A minus R: Implications and Challenges for Central Coast Farming

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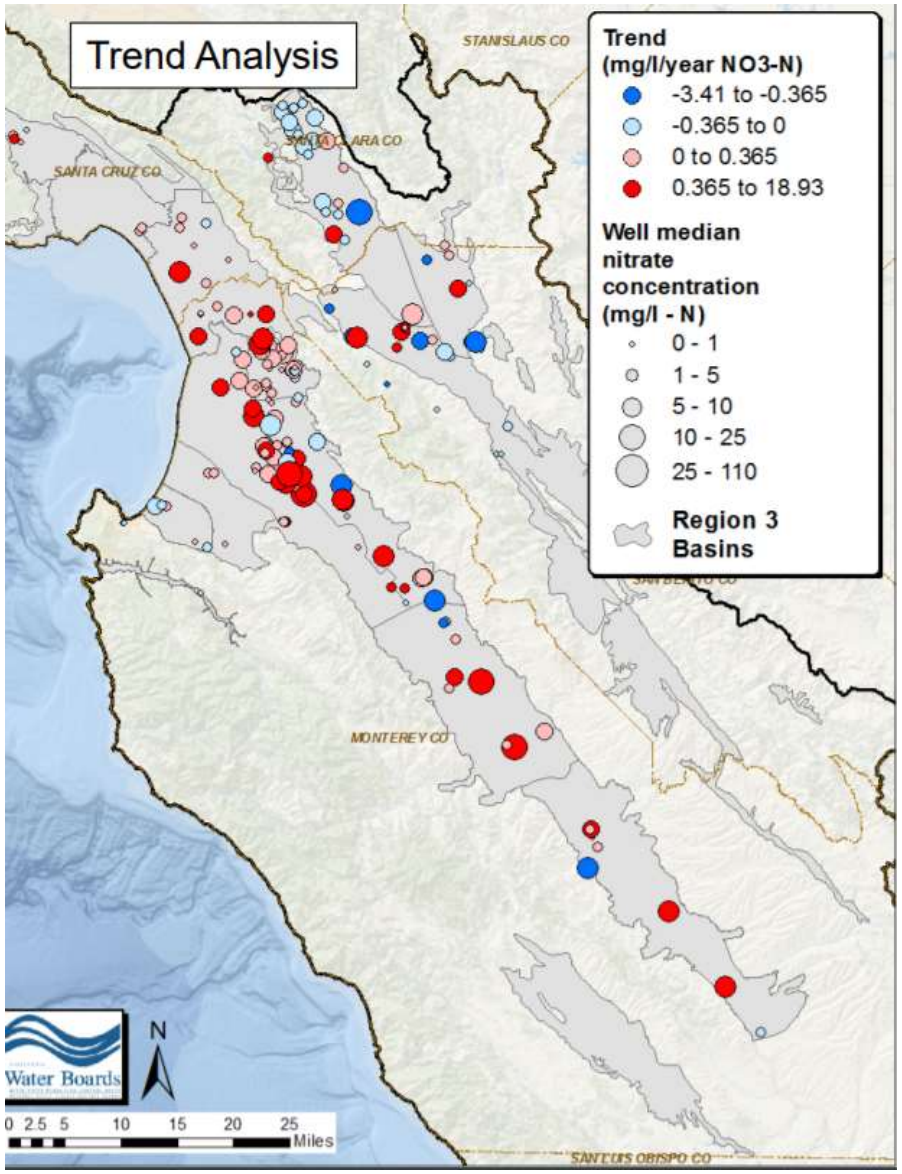
UCCE Monterey, San Benito, and Santa Cruz Counties

A majority of agriculture wells on the Central Coast have Elevated levels of Nitrate (> 10 ppm N)



Nitrogen and Water Use Reporting on the Central Coast began in 2014 (Ag Order 3.0)

TIER 2/TIER 3 FARMS WITH HIGH NITRATE LOADING RISK

TOTAL NITROGEN APPLIED REPORT - RANCH/RISK UNIT & FIELD/BLOCK

Page 1 of 3 - September 26, 2016 Version

EMAIL FORM AS AN ATTACHMENT: Attach completed and saved form to an email and send to AgNOI@waterboards.ca.gov

Reporting Period: 09/01/2015 to 08/31/2016

Any changes to the reporting period must be approved or form will not be accepted.

CONDITIONAL WAIVER OF WASTE DISCHARGE REQUIREMENTS FOR DISCHARGES FROM IRRIGATED LANDS - REGIONAL BOARD ORDER R3-2012-0011

Annually by October 1st, Tier 2 and Tier 3 dischargers with High Nitrate Loading Risk must report total nitrogen applied and present in the soil.

Hover over the cells/boxes with your mouse for more information on what is required. Refer to instructions for further detail.

Click below to clear the corresponding section of the form.

Section I | Section II | Section III | Section IV | All

SECTION I: GENERAL RANCH INFORMATION *(Space for more parcels and multiple counties available on page 2)*

AW#: | Ranch Global ID: | Ranch/Risk Unit or Field/Block Name: | Physical Ranch Acres Reporting:

County: | APN(s): | Fallow Acres: *(If fallow entire report period)*

If ranch is a greenhouse, nursery, or hydroponic, select from the dropdown: | Sum of Total Crop Acres: 0.0 *(Auto-calculates from Section IV)*

SECTION II: NITROGEN APPLIED WITH IRRIGATION WATER *(Include all uses, e.g. leaching; and all sources, e.g. CSIP or PVWMA delivered water)*

Section II-A: PVWMA/CSIP water use	*Section II-B: PVWMA/CSIP water*	*Section II-C: Well/city water (or other non-PVWMA/CSIP source)*		*Section II-D: Nitrogen applied*
Was PVWMA/CSIP water used during the reporting period?		**Average Nitrate Concentration in Well/City Water** *(mg/L)*	**Estimated Total Volume of Well/City Water Applied to Entire Reporting Acres During Reporting Period** *(gallons)*	**Nitrogen Applied with Irrigation Water** *(lbs/ranch-ac)*
		☐ *as Nitrate (NO3)* ☐ *as Nitrogen (NO3-N or N)*	*This field can be erased before submittal. Do not include volume of PVWMA/CSIP water applied.*	*This field auto-calculates. After completing Sections I-IV, check the estimated average acre-feet of water applied to each crop-acre grown*
-Section II-D will auto-calculate based on Sections II-B, II-C, and ranch acreage.		*To calculate the weighted average concentration if more than one sample from one or more sources of irrigation water was used, use the Excel tool 'weighted_avg_conc'*	*To convert from acre-feet or acre-inches to gallons, use the Excel tool 'convert_to_gallons'*	

SECTION III: NITROGEN APPLIED WITH COMPOST & AMENDMENTS

Physical Acres Receiving Compost & Amendments	**Nitrogen Applied in Compost & Amendments** *(total lbs)*

Applications of nitrogen from compost and amendments (not fertilizers) made to improve soil properties, and/or as a source of nitrogen to ALL crops grown during the reporting period may be reported here. Alternatively, the nitrogen may be distributed accordingly between the crops and reported in Section IV. Do not report this information in both sections.

SECTION IV: NITROGEN APPLIED WITH FERTILIZERS & OTHER MATERIALS AND NITROGEN PRESENT IN SOIL *(The Excel tool 'N_from_fertilizers' assists with calculations in this section)*

	Specific Crop(s) Grown and Harvested During Reporting Period *(Select from List on Page 3)*	Total Crop Acres	Nitrogen Present in Soil *(lbs/ac)*	Nitrogen Applied in Fertilizers and Other Materials *(lbs/crop-ac)*	O/C	Additional Information		Specific Crop(s) Grown and Harvested During Reporting Period *(Select from List on Page 3)*	Total Crop Acres	Nitrogen Present in Soil *(lbs/ac)*	Nitrogen Applied in Fertilizers and Other Materials *(lbs/crop-ac)*	O/C	Additional Information
1.							11.						
2.							12.						
3.							13.						
4.							14.						
5.							15.						
6.							16.						
7.							17.						
8.							18.						

Five Components to Agricultural Order 4.0 on the Central Coast:

- Irrigation and Nutrient Management – Ground Water
- Irrigation and Nutrient Management –Surface Water
- Pesticide Management – Ground and Surface Water
- Sediment and Erosion Control
- Riparian Habitat

East San Joaquin Waste Discharge Requirement set precedence for reporting applied and removed nitrogen

STATE OF CALIFORNIA
STATE WATER RESOURCES CONTROL BOARD

ORDER WQ 2016-

In the Matter of Review of

Waste Discharge Requirements General Order No. R5-2012-0116
for Growers Within the Eastern San Joaquin River Watershed
that are Members of the Third-Party Group

Issued by the
California Regional Water Quality Control Board,
Central Valley Region

SWRCB/OCC FILES A-2239(a)-(c)

BY THE BOARD:

In this order, the State Water Resources Control Board (State Water Board or Board) reviews on its own motion Waste Discharge Requirements General Order No. R5-2012-0116 issued by the Central Valley Regional Water Quality Control Board (Central Valley Water Board) for Growers within the Eastern San Joaquin River Watershed that are Members of a Third-Party Group (hereinafter "Eastern San Joaquin Agricultural General WDRs" or "General WDRs"). The Eastern San Joaquin Agricultural General WDRs authorize discharges from irrigated lands[1] operations to waters of the state within the Eastern San Joaquin River Watershed and set forth a number of requirements for monitoring and planning, for implementation and evaluation of management practices, and for participation in various education and outreach events. For the reasons discussed herein, the State Water Board generally upholds the structure and requirements of the Eastern San Joaquin Agricultural General WDRs, but directs a number of revisions, primarily to add greater specificity and transparency in reporting of management practice implementation, to require reporting of certain nitrogen application-related data needed for management of excess nitrogen use, and to expand the surface water and groundwater quality monitoring programs of the General WDRs. Many of the revisions to the Eastern San Joaquin Agricultural General WDRs implement the conclusions of an agricultural expert panel that made

[1] Irrigated lands are lands irrigated to produce crops or pasture for commercial purposes, nurseries, and privately and publicly managed wetlands. (Eastern San Joaquin Agricultural General WDRs, Attach. E, Definitions, p.3.)

coefficient determined via direct testing of the harvested materials. The nitrogen removed coefficient expresses the amount of nitrogen for a given crop per unit of crop yield.

The multi-year A/R ratio, as proposed by the panel and implemented in this order, is distinguished from previous ratios in two ways. First, it utilizes removed nitrogen instead of nitrogen uptake/consumption. This is an important simplification as it is based on a measurement instead of an estimate. The basis of any good performance metric is that it relies on quantitative measurements that can be performed simply and repeatedly with relative accuracy and that it is easy to understand. The uptake/consumption of nitrogen by a crop as it was employed by the previous orders was based on estimation, not a measurement. Often the published guidance regarding plant uptake/consumption has wide ranges of values from which to select, with variation from low to high values ranging as much as 40 percent. Because of these inherent complexities and inaccuracies, using uptake/consumption as part of a performance metric is problematic. Second, utilizing the measurements of applied and removed nitrogen over several years allows for variations that happen from year to year to cancel out and the carryover of nitrogen in soil to become insignificant for purposes of tracking and reporting. A multi-year approach to a performance metric related to nitrogen management serves to simplify some of the inherent complexity of trying to perform a nitrogen balance on an annual basis and justly account for nitrogen present in its many varied states within a field and crop system.

When evaluated over multiple years, the A/R ratio provides a reliable measurement of the nitrogen left in the field. In each consecutive year, the nitrogen left in the field from the prior year, as approximated by the A/R ratio, will either be utilized by the next crop or move further down in the soil column with potential to be leached to groundwater. If, over several years, the ratio of nitrogen applied and nitrogen removed from the field remains high, a significant portion of the nitrogen applied to the field is remaining in the field and potentially reaching groundwater over time through percolation.[108] A high multi-year A/R ratio thus alerts the grower, the third-party group, and the regional water board to the need to address over-application at the field level. As recommended by the Agricultural Expert Panel, a multi-year A/R ratio may also provide the basis for acceptable multi-year A/R ratio target values, with reduction in the multi-year A/R ratio toward the target ratio for an area over time acting as a proxy for reduction in nitrate discharge to groundwater.[109] The Agricultural Expert Panel Report identified a shift to using the A/R ratio in nitrogen management as critical in reducing nitrogen leaching to groundwater because the multi-

[108] *Ibid.*

[109] *Id.*, pp. iii, 24, 38.

What is A and R?

A_{fer} (Applied N from fertilizer)

Amount of nitrogen applied in fertilizers, compost, and other amendments

A_{irr} (Applied N from irrigation water)

Amount of nitrogen applied through the irrigation water based on the groundwater nitrate concentration

$A_{fer} + A_{irr}$

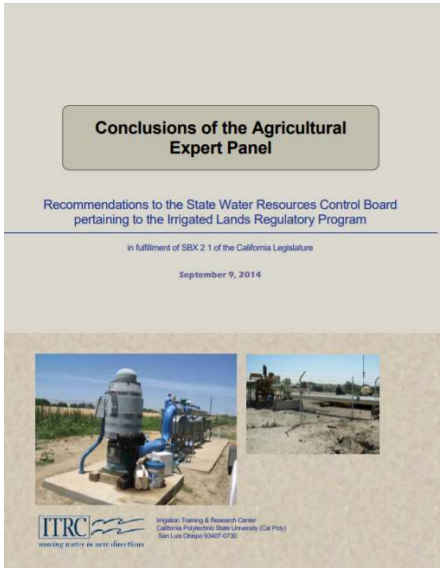
Total amount of nitrogen applied

R (Removal)

Amount of nitrogen removed through harvest, pruning, or other methods, and the nitrogen sequestered in permanent wood of perennial crops

Origin of A-R and A/R?

Conclusions of the Agricultural Expert Panel (2014)



7. The Panel recommends a relatively simple metric to identify progress for this particular regulatory issue. [Q7a][Q9] The reasons for recommending this metric, as opposed to other proxy values or metrics, are discussed in detail in this report.

The metric, to be measured and reported by farmers is the "A/R ratio", where:

$$A/R = \frac{\text{Nitrogen Applied}}{(\text{Nitrogen removed via harvest}) + (\text{Nitrogen sequestered in the permanent wood of perennial crops})}$$

Where "Nitrogen Applied" includes nitrogen from any source. Example sources are organic amendments, synthetic fertilizer, and irrigation water. [Q4b]

A – R vs A/R

A/R is a value to indicate if more N is applied than removed by the crop

A – R allows for estimates of N loading to the aquifer

A/R	**A- R**
300/100 = 3	300 – 100 = 200 lbs N/acre

How is N removal (R) estimated?

- Pounds (lbs) of fresh harvested product per acre
- Dry matter content (%)
- N content of dry matter (%)

1. Crop Coefficient = % Dry matter × % N ÷ 10,000
2. lbs of N removed = lbs fresh product × Crop Coeff.

Preliminary N removal (R) coefficients for central coast crops

Commodity	Dry matter content	N content	N REMOVAL COEFF
	%	%	
Broccoli	9.2	5	0.004600
Brussels Sprout	15.1	4.3	0.006493
Cabbage Green	7.5	2.9	0.002175
Cabbage Red	8	2.8	0.002240
Cauliflower	7.2	4	0.002880
Celery	6.3	1.9	0.001197
Cilantro	12.6	4.8	0.006048
Kale Baby	12	4.2	0.005040
Mizuna/Spring mix/Mixed greens	7.1	5.7	0.004047
Pepper Bell	7.1	2.6	0.001846
Spinach Bunch	6.4	5.8	0.003712
Spinach Clip	7.9	5.4	0.004266
Baby Lettuce	6.8	5.5	0.003757
Lettuce Leaf	5.9	4.7	0.002773
Lettuce Iceberg	4.7	3.5	0.001645
Lettuce Romaine	5.5	3.6	0.001980

Challenges for determining R coefficients on the central coast

- Number of commodities > 140
- Growers manage many small fields (< 20 acres)
- Different products produced from the same commodity (e.g. bulk, carton, hearts for lettuce; crowns, bunch, florets for broccoli)
- Dry matter content of cool season vegetables is affected by water management

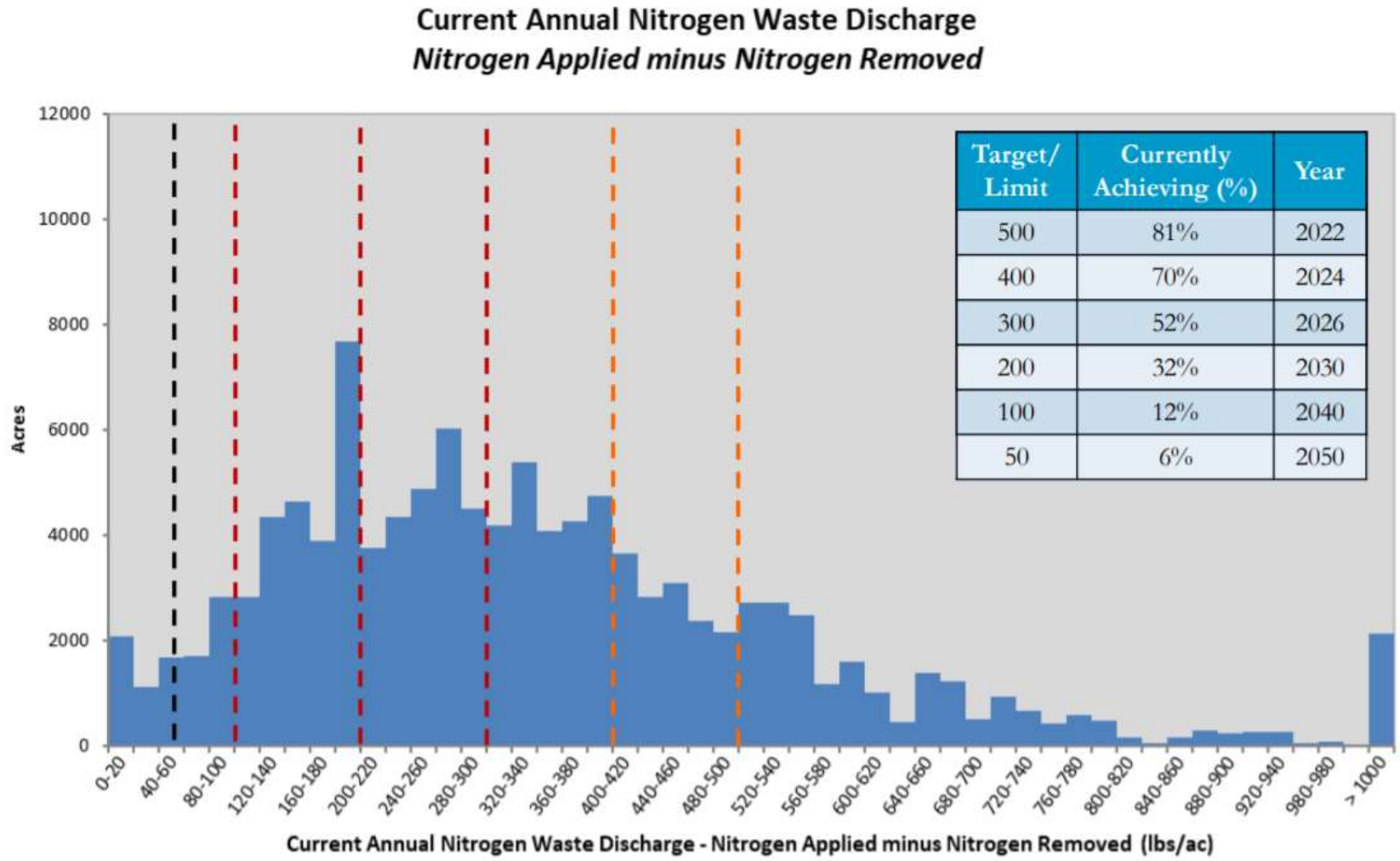
- **22 commodities represent 90% of acres on the Central Coast**
- **55 commodities represent 95% of acres on the Central Coast**

#	Crop	% acres	#	Crop	% acres
1	Lettuce	24.49	12	Peas	1.15
2	Grapes, Wine, Vineyard	19.52	13	Brussels Sprouts	1.07
3	Broccoli	12.12	14	Kale	0.83
4	Strawberry	6.34	15	Artichoke	0.76
5	Cauliflower	5.65	16	Cilantro	0.72
6	Spinach	5.39	17	Lemon	0.62
7	Celery	2.30	18	Onions	0.60
8	Spring Mix	2.18	19	Raspberry	0.60
9	Carrot	1.78	20	Peppers, Bell	0.39
10	Cabbage	1.53	21	Blackberry	0.36
11	Avocado	1.40	22	Mixed Greens	0.28

Proposed nitrogen discharge limits in Ag Order 4.0 become more difficult over time

	TABLE 1: IRRIGATION & NUTRIENT MANAGEMENT FOR GROUNDWATER PROTECTION
	Ag Order 4.0 – Updated Option
Time Schedule*	*The following years apply to Phase 1 ranches.* *For Phase 2 ranches, add 2 years to Phase 1.* *For Phase 3 ranches, add 4 years to Phase 1.* **Discharge Target** (lbs/ac/ranch/year) $A_{FER} + A_{IRR} - R = 500$ for 2022 $A_{FER} + A_{IRR} - R = 400$ for 2024 **Discharge Limit** (lbs/ac/ranch/year) $A_{FER} + A_{IRR} - R = 300$ for 2026 $A_{FER} + A_{IRR} - R = 200$ for 2030 $A_{FER} + A_{IRR} - R = 100$ for 2040 $A_{FER} + A_{IRR} - R = 50$ for 2050 ***OR**, for ranches with high A_{IRR}* $A_{FER} = R$ for 2022 **Application Limit** Application limits begin for all ranches in 2021.

Currently only 50% of growers would meet the 300 lb N/acre/year limit in 2026



Target/ Limit	Currently Achieving (%)	Year
500	81%	2022
400	70%	2024
300	52%	2026
200	32%	2030
100	12%	2040
50	6%	2050

Central Coast Regional Water Quality Control Board Staff, March 20-21, 2019

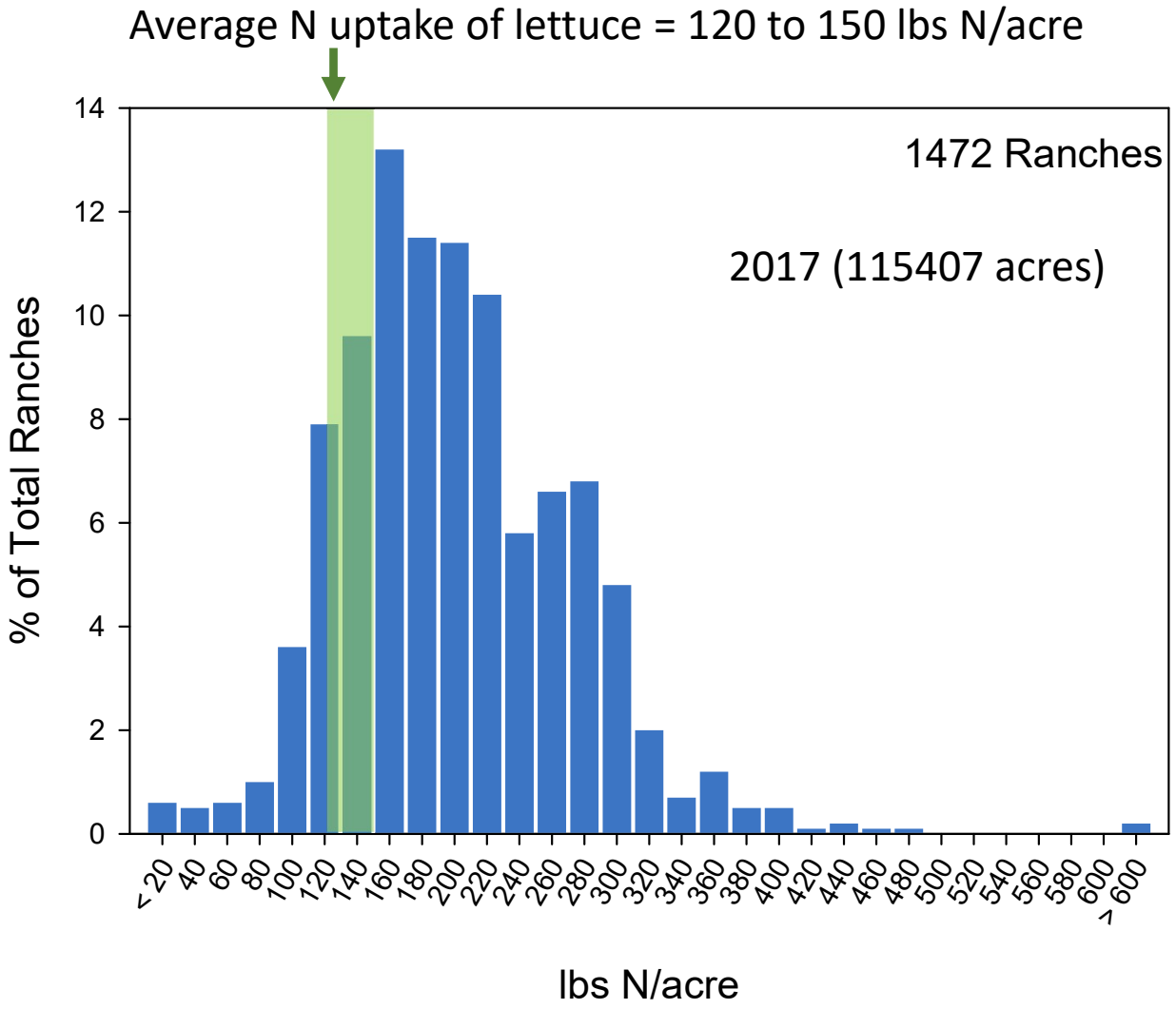
Ag Order targets will be a challenge for vegetables:

R is often < half of the N that the crop takes up over a season

Crop N uptake of various vegetables

Vegetable	Days to harvest	Seasonal Crop N uptake	N removal with harvest
		---------- lbs N/acre ----------	
Broccoli	85–100	250–350	90–100
Cauliflower	75–95	250–300	70–80
Celery	90–110	200–250	140–160
Head lettuce	65–80	120–160	60–90
Romaine lettuce	65–80	120–160	60–90
Baby lettuce	30–35	60–70	40–50
Spinach	30–35	100–130	70–90

Applied N fertilizer (N_{fer}) was more than N uptake of lettuce for more than 70% of ranches



Double crop scenario

Applied N ($A_{fert} + A_{irr}$)	crop 1 romaine lettuce	crop 2 broccoli	Seasonal Total
Applied N (lbs N/acre)	150	200	350
water applied (inches)	15	20	
nitrate concentration (ppm)	20	20	
Applied N in water (lbs N/acre	69	92	161
Total Applied N (lbs N/acre)	219	292	511
Removed N			
Yield (lbs/acre)	30,000	16,000	
N coefficient	0.00198	0.0046	
Total N removed (lbs N/acre)	59	74	133
A-R (lbs N/acre)			**378**
A/R			**3.8**

Double crop scenario (high nitrate water)

Applied N ($A_{fert} + A_{irr}$)	crop 1 romaine lettuce	crop 2 broccoli	Seasonal Total
Applied N (lbs N/acre)	150	200	350
water applied (inches)	15	20	
nitrate concentration (ppm)	**45**	**45**	
Applied N in water (lbs N/acre	155	207	**362**
Total Applied N (lbs N/acre)	305	407	**712**
Removed N			
Yield (lbs/acre)	30,000	16,000	
N coefficient	0.00198	0.0046	
Total N removed (lbs N/acre)	59	74	133
A-R (lbs N/acre)			**579**
A/R			**5.4**

Double crop scenario (reduce fertilizer)

Applied N ($A_{fert} + A_{irr}$)	crop 1 romaine lettuce	crop 2 broccoli	Seasonal Total
Applied N (lbs N/acre)	**100**	**120**	**220**
water applied (inches)	15	20	
nitrate concentration (ppm)	45	45	
Applied N in water (lbs N/acre	155	207	362
Total Applied N (lbs N/acre)	255	327	**582**
Removed N			
Yield (lbs/acre)	30,000	16,000	
N coefficient	0.00198	0.0046	
Total N removed (lbs N/acre)	59	74	133
A-R (lbs N/acre)			**449**
A/R			**4.4**

Double crop scenario (reduce fertilizer + reduced water)

Applied N ($A_{fert} + A_{irr}$)	crop 1 romaine lettuce	crop 2 broccoli	Seasonal Total
Applied N (lbs N/acre)	**100**	**120**	220
water applied (inches)	**10**	**15**	
nitrate concentration (ppm)	45	45	
Applied N in water (lbs N/acre	104	155	**259**
Total Applied N (lbs N/acre)	204	275	479
Removed N (R)			
Yield (lbs/acre)	30,000	16,000	
N coefficient	0.00198	0.0046	
Total N removed (lbs N/acre)	59	74	133
A-R (lbs N/acre)			**346**
A/R			**3.6**

Considerations for A_{fer} and A_{irr}

- **Organic amendments and fertilizers– release of plant available N depends on the C:N ratio (%N)**

- **Very little of the N in water applied during germination and crop establishment is taken up by the plants**

Rate of N released from organic fertilizers depends on the N content

	Days incubated at 68 °F		
Fertilizers	**14 days**	**28 days**	**56 days**
Dry	---------- % of N released ----------		
2.5-2-2.5	4	8	15
4-4-2	30	32	41
8-5-1	44	46	58
10-5-2	45	52	57
12-0-0	51	58	61
Liquid			
2.5-2-1	31	32	52
4-1-3	53	57	69

Smith et al. 2020

Is this all doom and gloom?

There will be a 45-day period to comment on the draft Ag Order

Could A-R limits apply only to new nitrogen (A_{fer})?

$A_{fer} + A_{irr} - R$

Relates to total nitrate loading to aquifer (nitrate concentration of leachate)

$A_{fer} - R$

Relates to loading of new N to the aquifer

Could growers receive credits (C)?

A - R- C

Practices that increase R

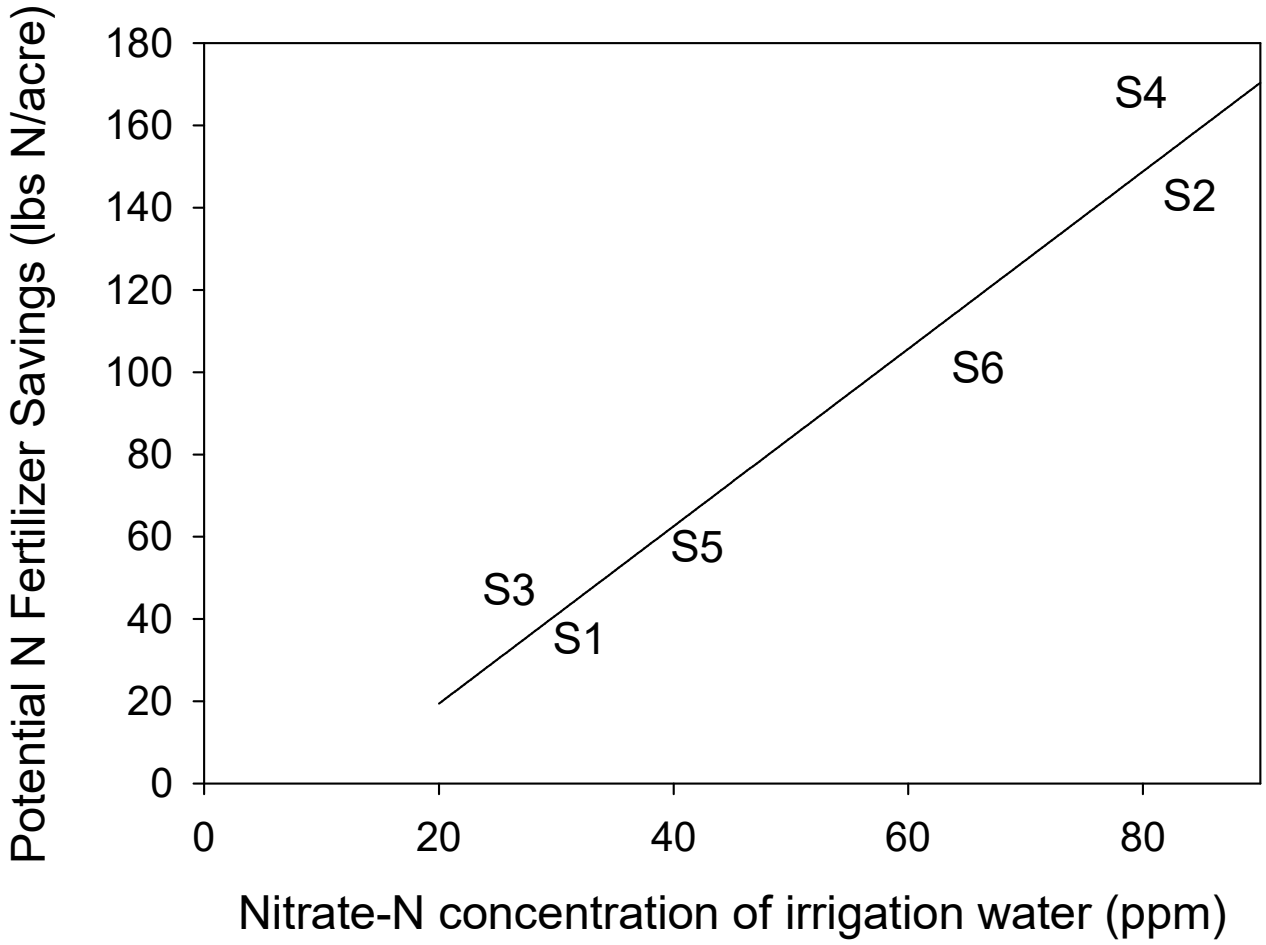
- Harvesting crop residue (broccoli residue for animal feed)
- Denitrification bioreactor
- Increasing soil organic carbon through addition of high C:N ratio amendments and crop residues (0.1% increase in organic carbon sequesters about 200 lbs N/acre/ft)

Practices that decrease A

- Organic fertilizers and amendments with low %N

The soil nitrate quick test has helped growers use less nitrogen fertilizer

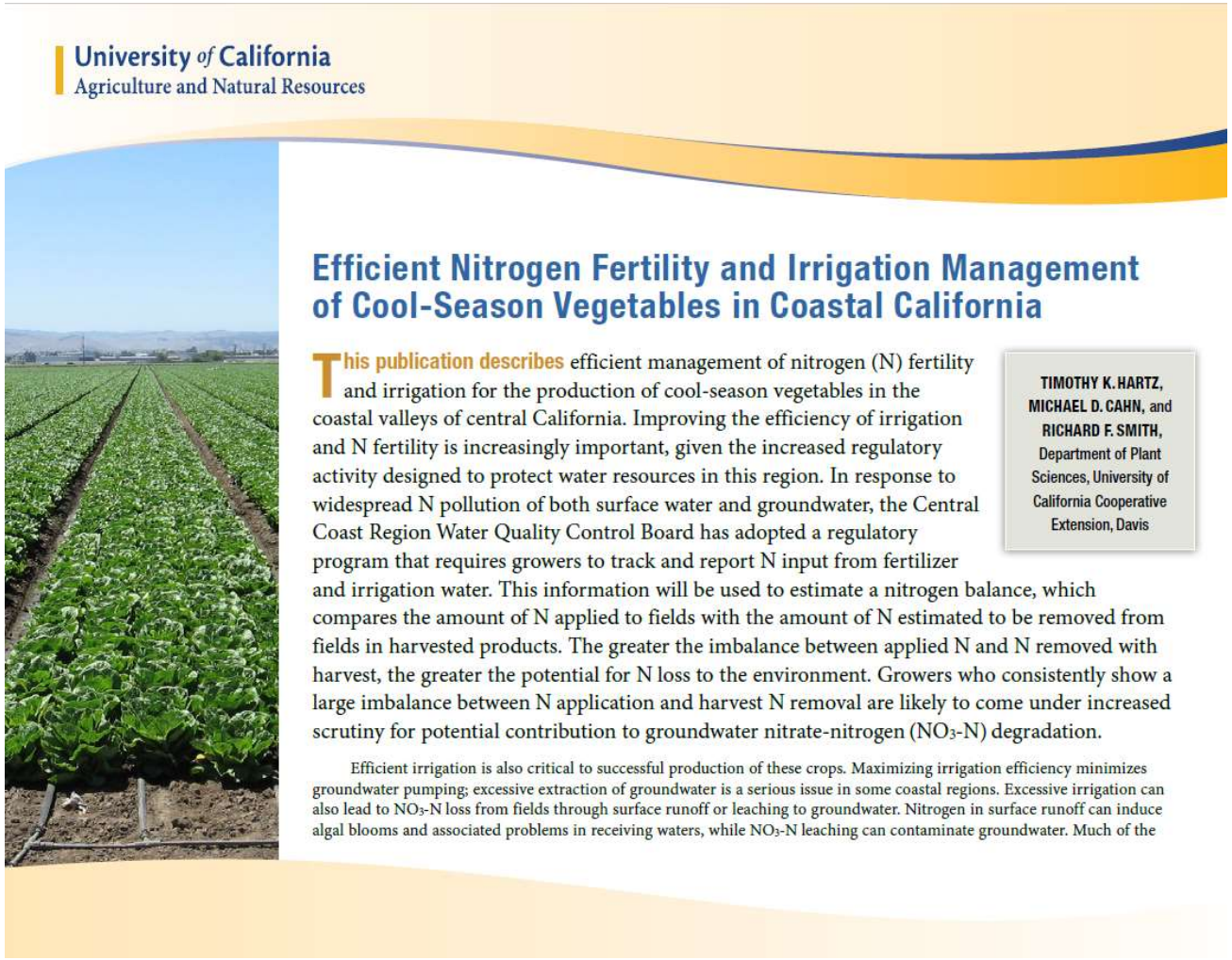
How much fertilizer* could potentially be saved by crediting N in water?



*based on average fertilizer rate of 175 lb N/acre for lettuce

Using single-use subsurface drip may help reduce water and nitrogen applications

More information on irrigation and nutrient management is at the UC ANR website



University of California
Agriculture and Natural Resources

Efficient Nitrogen Fertility and Irrigation Management of Cool-Season Vegetables in Coastal California

TIMOTHY K. HARTZ, MICHAEL D. CAHN, and RICHARD F. SMITH, Department of Plant Sciences, University of California Cooperative Extension, Davis

This publication describes efficient management of nitrogen (N) fertility and irrigation for the production of cool-season vegetables in the coastal valleys of central California. Improving the efficiency of irrigation and N fertility is increasingly important, given the increased regulatory activity designed to protect water resources in this region. In response to widespread N pollution of both surface water and groundwater, the Central Coast Region Water Quality Control Board has adopted a regulatory program that requires growers to track and report N input from fertilizer and irrigation water. This information will be used to estimate a nitrogen balance, which compares the amount of N applied to fields with the amount of N estimated to be removed from fields in harvested products. The greater the imbalance between applied N and N removed with harvest, the greater the potential for N loss to the environment. Growers who consistently show a large imbalance between N application and harvest N removal are likely to come under increased scrutiny for potential contribution to groundwater nitrate-nitrogen (NO_3-N) degradation.

Efficient irrigation is also critical to successful production of these crops. Maximizing irrigation efficiency minimizes groundwater pumping; excessive extraction of groundwater is a serious issue in some coastal regions. Excessive irrigation can also lead to NO_3-N loss from fields through surface runoff or leaching to groundwater. Nitrogen in surface runoff can induce algal blooms and associated problems in receiving waters, while NO_3-N leaching can contaminate groundwater. Much of the

https://ucanr.edu/sites/StrategicInitiatives/files/301160.pdf

UCCE Monterey County Crop Notes, March 1963

MISUSE OF LIQUID FERTILIZER

Introduction of liquid fertilizer into water wells is not only inefficient but highly hazardous to the underground water supply. This procedure has been used in some areas of California and, therefore, we bring it to your attention.

The purpose is to irrigate with nutrient-enriched water. Fertilizer is lost in the well and the possibility of polluting the underground strata is very serious. Agricultural chemicals need to be handled in a very judicious manner so that undue criticism and regulations may be avoided.

Jim Lugg


Thank you