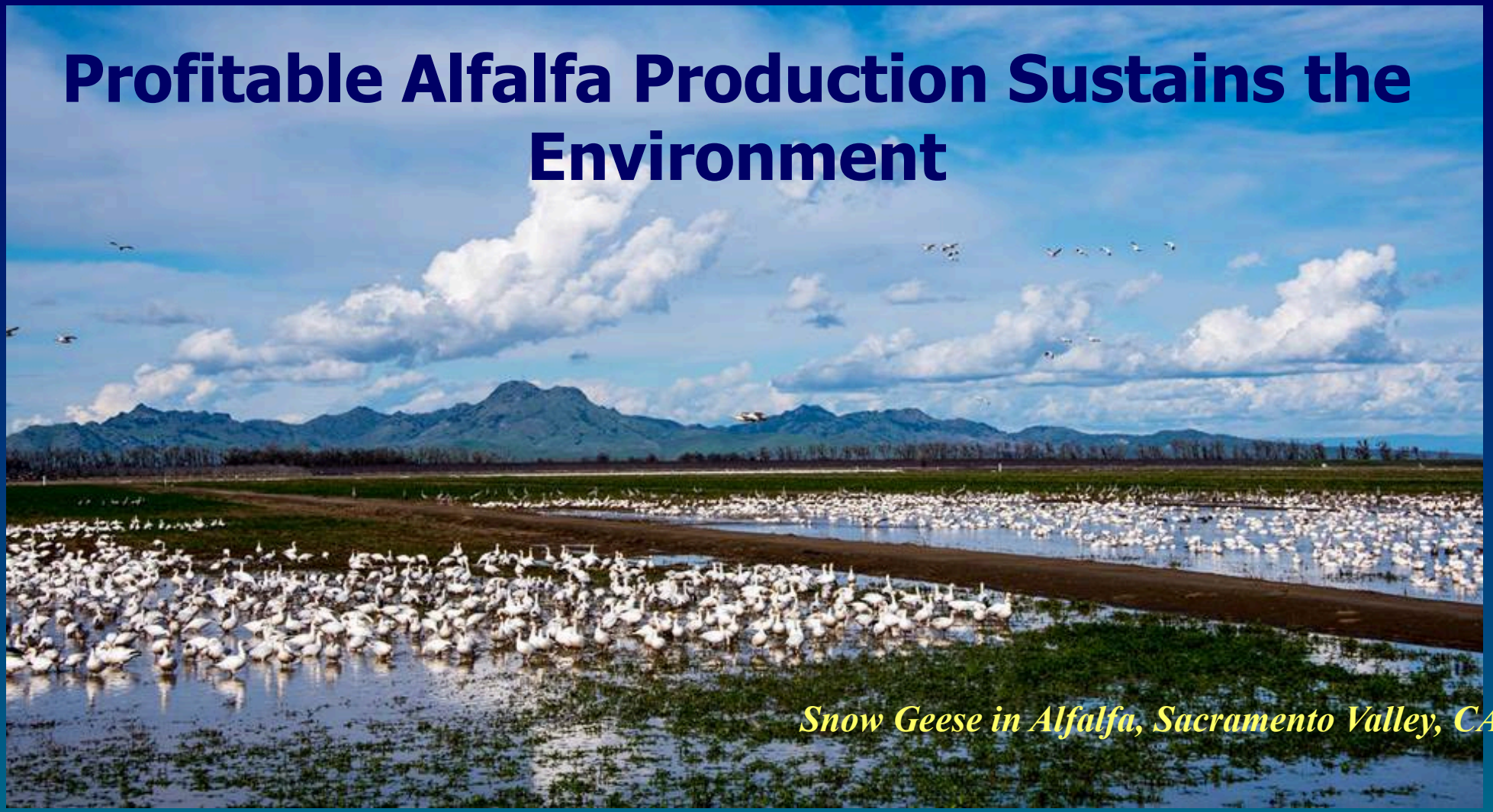
Profitable Alfalfa Production Sustains the Environment



Snow Geese in Alfalfa, Sacramento Valley, CA

Dan Putnam and Emily Meccage

University of California, Davis

http://alfalfa.ucdavis.edu

Forage Genetics International

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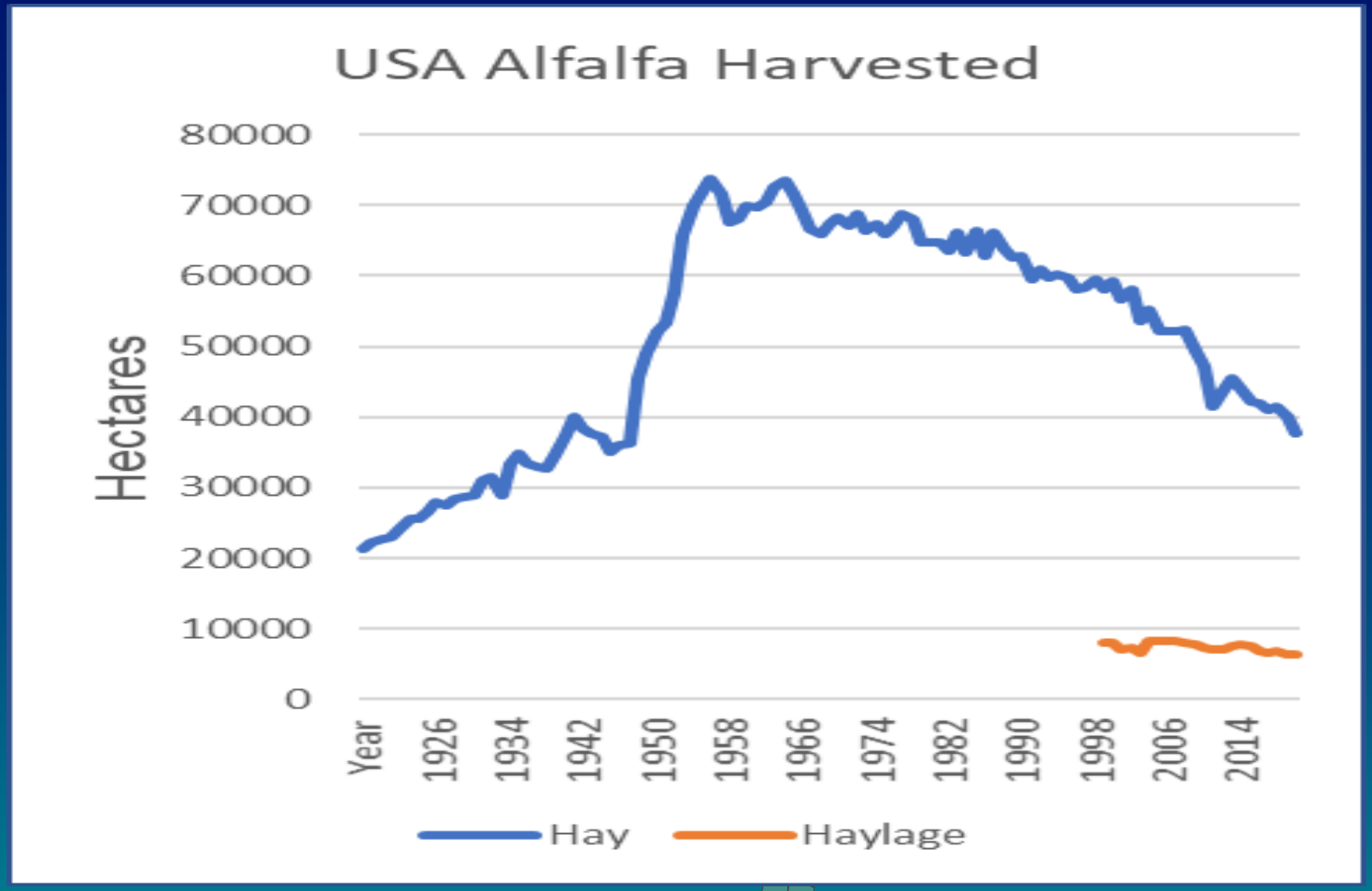
Profitable Alfalfa Production Sustains the Environment

- A statement of fact
- A vision for the future

What is this crop worth?

Photo: Charlie Brummer

Alfalfa Hectares (USA)



Direct Economic Value (USA)

Table 1. Value of Production, Top 10 Crops, with value of the two major livestock sectors, United States 2019-2021

Crop/Product	2019	2020	2021	RANK ($)
	(US$ Billion Dollars)			
Cattle and Calves	66.3	63.1	72.2	
Corn Grain	48.9	64.3	82.6	1
Soybean	30.5	45.7	57.5	2
Milk and Cream	41.9	40.6	40.7	
Hay/Silage/Greenchop (all)	20.5	19.9	21.9	3*
Hay (alfalfa)	**10.8**	**10.2**	**11.6**	**3rd or 4th**
Wheat (all)	8.9	9.4	11.9	3rd or 4th
Cotton (all)	5.9	4.8	7.5	5
Potatoes	4.2	3.9	4.1	6
Rice	2.6	3.3	3.1	7
Sorghum	1.1	1.8	2.5	9
Peanuts	1.1	1.3	1.5	8
Sugarbeet	1.2	1.1	1.7	10
All Field Crops	**130.8**	**163**	**201.1**	
All Fruit and Nuts	**29.0**	**29.1**	**	

*Source: USDA-NASS (NASS.USDA.GOV). *Hay/Foage/Greenchop includes all harvested grass and alfalfa forage, does not include pasture or rangeland. Alfalfa is a subset of all hay and forage.**data not yet avaialble*

What is the value to citizens?

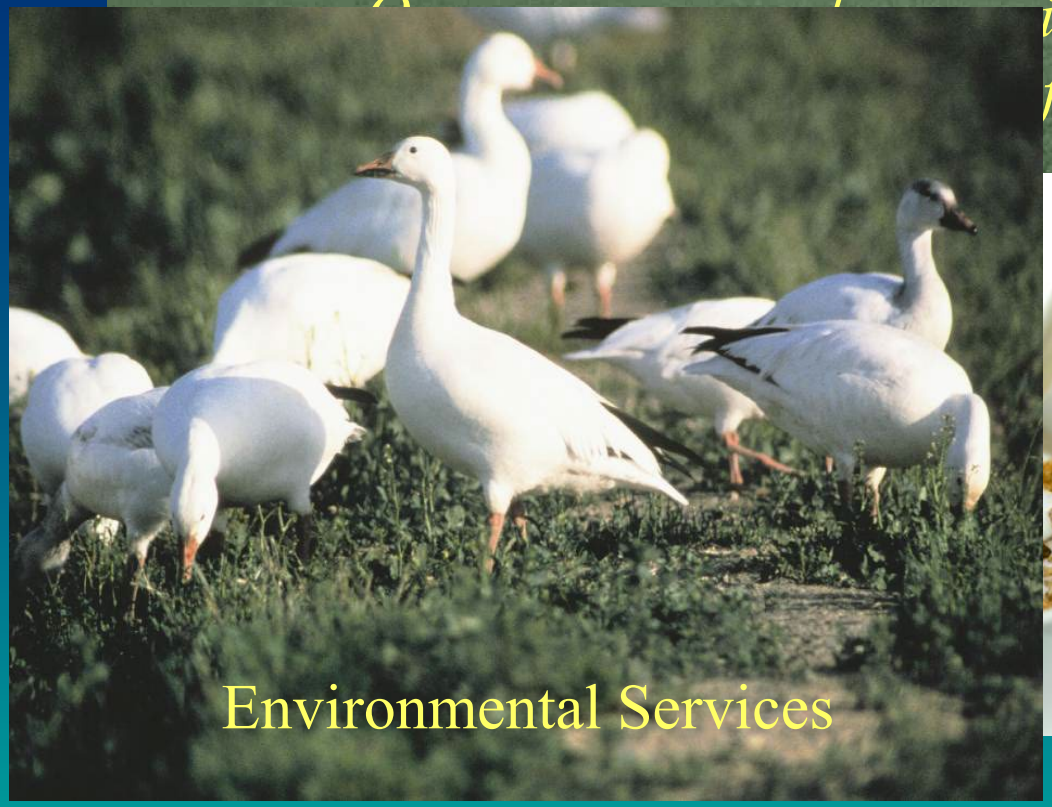
Value of Common California Crops to Farmers and Consumers				
Crop	Value to Farmer per acre	Common Consumer Unit	Retail Value per acre	California Consumer Value (x 1,000)
Wheat	$510	Loaf of Bread	$11,000	$1,100
Alfalfa	$1,800	Gallon of Milk	$4,100	$4,428
Almonds	$3,600	Can of Nuts	$8,680	$12,800
Lettuce	$11,400	Head of Lettuce	$64,258	$5,140
To				
Gr				
**				

Why is this important?

- "Value" to many indicates value to them (hay is a long-way off from the consumer!)
- Agriculture requires considerable resources (land/water)
  - Is it worth it?

Does the public recognize the role of forages in their daily lives?

ivalent of >2,000 gal
f food production…



Environmental Services

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Alfalfa/forages are the basis of a Food-Producing System:

Efficiency

Forages/Crops

Efficiency

Crop Residues

Soil/Water

Dairy Cows

Dairy Wastes

Efficiency

Food Products

Waste recycling

Broader Questions:

- Can agriculture provide **solutions** to important problems facing the public, rather than being (or being seen as) a problem itself?
- "**Environmental services**" beyond providing a highly-productive food system?
- Can forages help with **Climate Balance** (soil N, C)?
- All of agriculture has an impact: What is the **food produced per unit environmental** impact?

Alfalfa – An Environmental Balance Sheet

KEY POSITIVES:

- Basis of nutritious food for millions
- Protecting the soil from wind or water erosion
- Crop Rotation
- No N-fertilizer requirements (fossil fuel)
- Absorbing nitrates from depth
- An insectary for biological diversity
- Supporting habitat for wildlife
- CO_2 Fixation – improvement of air quality
- Mitigation of water pollution/air pollution
- Soil Health
- Alfalfa – the BEST crop for a drought!!

Alfalfa – An Environmental Balance Sheet

KEY NEGATIVES:

- Sum total water needs (seasonal)
- Does alfalfa 'take' water from environment?
- Off-site movement of pesticides used in alfalfa
- Damage to nesting birds or other wildlife with harvesting
- Linkage with dairy manure and air quality problems (Note: forages are also a solution to dairy manure problems).

Sustainability Benefits of Alfalfa

Sustainability Benefit	Alfalfa	Corn[1]	Soybean[1]	Short Term Cover Crops
Nitrogen Credits in Crop Rotation	++		+	+
Carbon Sequestration	++	0/-	0/-	+
Improved Soil Structure	+			+
Reduced Water Erosion	+			+
Reduced Wind Erosion	+			+
Decreased Nutrient Leaching/runoff	+			+
Increased Soil Microbial Diversity	+			+
Wildlife Habitat/Diversity Benefit	++			+
High Water Use Efficiency	+	+	+	+
Resilience to drought/climate	++			+

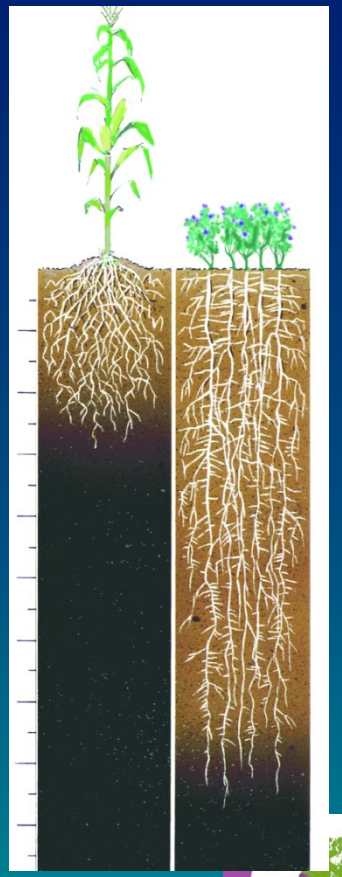
Fragility of soils and Agriculture

Figure 2. **The dust bowl of the 1930s in the US Great Plains and more recently, water erosion (right) in row crops, is a reminder of the fragility of our soil resource. High-yielding alfalfa crops protect soils from erosion.**

What about our Soil?

Alfalfa-
Significant Soil Benefits

- Crop Rotation
- Perennial cover
- Erosion Control
- Nitrate mitigation
- Particulate mitigation
- Carbon Capture
- Nitrogen Benefits
- Soil Tilth (health/quality)
- Wildlife, biodiversity



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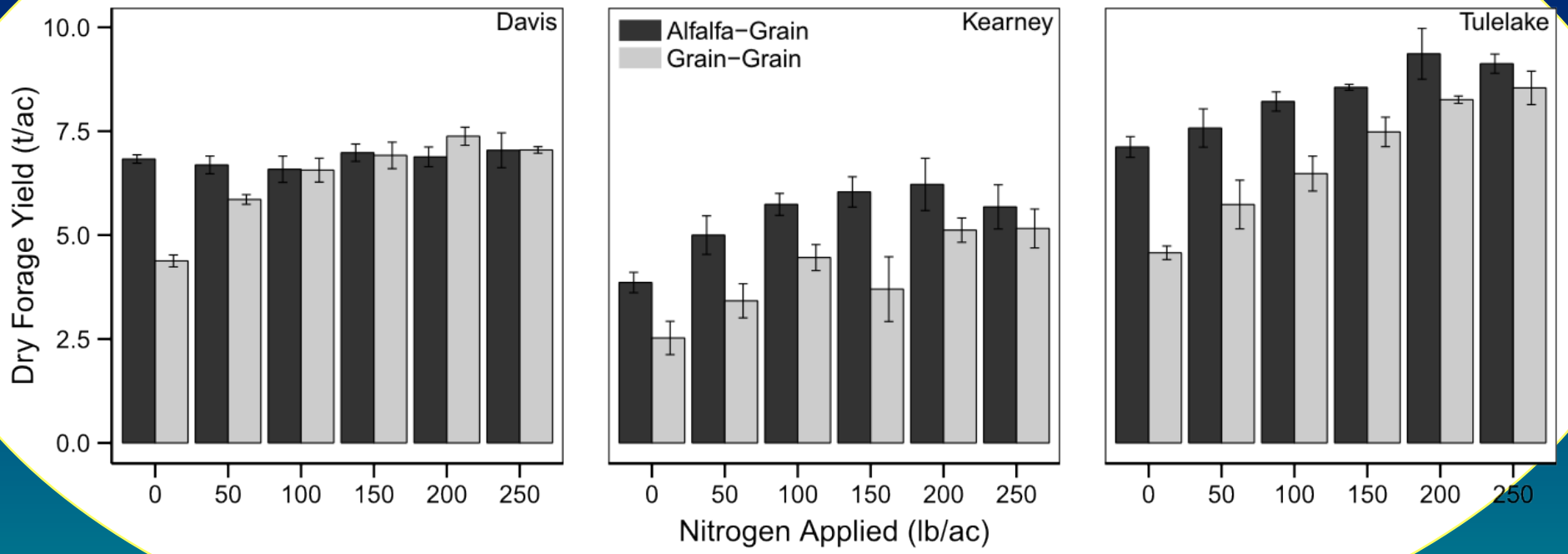
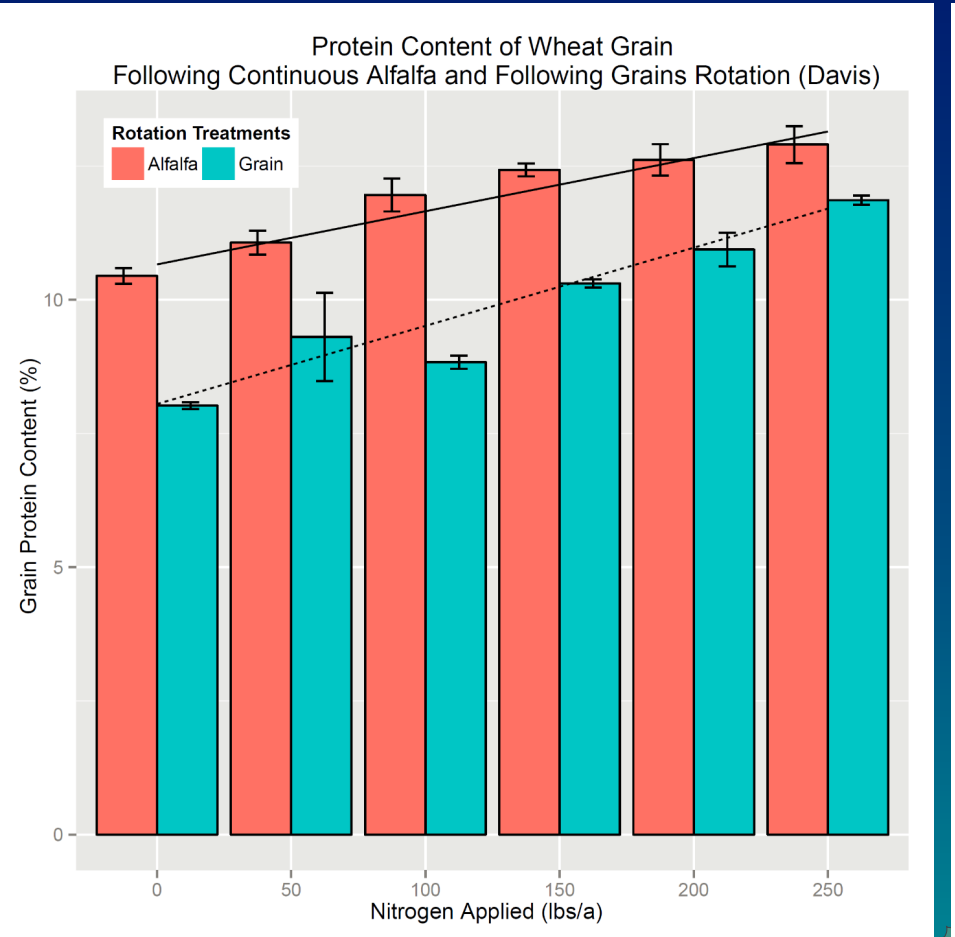
Crop Rotation Effects: Alfalfa-Wheat

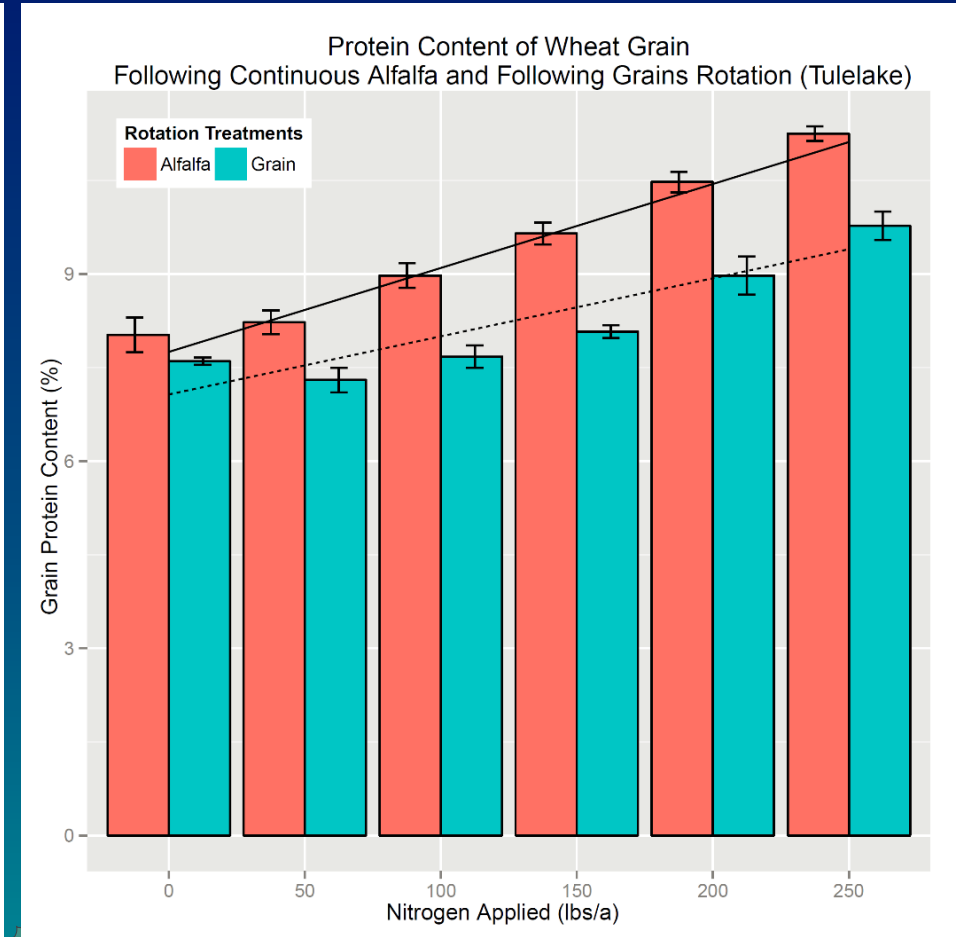
Davis Kearney Tulelake



Grain protein content



Davis

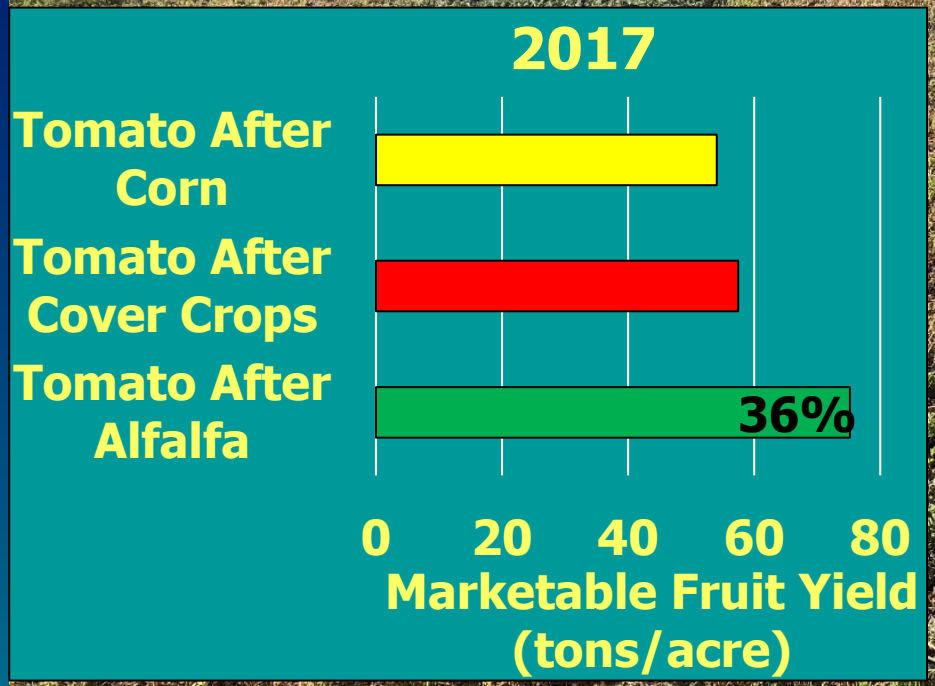


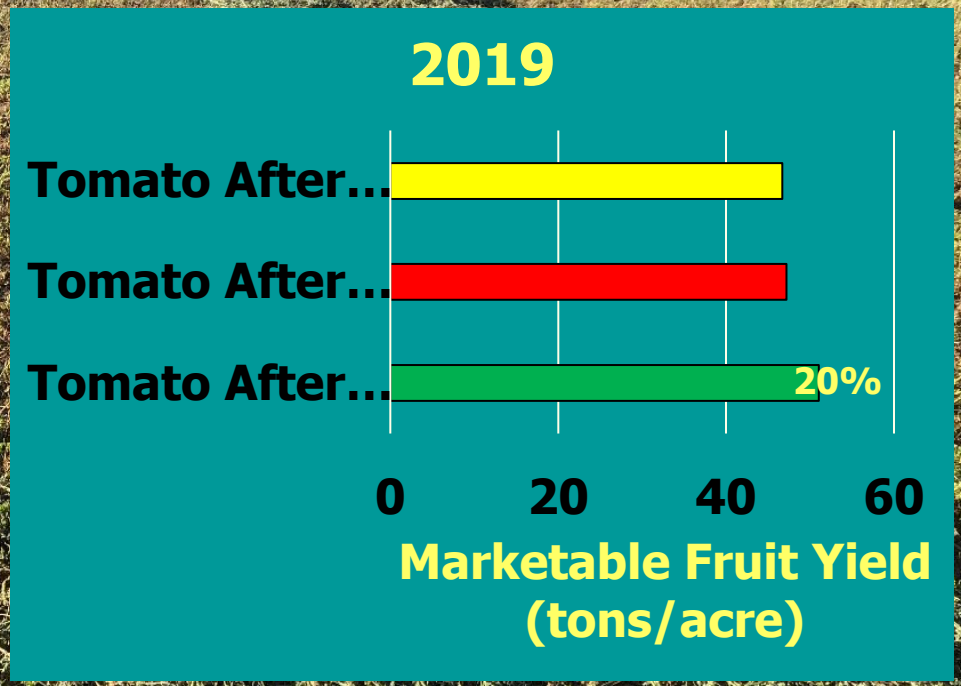
Tulelake

Soil Structure

Benefits of Alfalfa in Crop Rotations

Rotation Effects on Yields





Nicole Tauches, Russelle Ranch, UC Davis

Decreased inputs for Cropping Systems
Lower N fertilizer requirements

- Research on N credits from alfalfa
  - Estimates anywhere from $30 +/ acre savings
  - Peterson and Russelle (1991) estimated decreased fertilizer inputs by 14% in Midwest
- Often no N in 1st year corn after alfalfa
  - N needs in 2nd year decre
- Enhanced yield follov
  - *Rotation effect*

	N Credit	
Alfalfa stand density	1st year after alfalfa	2nd year after alfalfa
Plants/ sq ft	lb N/ acre	
≥ 4	150	75
2-3	100	50
≤ 1	40	0

Data from: Rehm, Schmitt, Lamb, and Eliason, 2001. MN Extension Services.

Soil Health Benefits
C Sequestration

- **Alfalfa is a great C accumulator**
  - 22% more SOC when alfalfa included compared to continuous corn (Jarecki et al., 2005)
  - 26% greater SOC in silage corn-alfalfa compared to grain-corn soybean (Cates et al., 2016)
  - 5x amount of C stored under alfalfa vs. corn (Angers, 1992)
  - Store large amounts of SOC even when herbage mass removed (Saliendra, 2018)

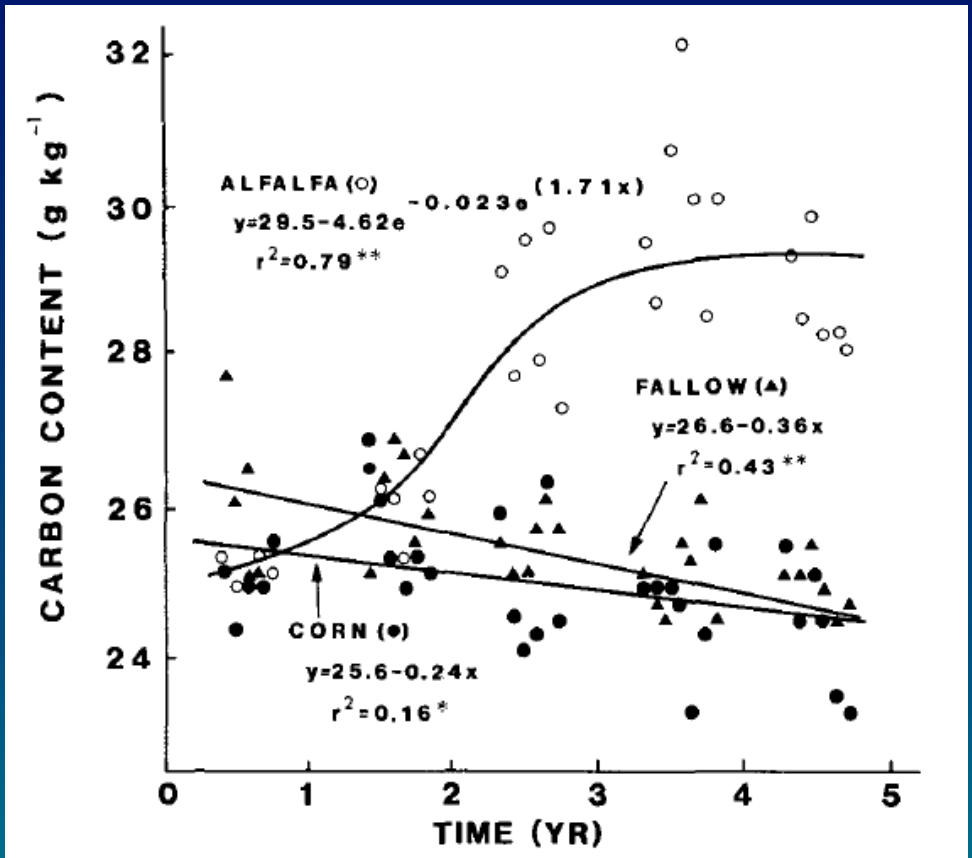
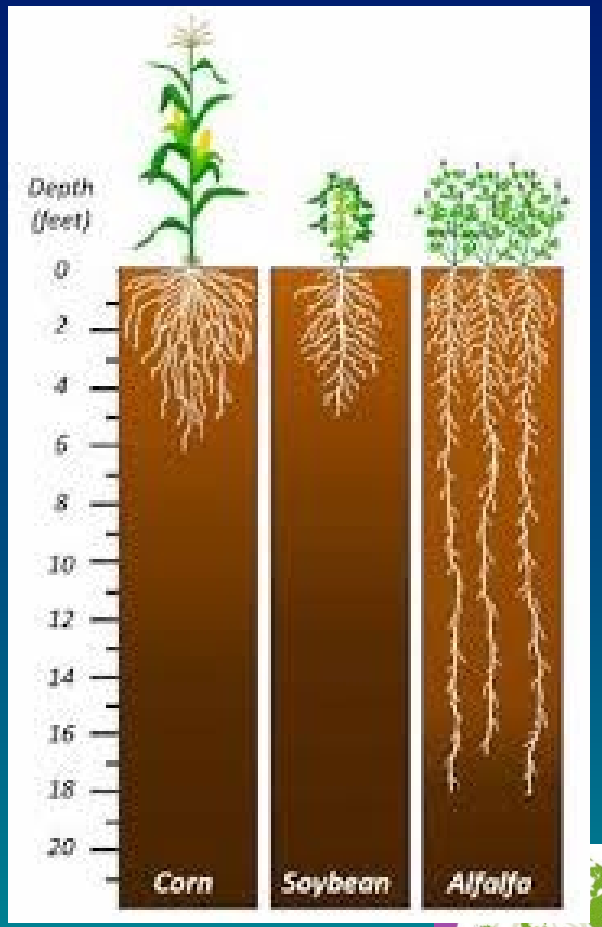


Fig. 4. Variation in C content with time under alfalfa, corn, and fallow.

From D. Angers. 1992. Soil aggregation and organic C under corn and alfalfa.

Soil Health Benefits
C Sequestration

- Alfalfa increases SOC gains deeper in the soil profile
- Corn often predicted to lose C
- Potential for increased C sequestration in alfalfa compared to perennial grassland (Saliendra, 2018)
  - Alfalfa under irrigation even higher C sinks



From Alfalfa, Wildlife, and the Environment. UC ANR, NAFA.

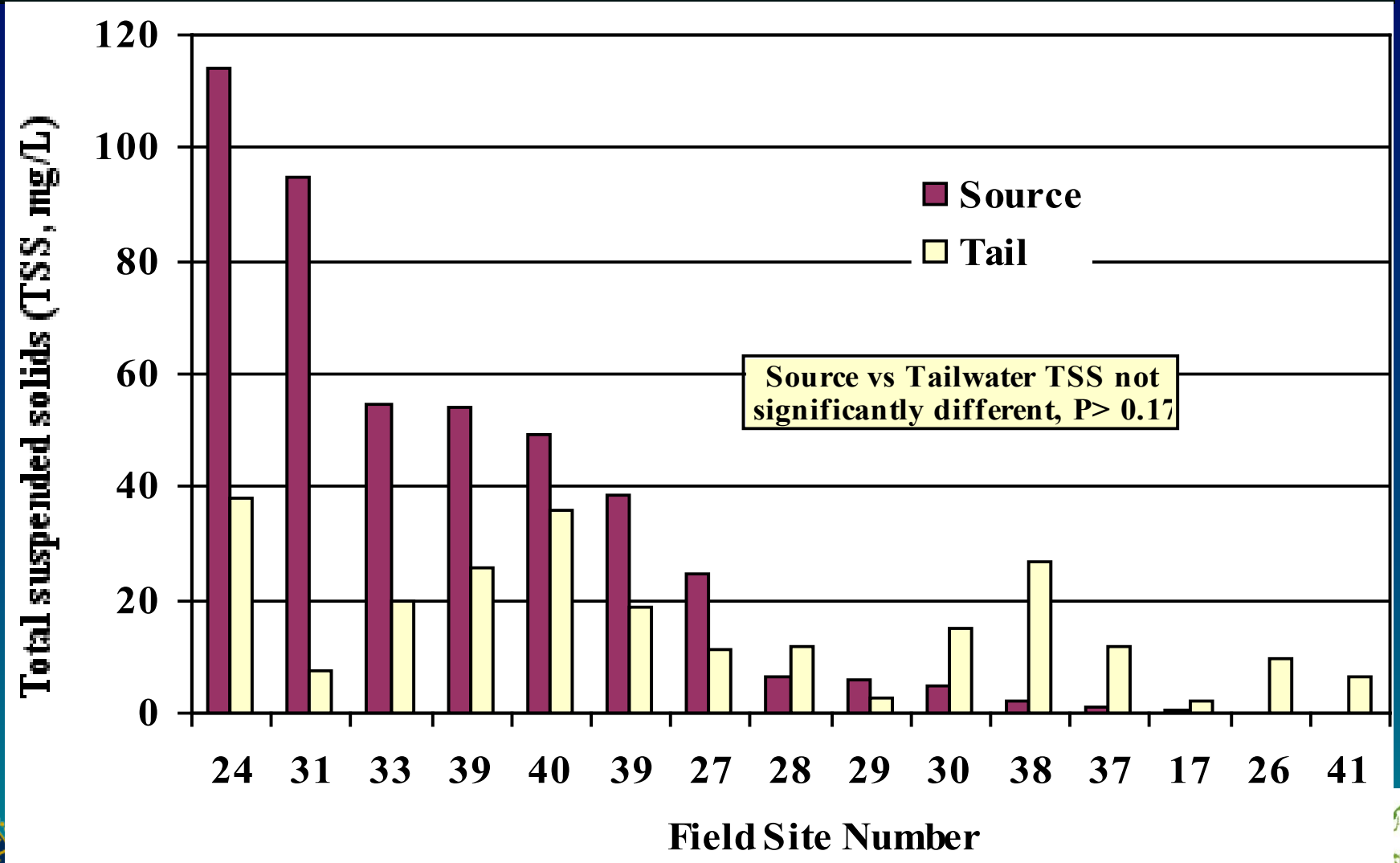
Carbon markets, Farmer benefits

- C credit markets emerging
  - Some are going to be based on tons C sequestered, other on acreage
  - Most are going to be privately-funded
  - Additional revenue stream for growers
- Example program released 1/25/21
  - Retroactive program
  - Paying $20/ T for historical practices in last 5 years
- Government interest?

Soil Health Benefits Decreased Erosion

- No cultivation after establishment
- Almost constant vegetative cover
  - Helps to "break up" raindrops
  - Reduce flow of water through fields
  - Adds organic matter improving soil tilth
- Research has found alfalfa significantly:
  - Reduced runoff, even with sloped soils
  - Increased infiltration rate
  - Impacts increase with alfalfa height

Soil Health Benefits

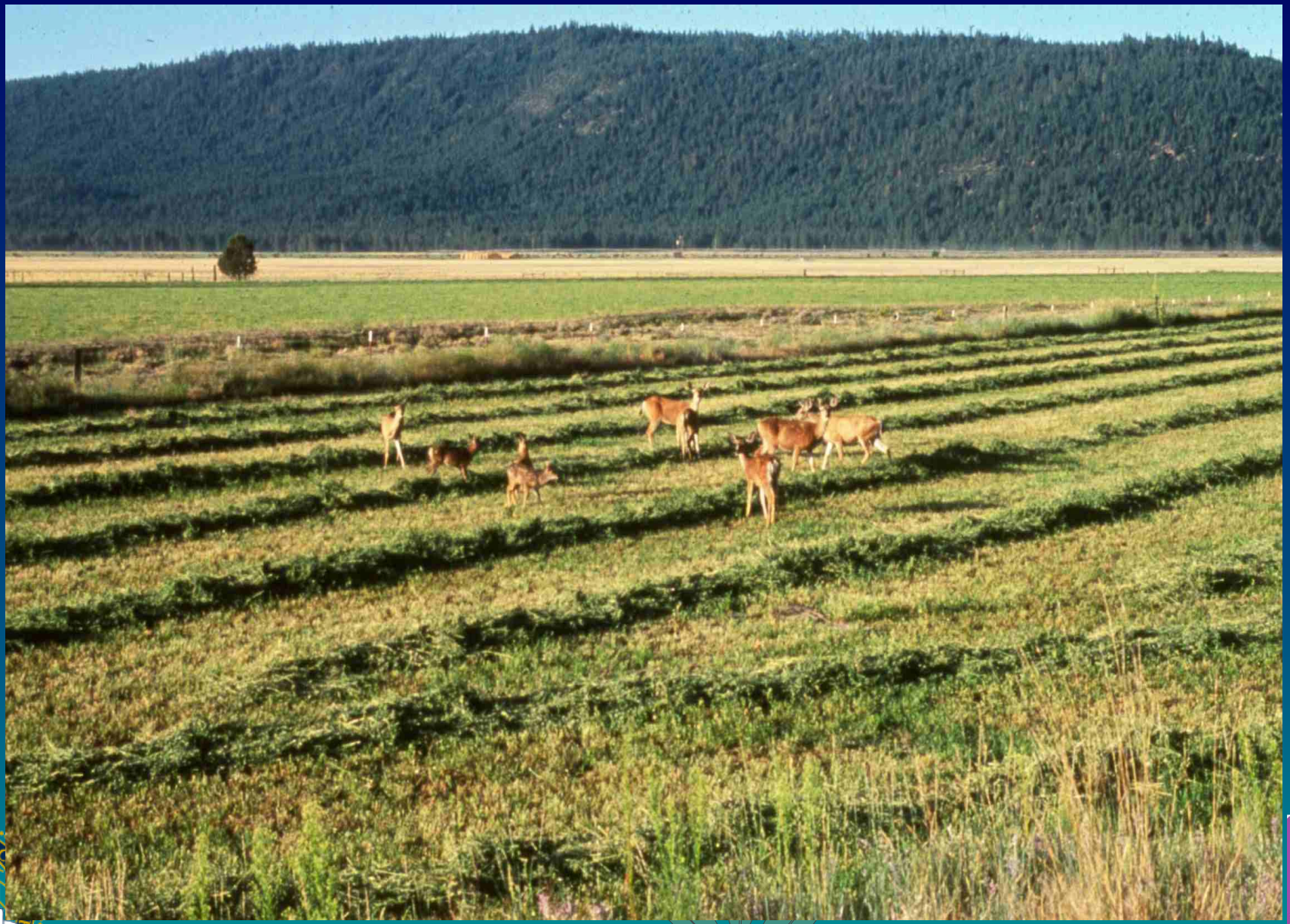


R. Long data

Wildlife Benefits

- Perennial
  - Stable habitat and food source
  - Many species of insects in a single field
- High feeding value
  - High desirability and nutrient density
- Below-ground diversity
  - ↑ diversity of insects, soil-dwelling organisms, and rodents
- Pollinator benefits
  - Alfalfa very attractive to pollinators
  - Important food source and habitat

Migratory Geese (Sacramento Valley_



Bald Eagle – Butte Valley, CA

14 Bald Eagles on Pivot

Alfalfa– Butte Valley, CA

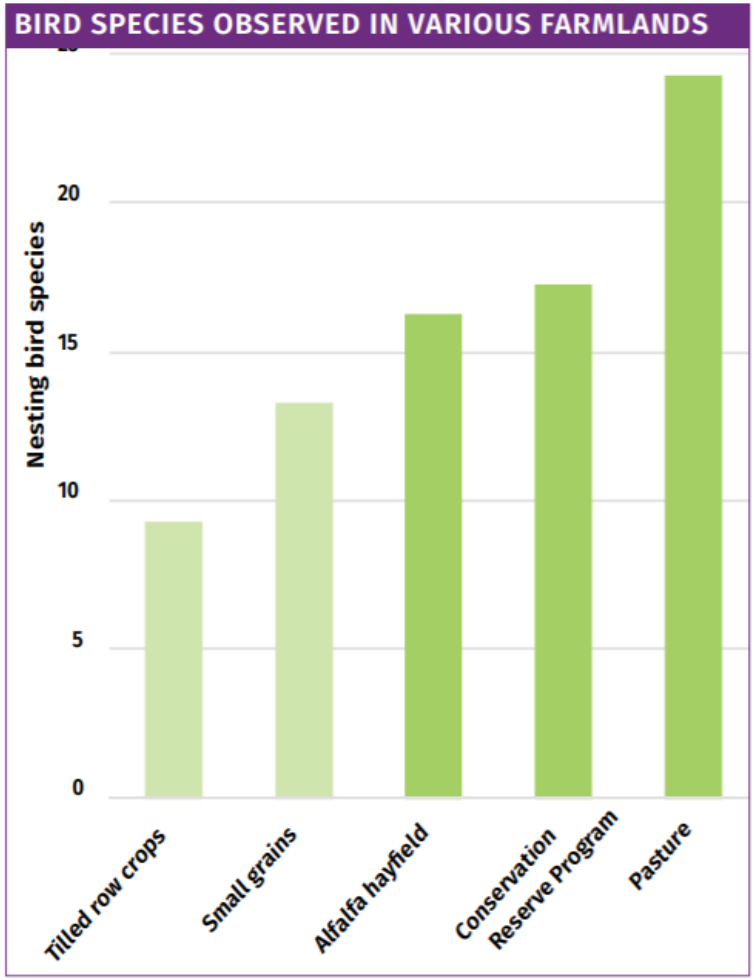
ALFALFA AS AN INSECTARY

Beneficial Insects

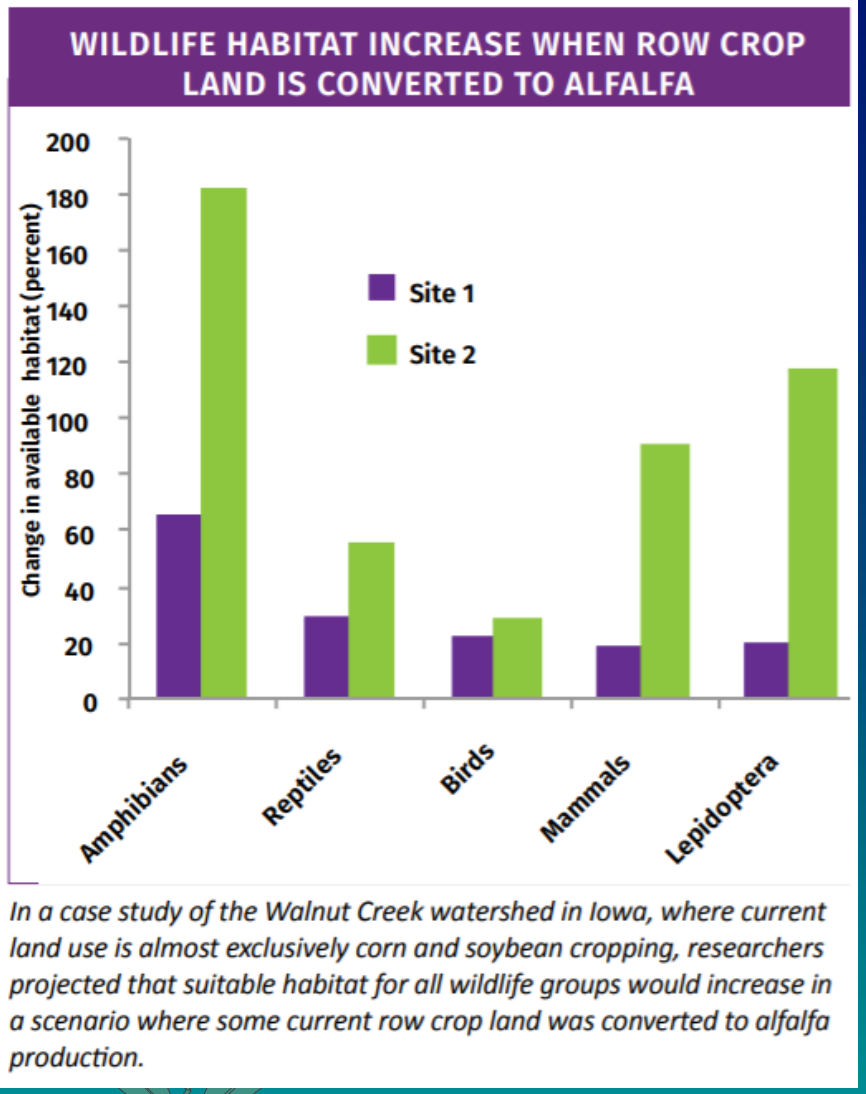
- Alfalfa promotes Insect Diversity
- ~1,000 species observed in field
- Beneficial insects control Pests
- Important Role for IPM

Alfalfa as biocontrol - Strawberries

Alfalfa Habitat Provisioning



Number of bird species observed nesting in various farmland habitats in Iowa. Darker green bars represent habitats that frequently include alfalfa.



In a case study of the Walnut Creek watershed in Iowa, where current land use is almost exclusively corn and soybean cropping, researchers projected that suitable habitat for all wildlife groups would increase in a scenario where some current row crop land was converted to alfalfa production.

From:
Alfalfa, Wildlife, & the Environment, v.2

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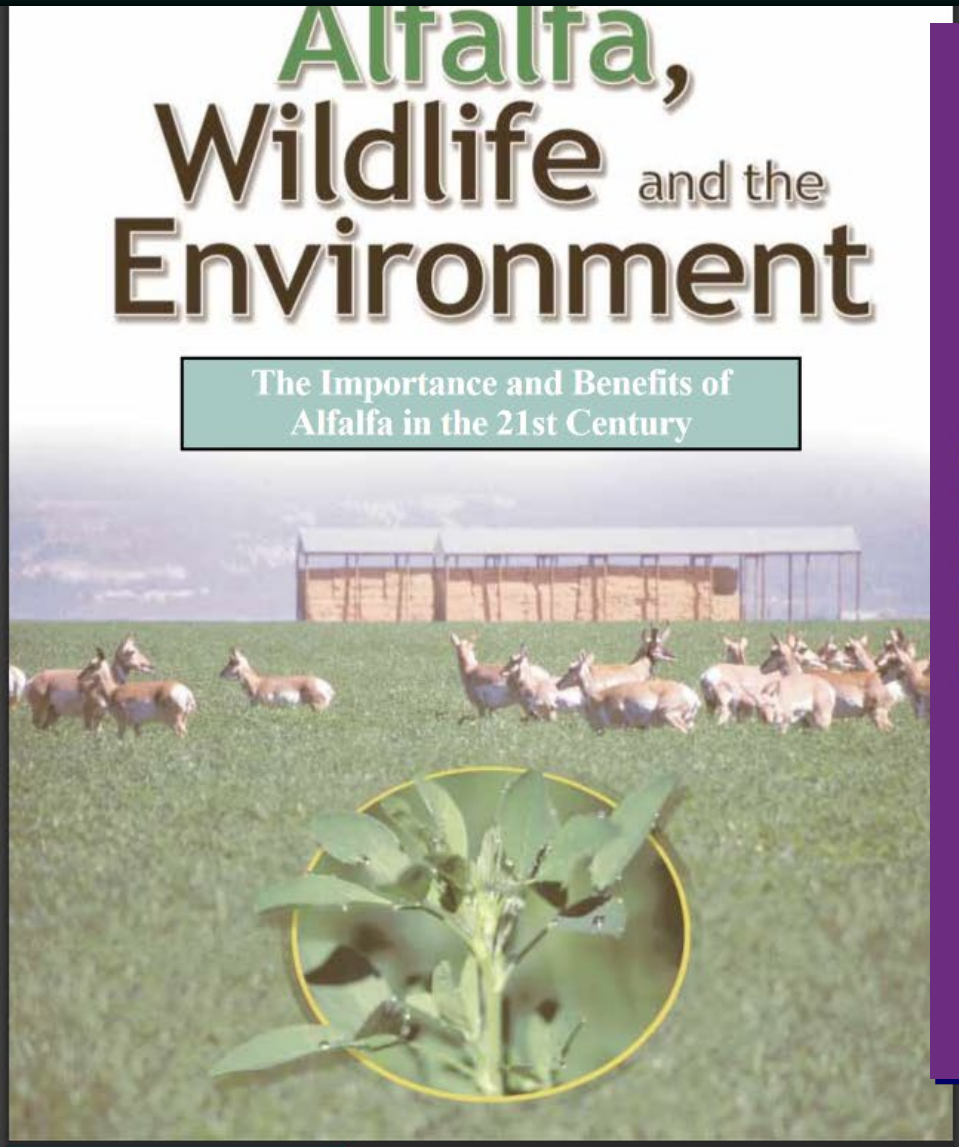
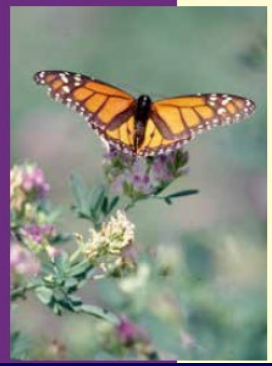
Alfalfa & the Environment





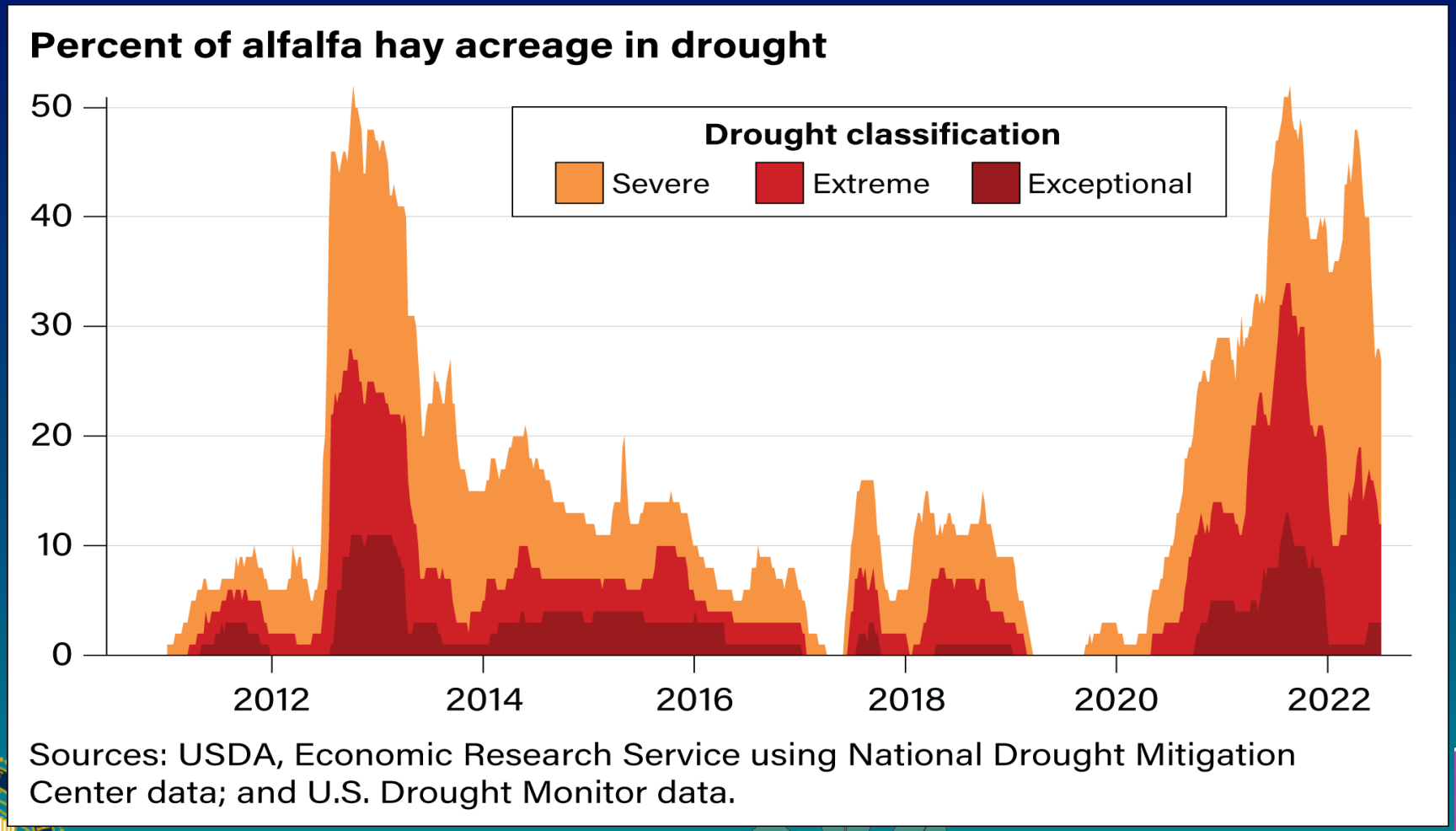
Alfalfa, Wildlife & the Environment

SECOND EDITION

Adria Fernandez
Craig Sheaffer
Nicole Tautges
Dan Putnam
Mitchell Hunter

But… what about water?

Drought/Climate Change



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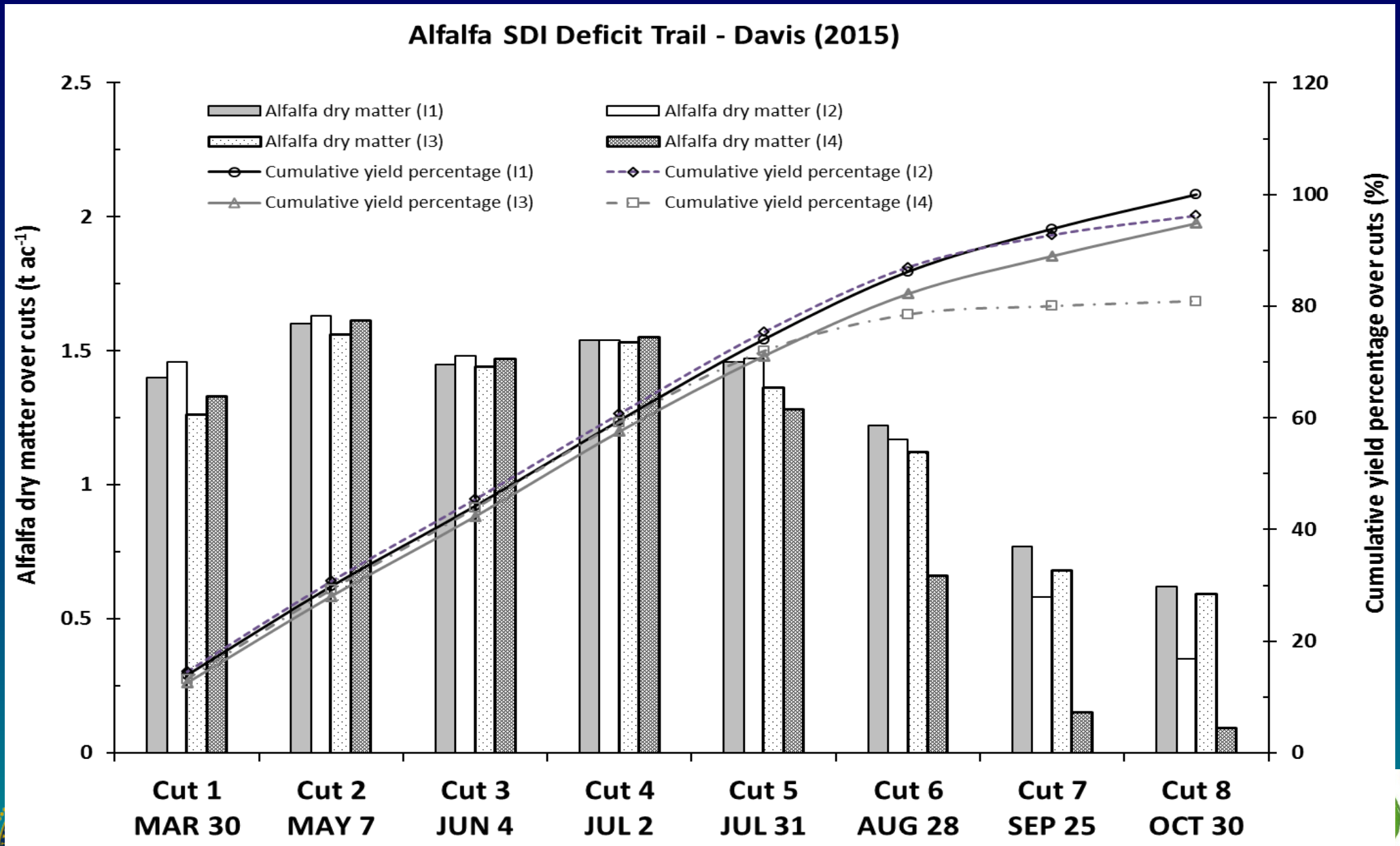
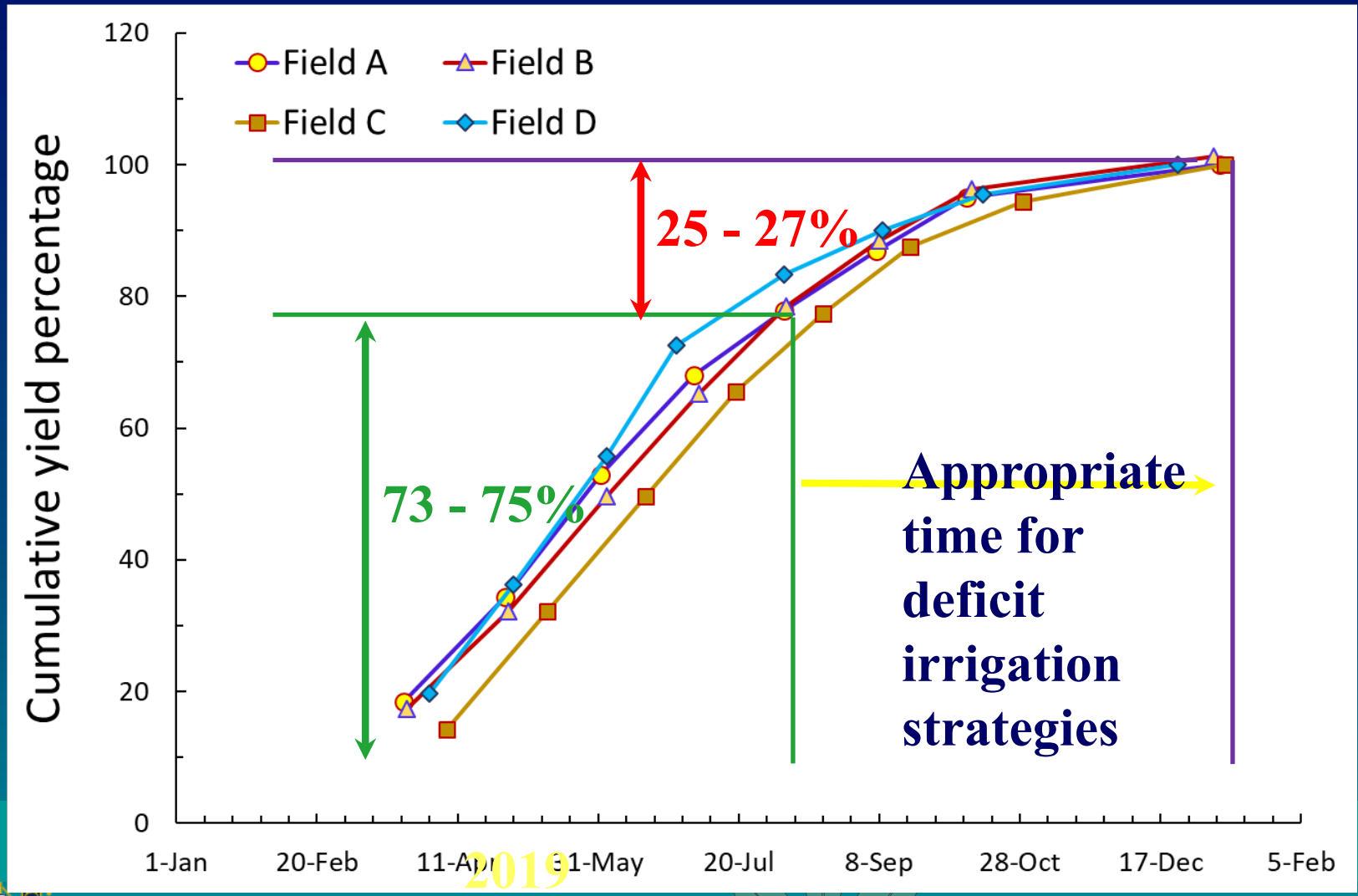
Alfalfa – the Best Crop for a Drought/ Sustainable water use

- Very high "Water Productivity" – DM produced for each unit of water
- Deep roots – recovery of soil moisture
- Perennial (starts early)
- Can successfully 'dry down' alfalfa and still have economic returns (recovers nicely)
- Can accept degraded water (saline, waste)
- High flexibility in drought

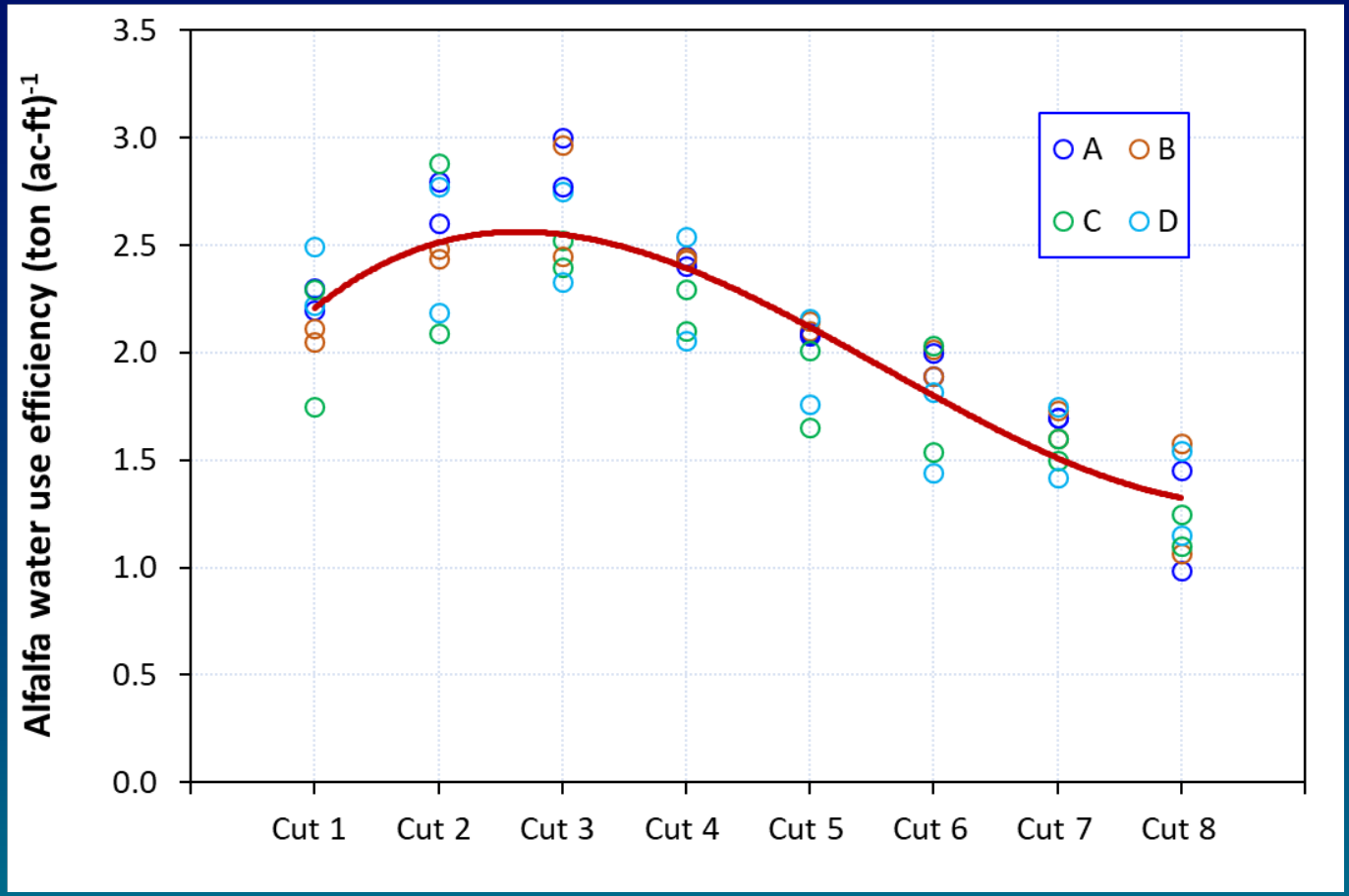

Alfalfa SDI Deficit Trail - Davis (2015)
Alfalfa dry matter (I1)
Alfalfa dry matter (I2)
Alfalfa dry matter (I3)
Alfalfa dry matter (I4)
Cumulative yield percentage (I1)
Cumulative yield percentage (I2)
Cumulative yield percentage (I3)
Cumulative yield percentage (I4)
Alfalfa dry matter over cuts (t ac-1)
Cumulative yield percentage over cuts (%)
2.5
2
1.5
1
0.5
0
120
100
80
60
40
20
0
Cut 1 MAR 30
Cut 2 MAY 7
Cut 3 JUN 4
Cut 4 JUL 2
Cut 5 JUL 31
Cut 6 AUG 28
Cut 7 SEP 25
Cut 8 OCT 30

Alfalfa seasonal yield patterns in CA's low desert

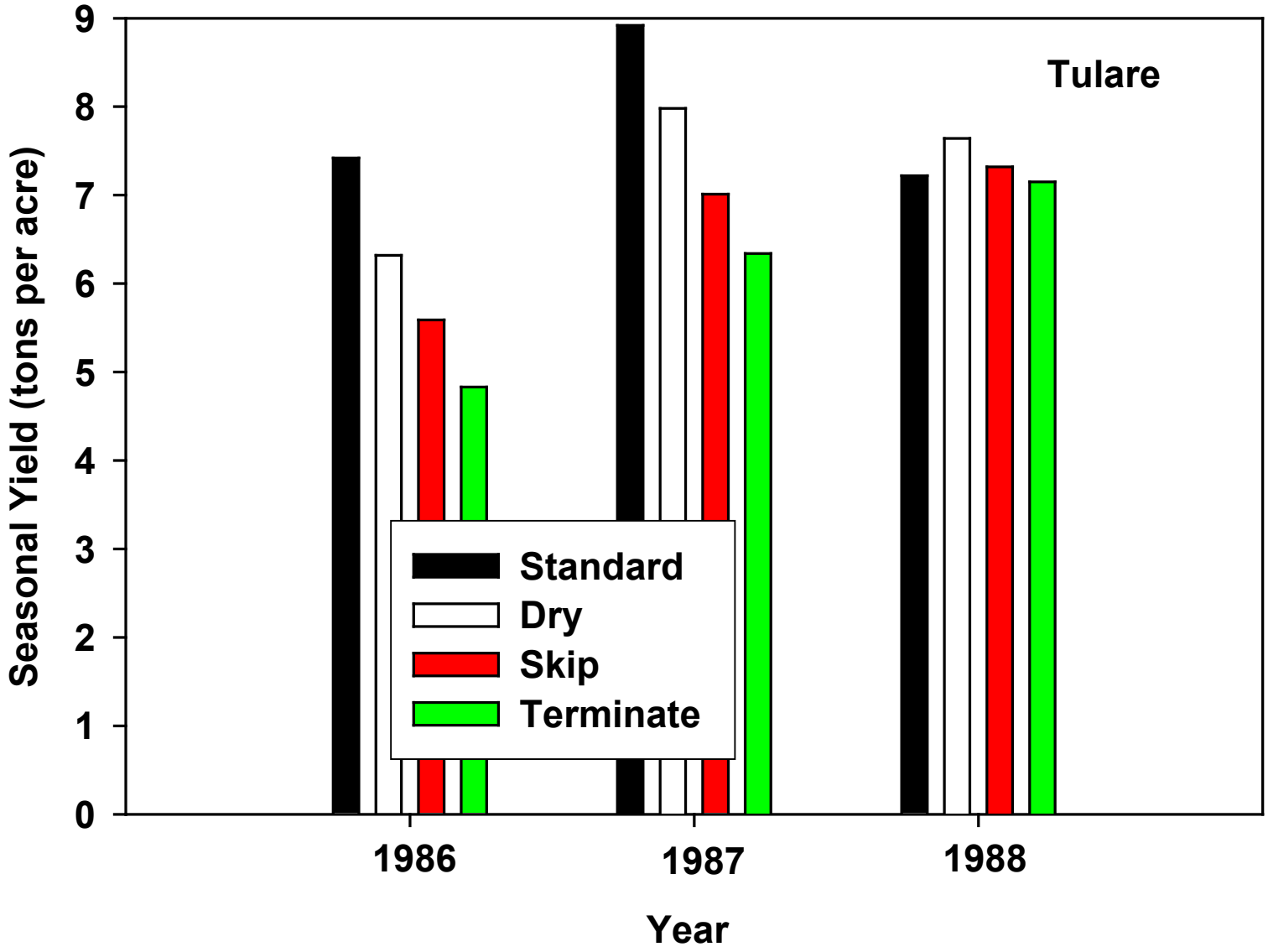


Slide: Ali Montazar, UCCE

Alfalfa Water Use Efficiency (WUE) over the season



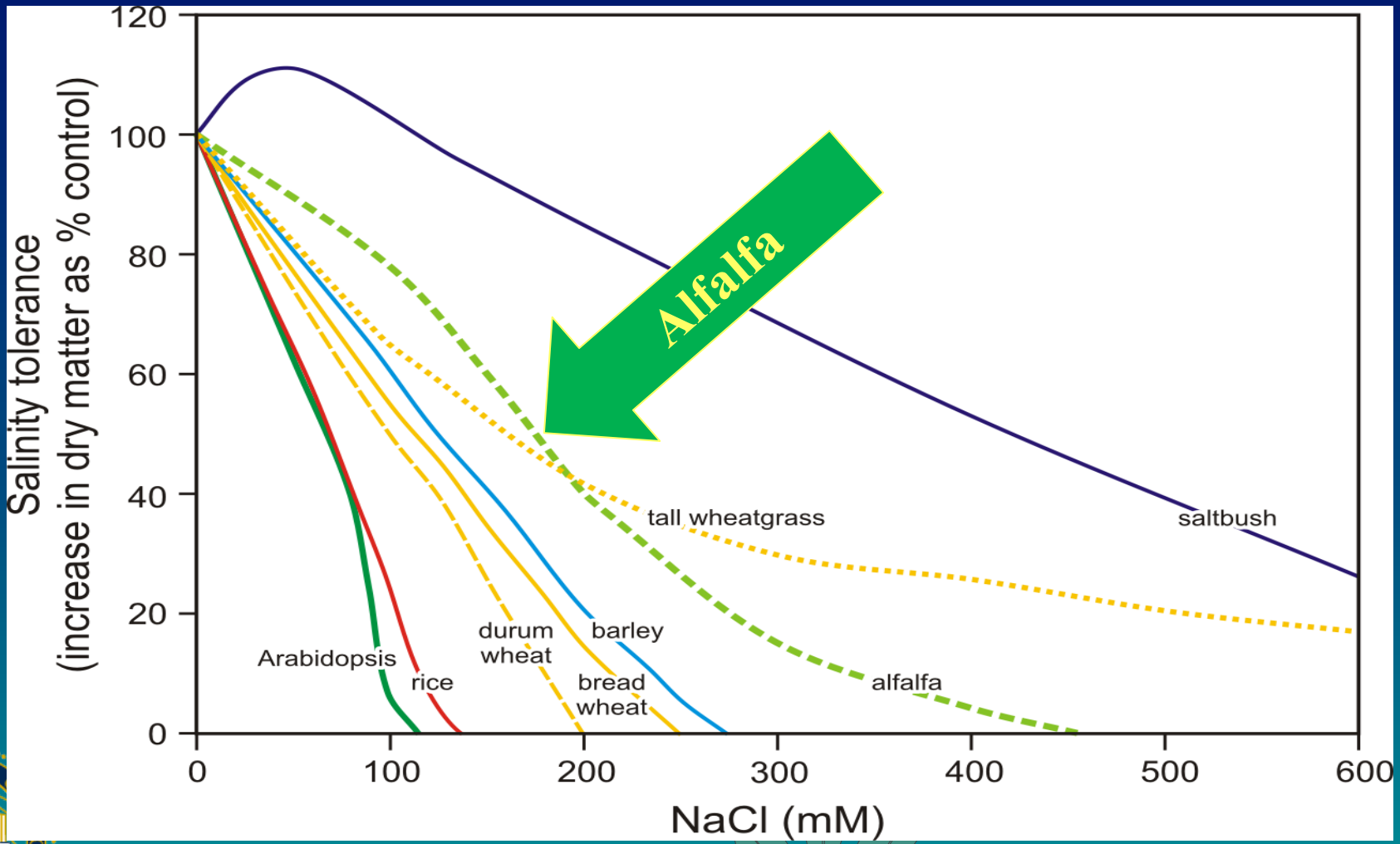
Alfalfa has higher water use efficiency in early to mid-season (Mar-Jul) than mid- to late season (Aug-Dec).


Tulare
Seasonal Yield (tons per acre)
0
1
2
3
4
5
6
7
8
9
1986
1987
1988
Year
Standard
Dry
Skip
Terminate

Tulelake, July Harvests

- 6” of winter rains

Salinity tolerance
(Australian work)



Munns & Tester, Ann Rev Plant Biol, 2008

Salinity Effects on Alfalfa over 4 Years (Fresno County)

Table 1. Effect of salinity on yield, average of 35 alfalfa varieties, over four years, Five Points, CA, 2017-2020 (planted 3/29/17). Water with ECw of 8 to 11 dS/m was applied to saline plots, and 1-2 dS/m to low saline plots. Soil salinity at the completion of the trial ranged from 12-16 dS/m EC depending upon depth. Unpublished data (D.H. Putnam, UC Davis).

	2017 Season Yield - 4 cuts		2018 Season Yield 7 cuts		2019 Season Yield 8 cuts		2020 Season Yield 7 cuts		Cumulative Average (t/A)	
	Salinity Level									
	Low	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
	tons/acre									
Minimum	3.5	3.6	10.2	7.9	11.4	9.9	12.0	7.7	39.0	30.5
Maximum	6.0	5.5	14.6	11.3	16.2	13.3	17.3	13.0	52.7	42.7
Average	4.8	**4.6**	12.3	**9.6**	14.4	**11.5**	**14.7**	**10.2**	**46.1**	**36.1**
Yield loss	**4%**		**22%**		**20%**		**31%**		**22%**	
Treatment Mean	4.7		11.0		13.0		13.0		41.1	
CV%	16.3		16.5		12.8		20.5		10.0	
LSD (p=0.05)	0.2		1.8		1.6		0.6		1.0	

Water Use and Alfalfa

- Alfalfa has major advantages with regards to water efficiency
  - High WUE, deep roots, salinity tolerance
- High Seasonal Demand is a function of year-long growth habit
- Unlike many crops alfalfa can be 'deficit irrigated' (reduced yields, but economically viable).
- Protects soil during drought

Alfalfa: Important to a Water-Challenged Future

THE IMPORTANCE OF ALFALFA IN A WATER-UNCERTAIN FUTURE

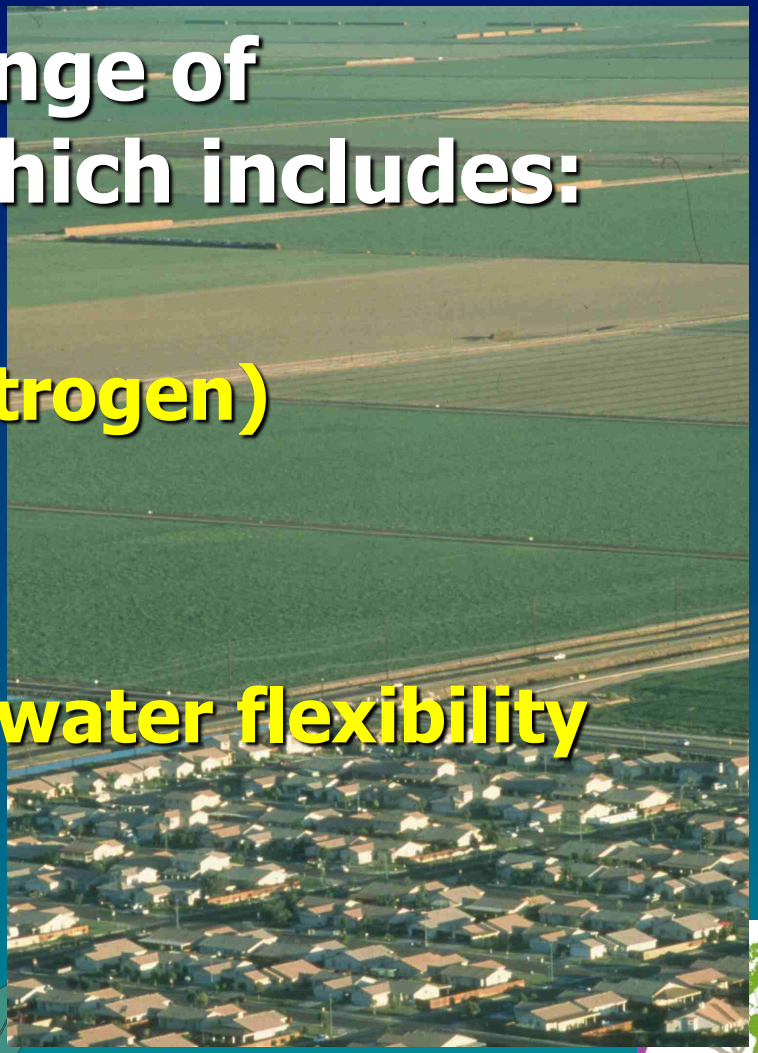
Dan Putnam, Umair Gull, Khaled Bali[1]

ABSTRACT

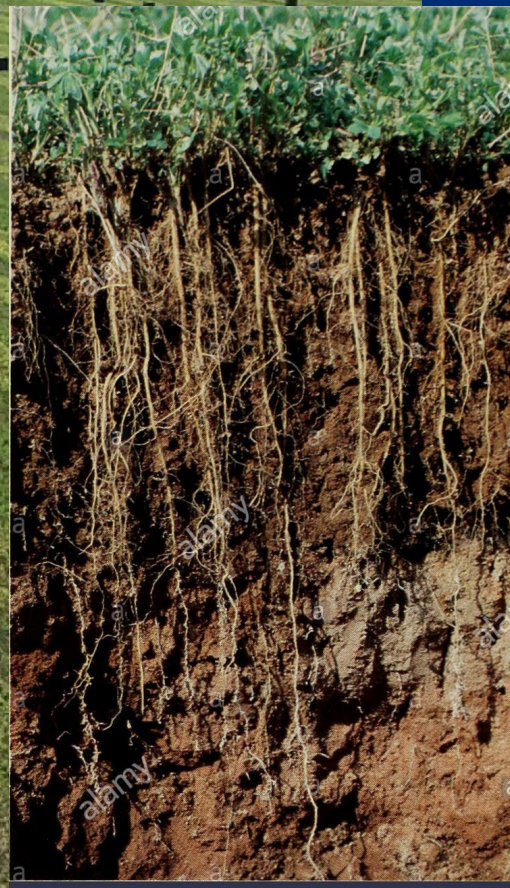
It is a favorite sport of journalists to point to crops that use lots of water (almonds, alfalfa) as being worthy of scorn during a drought. However, this simplistic examination of water demand vs. supply is not likely to be productive. Water use should be balanced with productivity, economic return, and…food production. A more important consideration is the resiliency of agricultural food-producing systems given the certain variation in water supply which is a current and future reality. Alfalfa has a key role to play in a water-uncertain future due to its high flexibility during times of insufficient and excess water, due to important biological features: 1) its deep roots which allow the use of residual moisture, 2) multiple harvests can give partial economic yields when irrigation ceases, 3) alfalfa roots survive summer dry-downs, and regrows when re-watered, 4) it can be flooded in winter to recharge aquifers, and 5) high salinity tolerance. Alfalfa has proved to be highly flexible and resilient in surviving droughts while sustaining productivity, even when as little as ½ the water requirement is applied. Contrary to superficial thinking on crop choice concerning water supply, alfalfa, with its high flexibility, is an important component to adjust to a water uncertain future.

Conclusions:

- Alfalfa provides a wide range of environmental services which includes:
  - Soil Improvement
  - GHG mitigation (carbon, nitrogen)
  - Wildlife habitat
  - Crop Rotation Benefits
  - High Water-use efficiency/water flexibility



Profitable Alfalfa Production Benefits the Environment



Thank You

Sand Hill Cranes in Alfalfa

Steve Beckley, ph