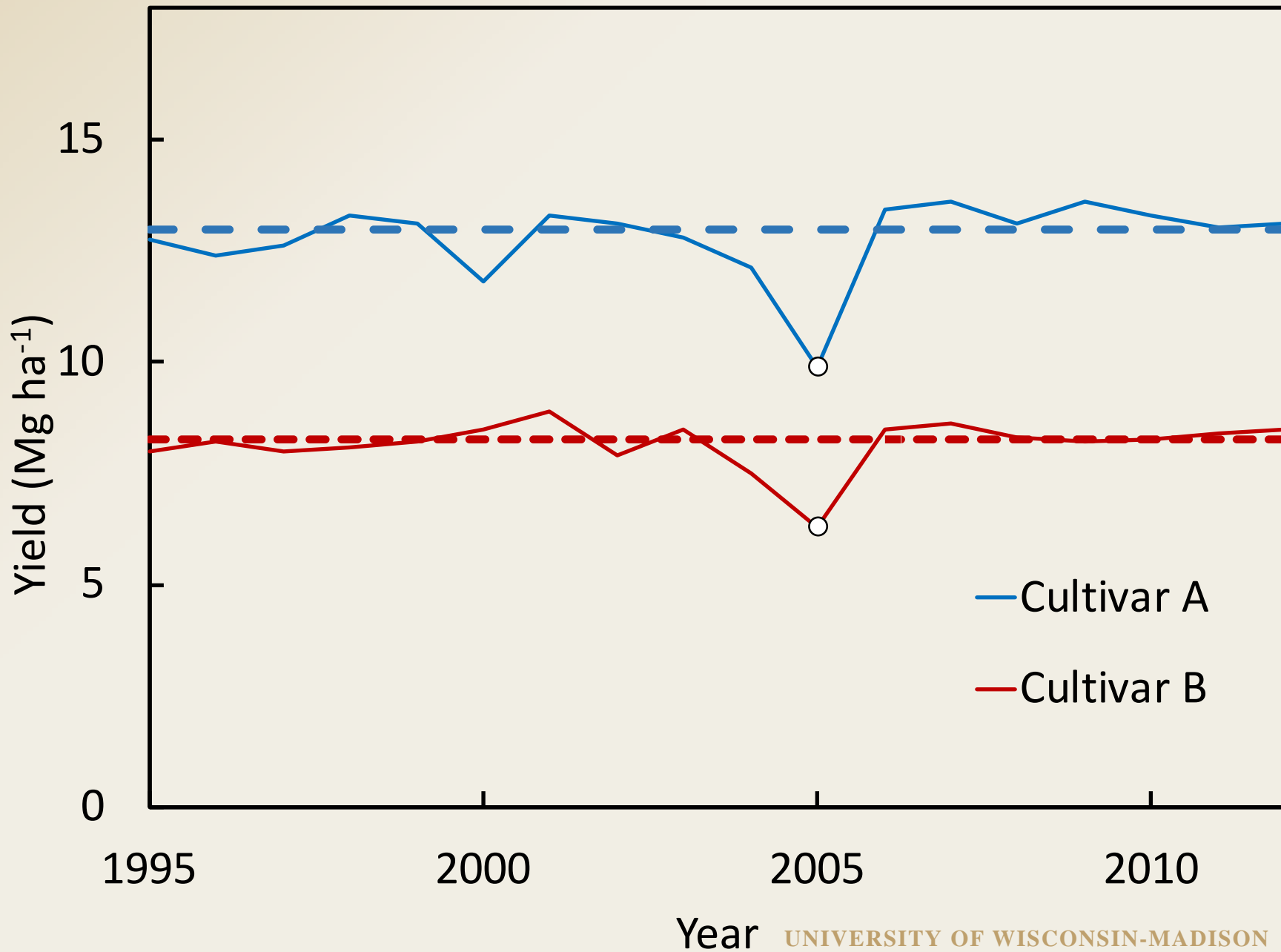
Projected increase by 2041-2070 as compared to 1971-2000 for US Midwest, temperature, rainfall, and consecutive dry days. Source: 2014 National Climate Assessment. U.S. Global Change Research Program.

<http://nca2014.globalchange.gov/report/regions/midwest>

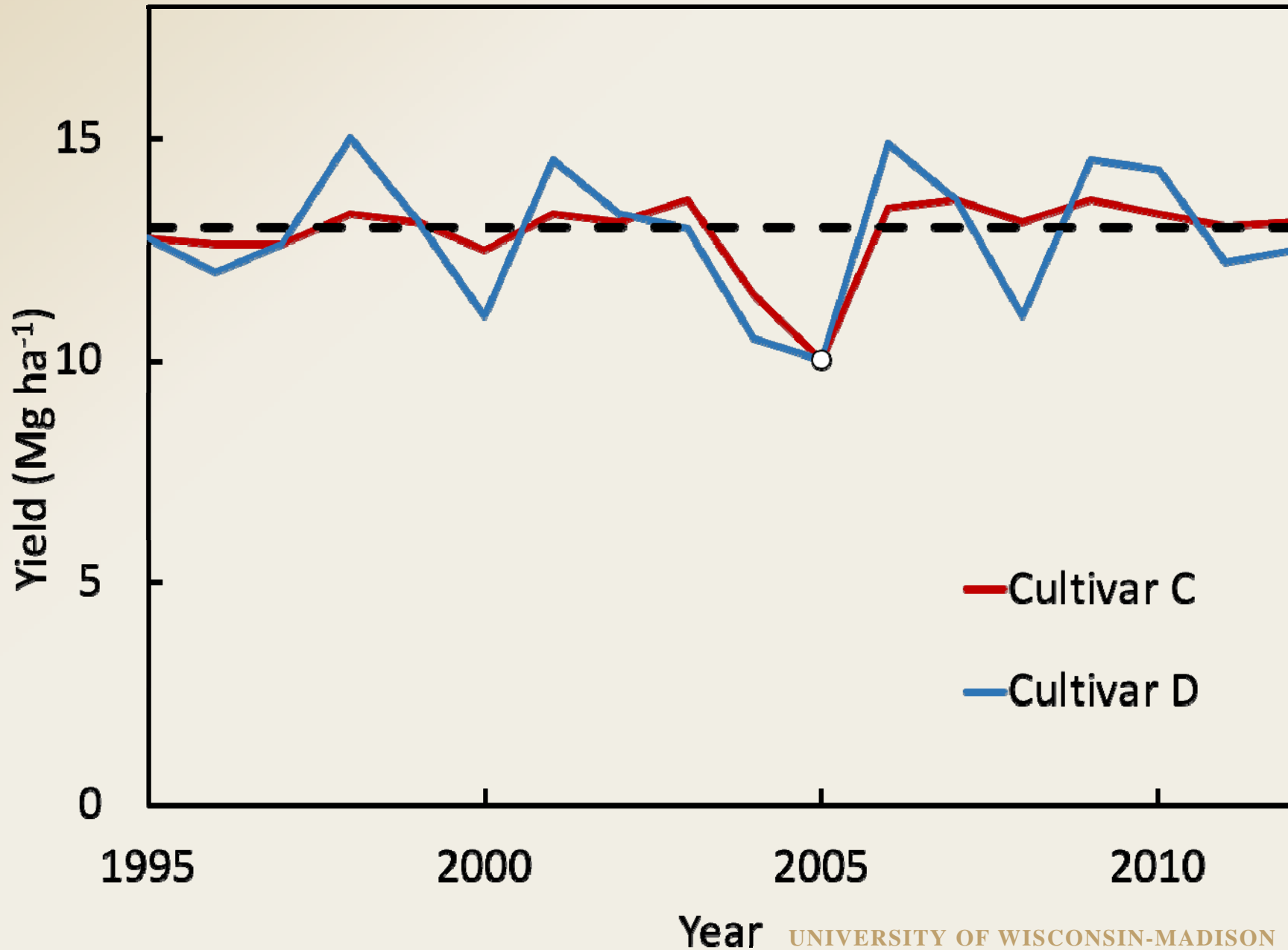


Data from NASS, 2018, and NOAA, 2018

Productivity

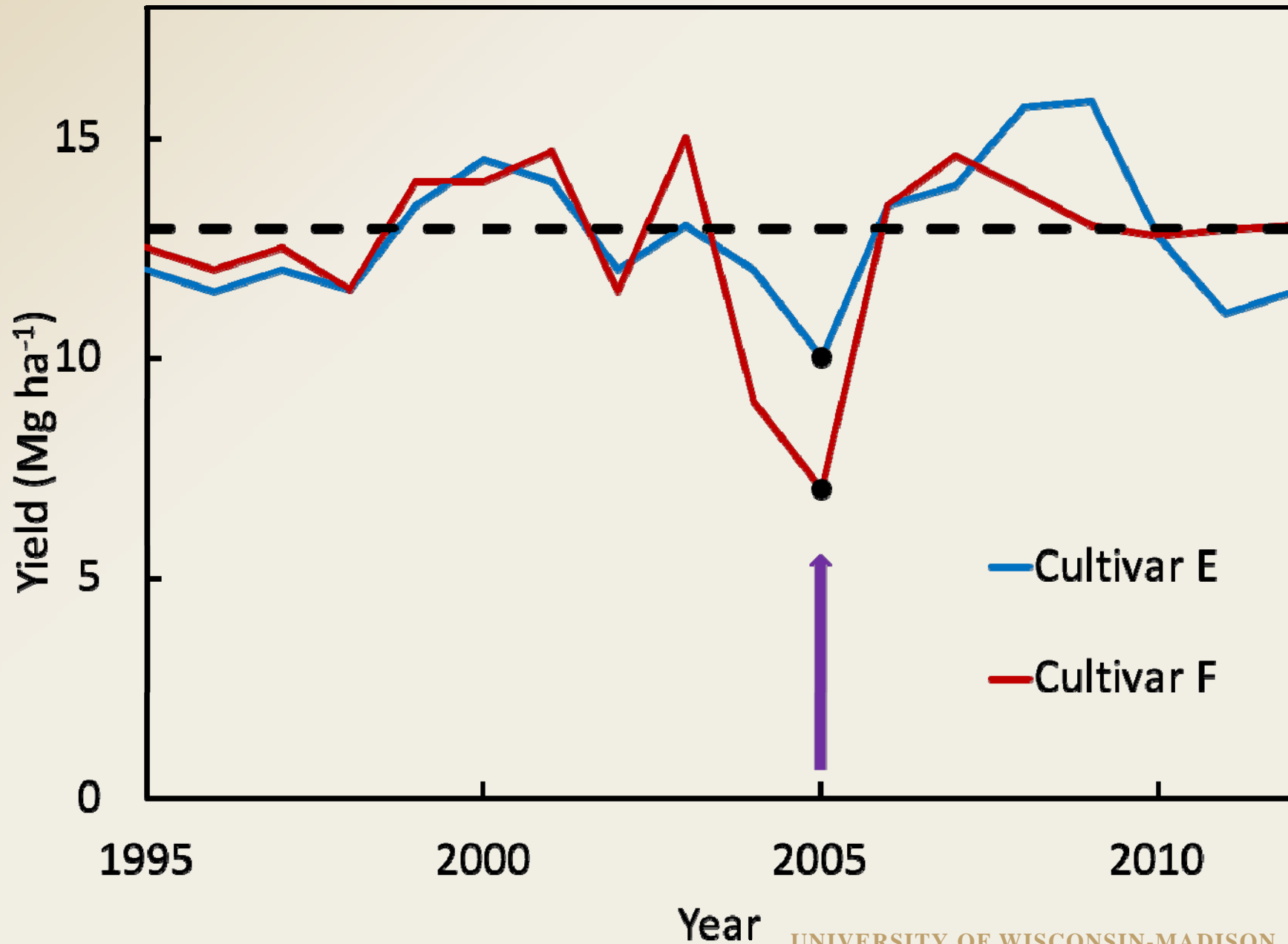


Stability





Resilience





Questions and Hypotheses

- Are there **more resilient cultivars**?

H 1) Cultivars differ in resilience across environments.

- Is resilience associated with **productivity or stability**?

H 2) Cultivar productivity is not associated with cultivar stability or resilience.

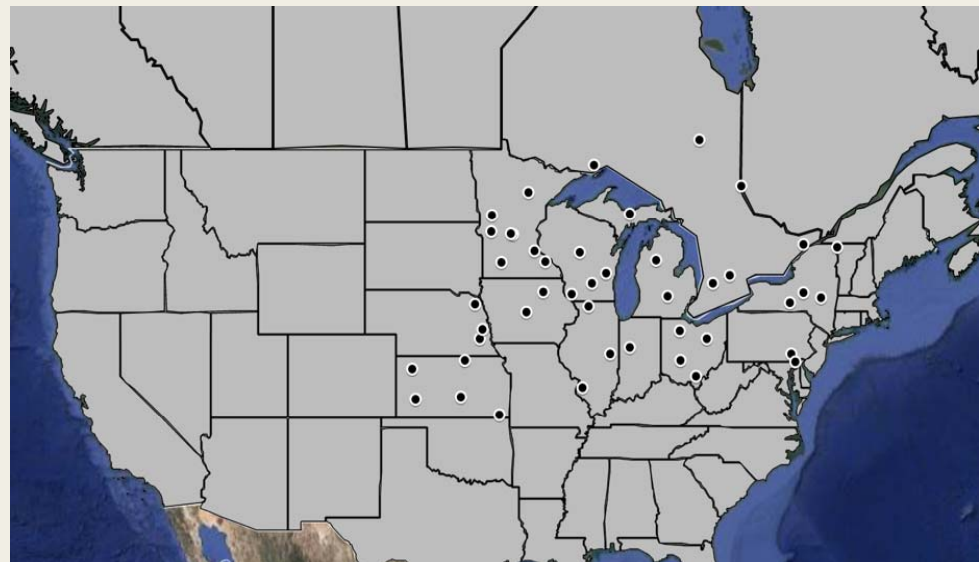
- Is resilience associated with **stress tolerance traits**?

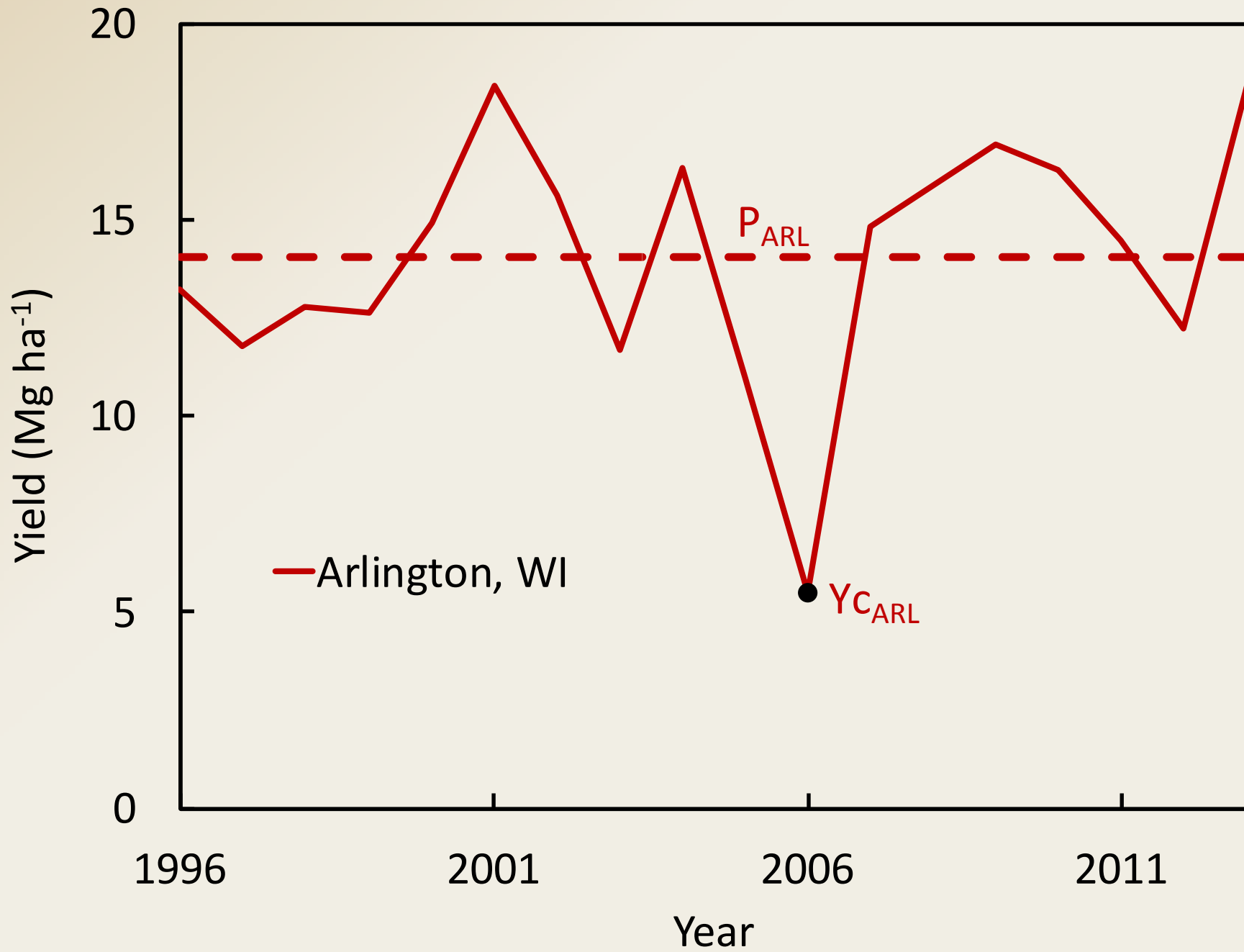
H 3) Cultivar stability and resilience is positively associated with winter survival and disease resistance.



Database

- 679 alfalfa cultivars from 1060 public trials from 1995 – 2013, for 11 US states (IA, IL, IN, KS, MI, MN, NE, NY, OH, PA, WI) and Ontario (Canada).
- 45 locations with more than 5 consecutive years.
- 168 Cultivars with more than 40 data points (location x years) at 28 locations.







Methods

- to estimate productivity and stability of cultivar for each location, LSM by location from model:

$Y = \text{Cultivar} + \text{Stand Age} + \text{Year}$

using a dataset without the crisis year.

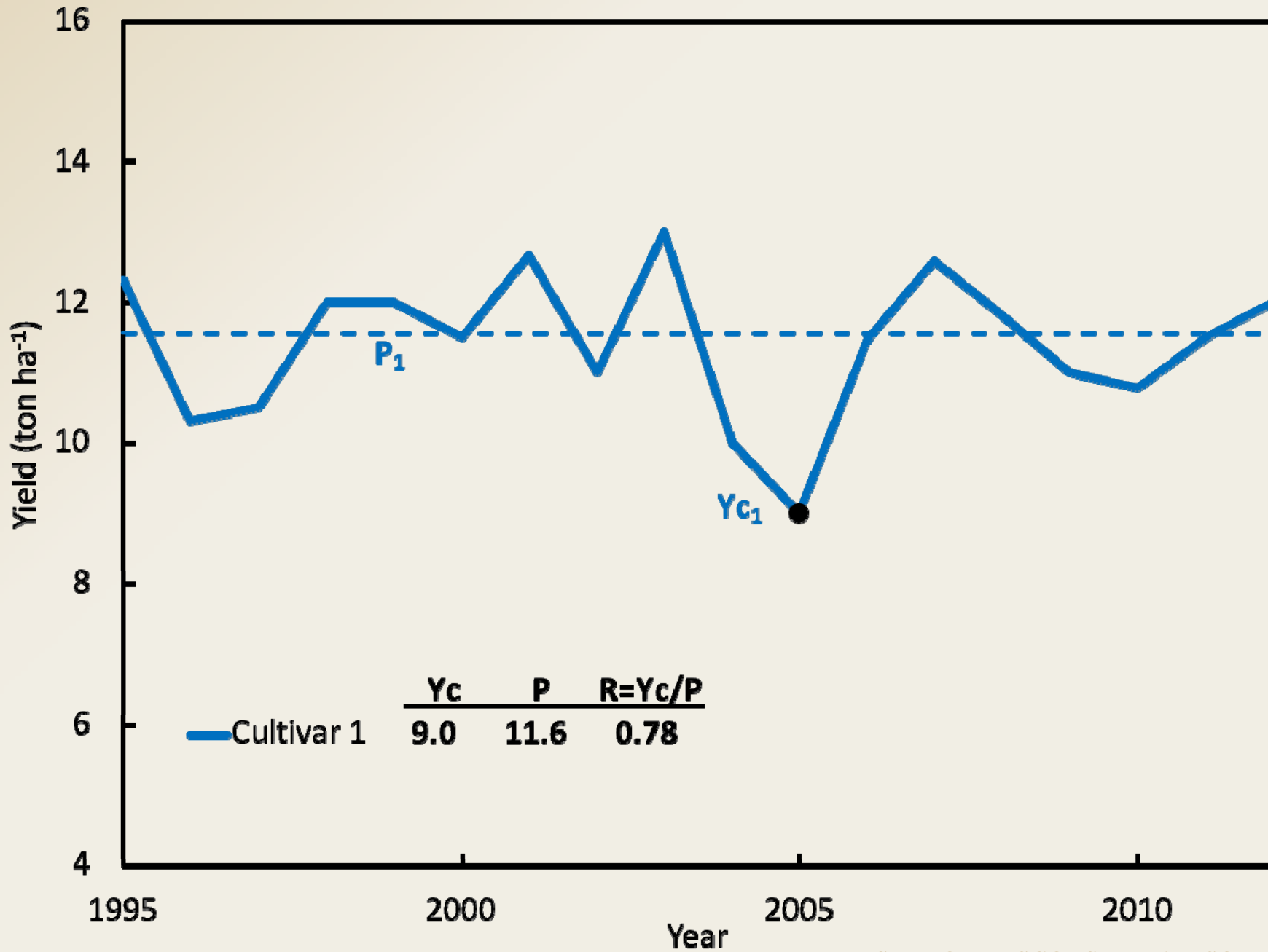
$$P_{jl} = \frac{\sum_i^{n-1} Y_{ijl}}{n-1} \qquad S_{jl} = \frac{P_{jl}}{SE(P_{jl})}$$

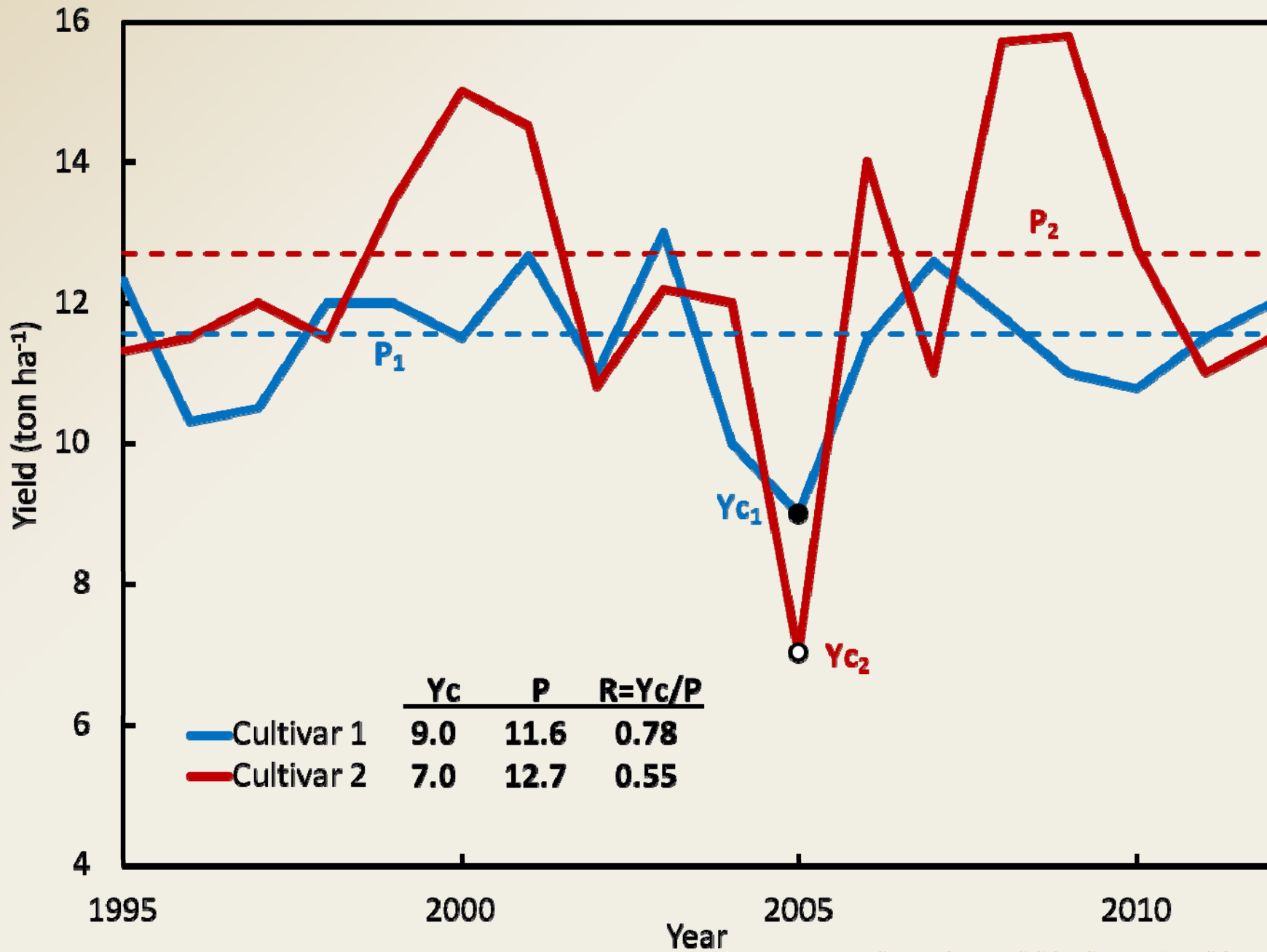
- To estimate resilience, LSM by location and year from model:

$Y = \text{Cultivar} + \text{Stand Age}$

using a dataset with all years.

$$R_{jl} = \frac{Y_{cjl}}{P_{il}}$$

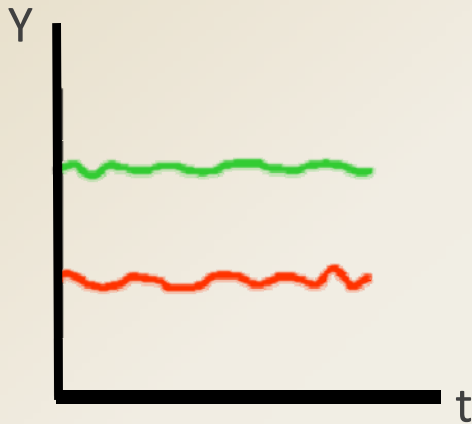




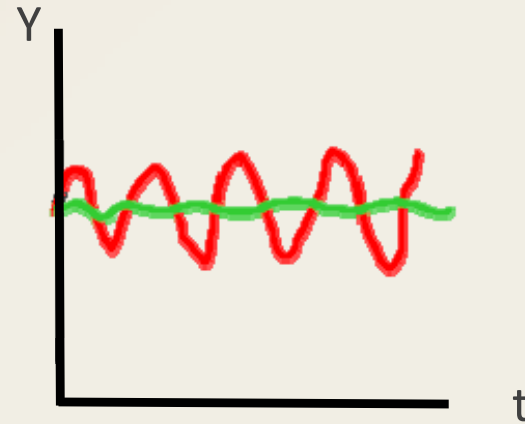


Operational Definitions

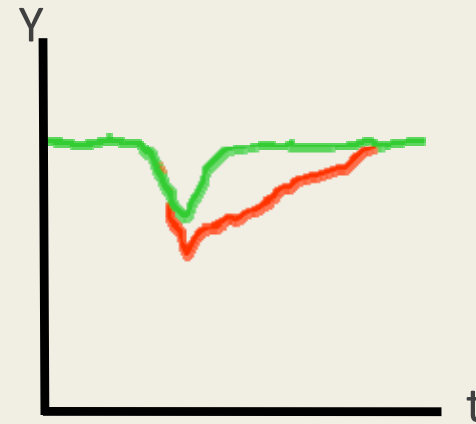
Productivity
= mean yield



Stability
= mean/std error



Resilience
= min/mean



Questions

- Are there more resilient cultivars?
- Is resilience associated with productivity or stability?
- Is resilience associated with stress tolerance traits?

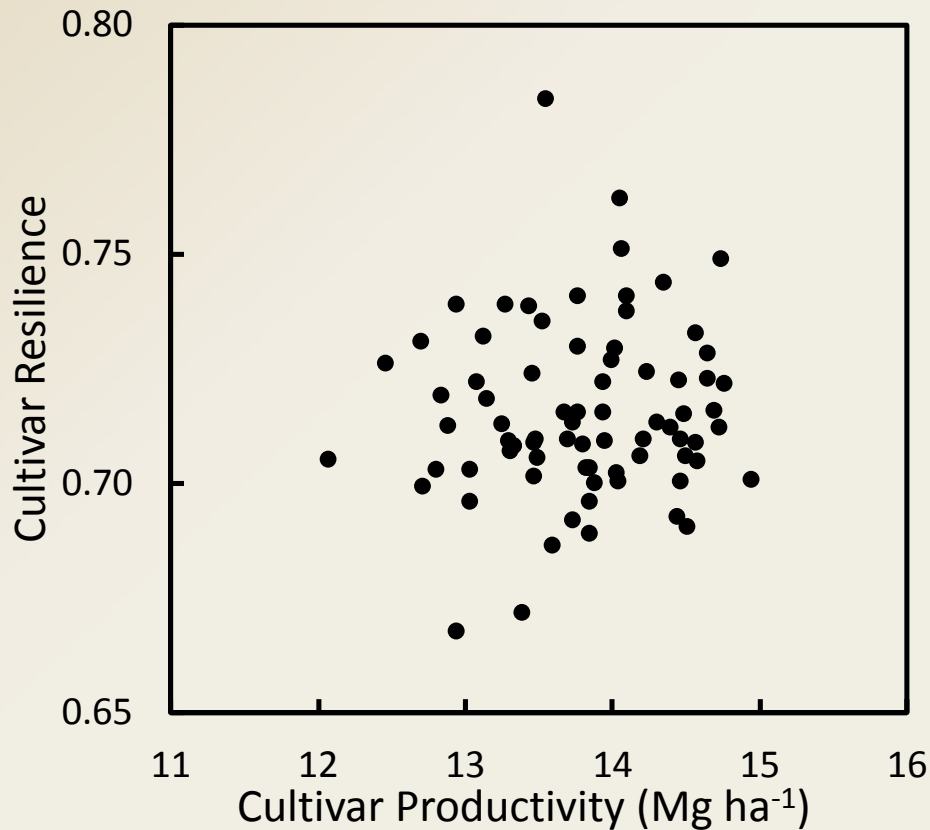
Are there more resilient cultivars?



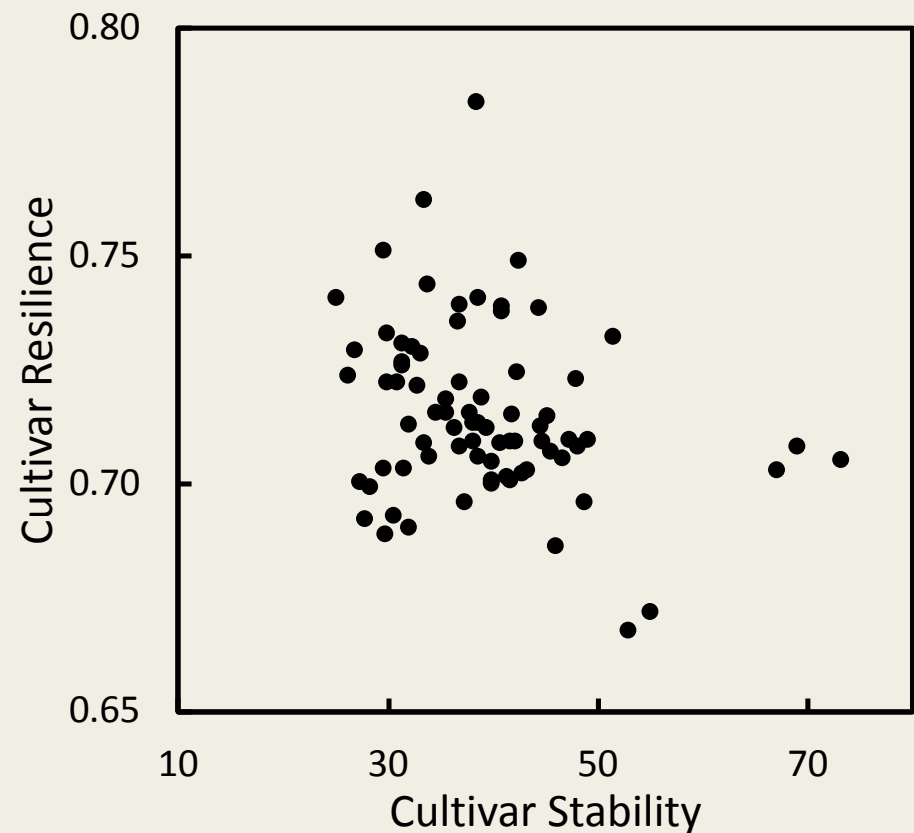
Cultivar	N	Productivity P<0.01		Stability P<0.01		Resilience P=0.03	
		Mean	SE	Mean	SE	Mean	SE
5312	26	13.3	0.5	69	3	0.71	0.01
5454	14	13.4	0.5	55	3	0.67	0.02
54H91	22	12.7	0.5	31	3	0.73	0.01
ABUNDANCE	7	13.5	0.5	37	4	0.74	0.02
DKA5018	6	14.7	0.5	42	5	0.75	0.02
ONEIDAVR	24	12.8	0.5	67	3	0.70	0.01
RELIANCE	7	13.5	0.5	38	4	0.78	0.02
SARANAC	9	12.9	0.5	53	4	0.67	0.02
VERNAL	44	12.1	0.5	73	2	0.71	0.01
WL342	7	14.3	0.5	34	4	0.74	0.02
WL357HQ	16	14.8	0.5	33	3	0.72	0.01



Is resilience associated with productivity or stability?



$p=0.68, r=0.05$

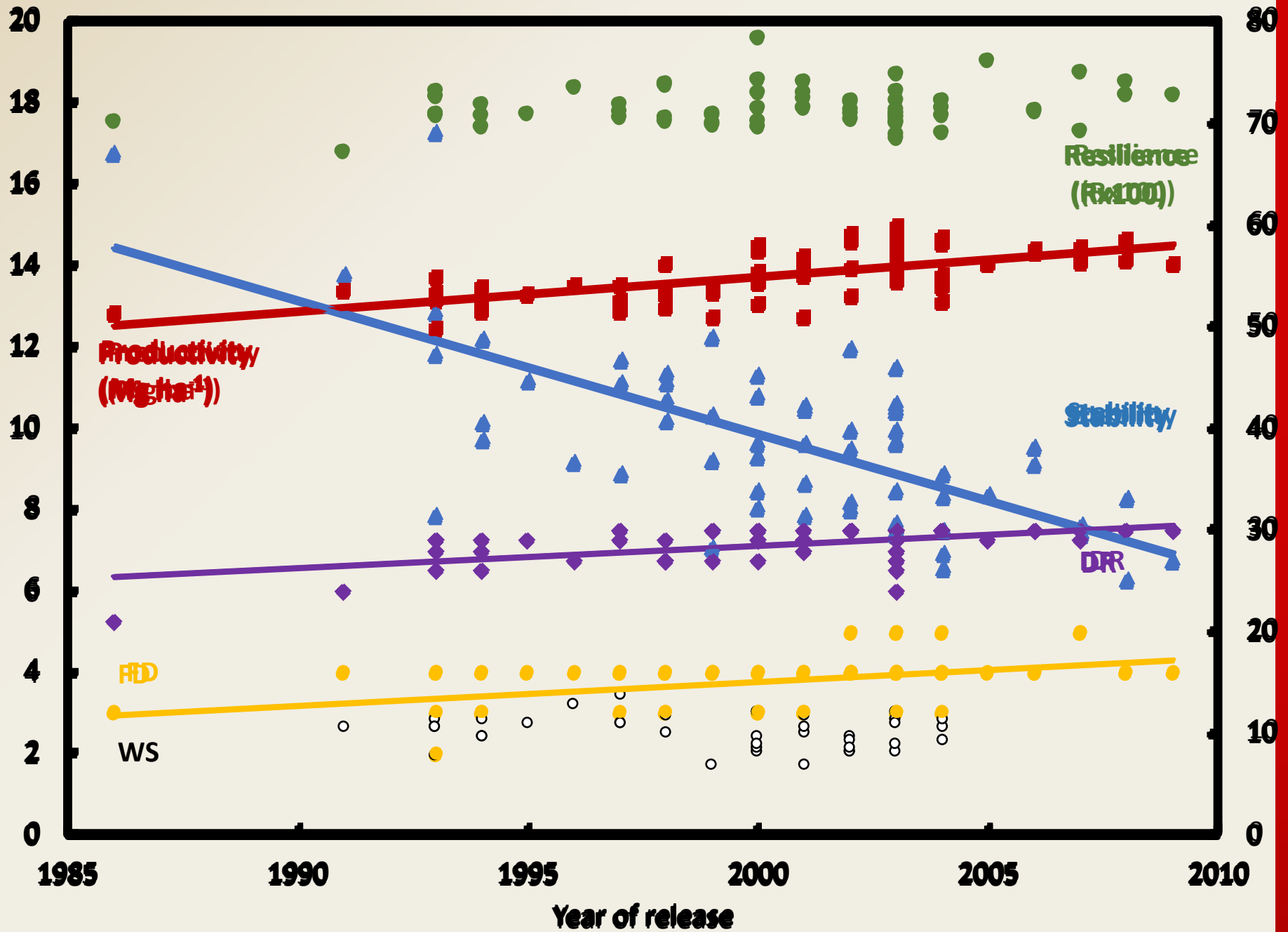


$p=0.06, r=-0.23$



Is resilience associated with stress tolerance traits?

r	Fall Dormancy	Disease Resistance	Winter Survival
Resilience	NS	0.28	NS
Stability	-0.30	-0.34	NS





Conclusions

- Alfalfa cultivars differ in stability and resilience; it is possible to identify superior cultivars for each variable.
- Resilience and stability represent two different dimensions of the long-term performance of cultivars.
- Cultivars with greater productivity may or may not have greater stability or resilience.
- A coordinated testing approach across many locations is proposed to improve alfalfa resilience in the future.



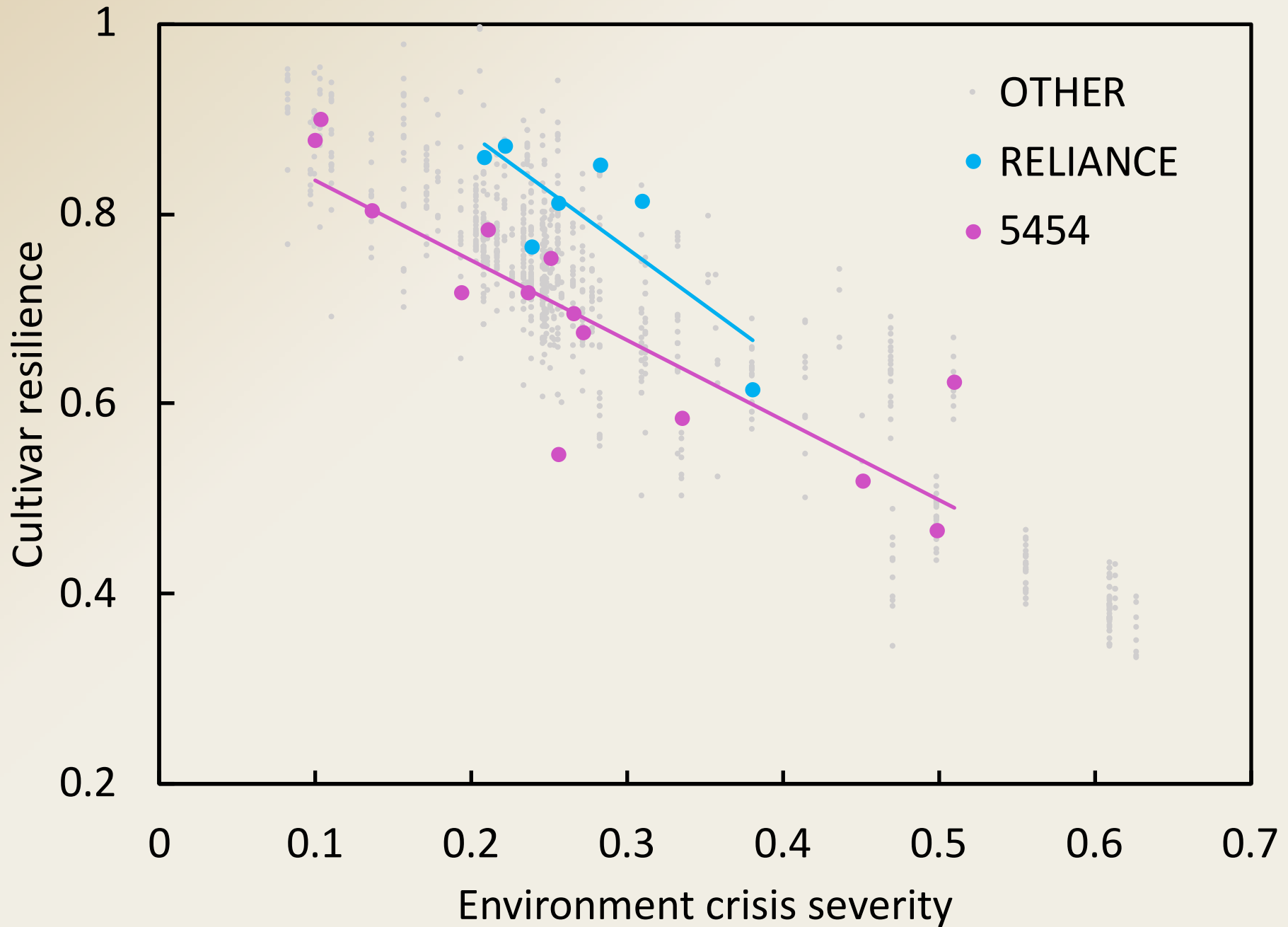
Future research

- Expand database: national alfalfa variety trials database, updated with modern cultivars.
- Experiments to measure resilience of alfalfa cultivars to water and cold stresses in field, and identify plant traits associated with resilience.
- Simulate yield of alfalfa cultivars under a wide range of climatic scenarios using modeling.



Thank you!

- Co-authors: Michael D. Casler and Dan Undersander
- Alfalfa breeders who contributed with yield data from their alfalfa variety trials
- Funding: Hatch Project WIS01986



$$CS_l = 1 - \frac{Y_{Cl}}{P_l}$$



