Nitrogen Management Plan Summary Report: 2016 Crop Year

San Joaquin County & Delta Water Quality Coalition

Irrigated Lands Regulatory Program
Central Valley Regional Water Quality Control Board

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TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

A	Total available nitrogen applied per acre
APN	Assessor Parcel Number
A/Y	Total available nitrogen applied over yield per acres
SJCDWQC	San Joaquin County and Delta Water Quality Coalition
HVA	High Vulnerability Area
MPEP	Management Practices Evaluation Program
MU	Management Unit
NMP	Nitrogen Management Plan
SR	Summary Report
NR	Not Reported
R	Nitrogen removed at harvest
T-R	Township-Range
Y	Yield per acre

LIST OF TERMS

ArcGIS – Geographic Information Systems mapping software

Central Valley or Valley – California Central Valley

Coalition –San Joaquin County and Delta Water Quality Coalition

Coalition/SJCDWQC region – The region within the Central Valley that is monitored by the San Joaquin County and Delta Water Quality Coalition

NMP Management Unit – Reporting unit in the NMP Summary Report

C_N coefficient – Crop-specific nitrogen coefficient which represents the amount of nitrogen removed by the harvested crop per unit of yield.

Regional Water Board – Central Valley Regional Water Quality Control Board

NMP SUMMARY REPORT ANALYSIS

INTRODUCTION

The San Joaquin County and Delta Water Quality Coalition (Coalition or SJCDWQC) is required to submit a summary of reported nitrogen applied and removed data as a component of the Coalition's Annual Report. The WDR (Order R5-2014-0029-R1) requires that the Coalition submit "At a minimum, the statistical summary of nitrogen consumption ratios by crop or other equivalent reporting units and the estimated nitrogen consumed for the different crop types and soil conditions will describe the range, percentiles (10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}), and any outliers. A box and whisker plot or equivalent tabular or graphical presentation of the data approved by the Executive Officer may be used." Outliers are defined by the Regional Water Board as any Management Unit in which the amount of nitrogen applied per unit of yield (A/Y) falls in the upper 10% of the distribution of Management Units growing the same crop within a Township-Range (T-R).

All Coalition members are required to prepare and implement a Nitrogen Management Plan (NMP) for their farms by June 15 of each year. Growers in groundwater high vulnerability areas (HVA) are required to have their NMP Worksheets certified, either by a nitrogen specialist, a crop specialist, or self-certified if the member passes the NMP self-certification course and to submit to the Coalition a Summary Report (SR) of their previous year NMP. The NMP SR is submitted annually by June 15, using the template survey approved on December 23, 2015.

Growers report their nitrogen use by Management Unit (MU). An NMP Management Unit (NMP MU) is a field, a parcel, or a group of parcels that grow the same crop and that are managed the same way with respect to nitrogen applications. Each NMP MU can correspond to a single parcel or include more than one parcel. The NMP SRs include the total available nitrogen applied (A) in pounds per acre, and the ratio of total available nitrogen applied to yield per acre (A/Y). Growers may also provide their yield per acre (Y), though this information is not required. The A/Y ratio is an indicator of the proportion of nitrogen removed from the field at harvest.

This NMP SR Analysis includes a reporting of A/Y values by crop type and by T-R, including a summary of ranges and percentiles (10th, 25th, 50th, 75th and 90th) and identification of outliers. When possible, the Coalition converts the yield to the amount of nitrogen removed (R) from the field at harvest, and evaluates A/R and A-R. All methods and calculations are explained in the section 'NMP Summary Report Analysis Methods'.

Once the data are analyzed, the Coalition provides a Nitrogen Use Evaluation report to each member. The Nitrogen Use Evaluation reports provide an estimate of the nitrogen removed per acre for each the members' MUs, and provides summary statistics that place their nitrogen use and nitrogen removal performance in the context of other growers of the same crop. These efforts are explained in the 'Outreach and Education' section.

AVAILABLE DATA

The Coalition mailed 2,147 NMP SRs in January of 2017 to members in HVAs. NMP SRs were received from 2,058 members (count includes members that were not required to return a NMP Summary Report; Table 1).

To ensure the highest percentage of returned surveys, the Coalition sent late reminder emails and postcards to members who have not yet submitted their NMP SR. The Coalition continues to receive reports from members, though no NMP Summary Reports received after March 30, 2018 are included in this report.

Of the 2,058 returned surveys, 167 were determined to have missing or unlikely data, and were flagged for follow-up with the member (see section 'Data Quality Control'). One hundred and ten of these 167 did not correctly report on 150 MUs covering and 6,110 acres (Table 3). Sixty returned NMP SRs were incomplete and did not report on a total of 3,830 acres. Both groups were considered incomplete, for a total of 167 members (including three members with data that fell into both categories) over 9,940 acres. Many of the incomplete NMP SRs, however, were partially analyzed, as members could have reported data that the Coalition flagged as potentially incorrect while other reported data did not get flagged. For example, if a grower reported two MUs where one MU was reported correctly with all required information complete and the other was flagged as incomplete, this member would be counted as having both a complete and incomplete survey.

For the 2016 crop year, the Coalition had and overall return rate of 93% of required members reporting on 98% of required acres in the Coalition region.

Table 1. Summary of members and acreages associated with returned NMP Summary Reports.

NMP Summary Reports Status	Count of Members	Sum of Acreage
Not Received - Required	143	5,046
Received - Not Required	54	2,570
Received - Required	2,004	193,541
Total Received	**2,058**	**196,111**

The most abundant crops in the Coalition region are almonds and grapes. Approximately half of the acreage associated with NMP SRs was from almond or vineyards (Figure 1). Other important crops in the Coalition region are walnuts, cherries, and alfalfa (Figure 1). Table 2 includes a summary of the acreage associated with each crop type for returned NMP SRs.

Figure 1. Major crops reported in the Coalition NMP Summary Reports.
"All Other" crops are listed in Table 2 starting with Forage Grass

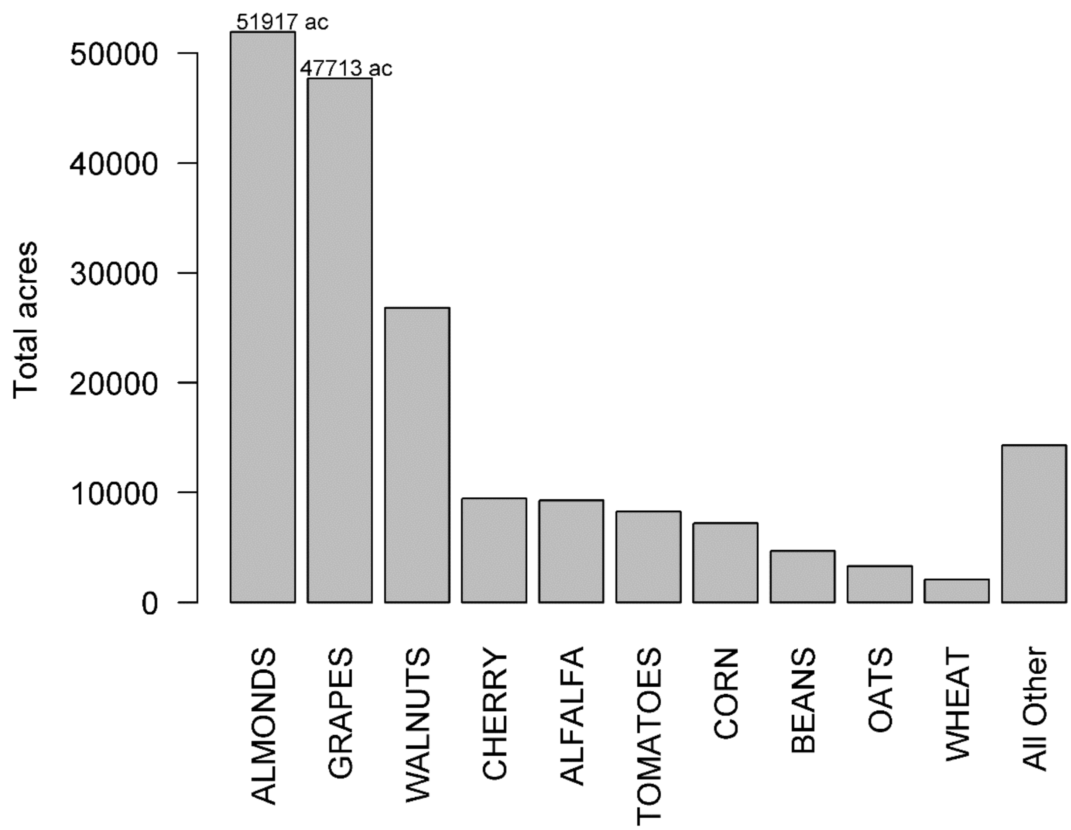


Table 2. Summary of crops reported in the SJCDWQC on NMP SRs, including the acreage and number of members reporting. Sorted by acreage.

CROP	COUNT OF MEMBERS	ACREAGE
ALMONDS	760	51,917
GRAPES	500	47,713
WALNUTS	401	26,809
CHERRY	262	9,461
ALFALFA	96	9,285
TOMATOES	69	8,267
CORN	81	7,224
BEANS	40	4,686
OATS	46	3,319
WHEAT	36	2,083
FORAGE GRASS	26	1,817
SAFFLOWER	14	1,582
MELONS	21	1,510
PUMPKINS	14	1,435
CARROT	10	1,130
OLIVES	19	1,105
APPLES	13	948
PEACHES	21	839
SMALL GRAIN (EXCL WHEAT AND OATS)	13	527
RICE	5	498
CUCUMBERS	6	477
SQUASH	12	459

Crop	Count of Members	Acreage
PEPPERS	7	266
COTTON	3	229
APRICOTS	5	227
BASIL	6	172
PISTACHIOS	3	167
STRAWBERRIES	15	127
ONIONS	5	107
BERRY	7	77
CLOVER	1	74
ASPARAGUS	4	73
SORGHUM/SUDAN	1	55
POMEGRANATES	4	53
CABBAGE	3	51
VEGETABLES	6	40
KIWIFRUIT	2	35
SWEET POTATOES	2	30
KALE	3	27
CILANTRO	2	24
PERSIMMONS	6	23
BOK CHOY	2	18
LETTUCE	1	14
NECTARINES	2	12
PEAS	2	10
GARLIC	4	9
BEETS	2	9
SPINACH	2	9
CHARD	1	8
PLUMS	2	5
EGGPLANT	2	4
CITRUS	1	3
BROCCOLI	2	3
JUJUBE	1	3
GREENS	1	2
POTATOES	1	2
MUSTARD	1	2
PLUM-APRICOT HYBRIDS	1	1
HERBS	1	1
CHESTNUTS	1	1
DANDELION	1	0.8
LEEKS	1	0.2
CELERY	1	0.2
RADISHES	1	0.2
TURNIPS	1	0.2
PARSLEY	1	0.1
Total Acreage		**185,065** [1]

[1] Total Acreage does not include 11,046 acres reported on unspecified crops, not farmed parcels, cover crops, nurseries, or pastures (See Data Quality Control Section below).

DATA QUALITY CONTROL

Completeness

The hardcopy of all received NMP SRs were reviewed for completeness. Any data that were considered incomplete were flagged for follow-up. A NMP SR was considered incomplete and required follow-up with the grower if:

1. Not all APNs designated as high vulnerability to groundwater were reported.
2. A crop was not provided. For example, a grower may have reported "row crops" and therefore the Coalition could not determine the specific crop type grown on the field.
3. Acreage of APNs was not provided and/or could not be determined through enrolled acreage.
4. NMP MU data could not be associated with a specific APN.
5. The NMP SR was missing any of the requisite NMP data, including amount nitrogen applied per acre, A/Y ratio, or a production unit for the yield.

Complete data were further reviewed for consistency by ensuring that all reported APNs were associated with the correct membership ID and were within the SJCDWQC boundary. Duplicated entries based on APN or MU were reconciled or removed.

Data Verification and Corrections

The Coalition reviewed the yield per acre (Y) and the nitrogen applied per acre (A) to determine if the reported data appeared reasonable. Yields varied by multiple orders of magnitude between all crops, ranging from 0 pounds per acre to more than 100,000 lbs/acre for some crops. Yields reported at higher than 250,000 lbs/acre and nitrogen application rates higher than 1,000 lbs/acre were determined likely to represent errors in the reporting and were flagged for review and follow up. Additionally, the Coalition identified MUs with data quality concerns by comparing reported A and Y values to the distribution of values per crop shown in **Error! Reference source not found.**. The Coalition estimates t hat any a NMP MU with an A or Y value that was twice the 75th percentile of all other data for the same crop was most likely reported incorrectly. The MUs identified as having an unlikely A or Y were flagged for review and follow-up; if the data were not reconciled, they were marked as incomplete and not included in the analysis of outliers.

All data flagged for follow-up due to incompleteness, inconsistencies, or unlikely yield or nitrogen applications were reviewed against the original submission to ensure these values were not the result of data-entry errors. In addition, 16% of NMP SRs were selected at random and reviewed for data entry accuracy.

Data Excluded from the Analysis

Some data received by the Coalition were not included in the analysis because the member reported crops for which no NMP SR is no data is required or for which no data is available. Parcels excluded from the analyses include those that fall within one or more the following situations:

1. APNs that were reported as not farmed (fallow, open).
2. Cover crops, as these receive no N applications and have no yield.
3. Rice field MUs, as these are reported by the California Rice Commission.

4. Nurseries and grass sod, as they have no yield in the traditional sense.
5. Pastures have no yield in the traditional sense, but farmers can estimate yields using available tools. Currently growers with pasture are not required to submit NMP SRs if fertilizers are not applied. The Coalition excluded pastures most of the time, but included some forage MUs where the growers reported A and Y.

The NMP MUs with incomplete data or data flagged with other quality concerns (that had not been addressed through follow-up by the time this report was prepared) were also excluded from the analysis. The number of NMP MUs and acreage excluded due to quality concerns are listed in Table 3. In total, 150 NMP MUs were excluded from the analysis due to data quality issues. After follow-ups and exclusions, the Coalition was able to use complete NMP SR data from 1,737 members farming 158,870 irrigated acres and 62 crops.

Table 3. Number of reported MUs and associated acreage excluded from the analysis due to incomplete data or unverified yields or nitrogen applications.

Crop	Count of MUs	Total Acres
ALFALFA	3	133
ALMONDS	49	2,099
BOK CHOY	1	18
CARROT	1	45
CHERRY	11	368
CORN	5	166
CUCUMBERS	1	2
FORAGE GRASS	3	225
GRAPES	34	1,207
MELONS	1	220
OATS	2	225
OLIVES	2	143
POMEGRANATES	1	1
SAFFLOWER	1	46
SMALL GRAIN (EXCL WHEAT AND OATS)	2	49
STRAWBERRIES	3	21
TOMATOES	1	7
VEGETABLES	2	5
WALNUTS	27	1,130
Total	**150**	**6,110**

Yield Estimation and Units

Growers are not required to report their yields on their NMP SR. In cases where yield was not provided, the Coalition used nitrogen applied and the A/Y ratio values submitted on the NMP SR to calculate the yield per acre. If the crop yield was reported in a production unit other than pounds, the Coalition converted the yield to pounds using the conversion values in Table 4

Table 4. Conversion factor for production units different from pounds.

Production Unit	Lbs Conversion
1/2-bushel carton (28 lbs)	28
1/2-bushel carton (30 lbs)	30
12, 1/2-pint baskets (6 lbs)	6
12, 1-pint (12 lbs)	12
15, 1/2-inch wirebound crate (50-53 lbs)	52
2 Layer Carton (22 lbs)	22
2 layer tray pack (20-25 lbs)	22
2/3 Carton (30 lbs)	30
4/5 Bushel Crate (20 lbs)	20
5-Dozen Bunches (20-25 lbs)	22
Bag (100 lbs)	100
Bag (25 lbs)	25
Bag (50 lbs)	50
Bale (200 lbs)	200
Bale (500 lbs)	500
Bin (1050 lbs)	1050
Bin (800 lbs)	800
Bin (850 lbs)	850
Bin (900 lbs)	900
Box (12 lbs)	12
Bundle (6 lbs)	6
Bushel (25 lbs)	25
Bushel (28-32 lbs)	30
Bushel (30 lbs)	30
Bushel (32 lbs)	32
Bushel (40 lbs)	40
Bushel (48 lbs)	48
Bushel (56 lbs)	56
Bushel (60 lbs)	60
Bushel (70 lbs)	70
Bushel Basket (40 lbs)	40
Carton (100 lbs)	100
Carton (13 lbs)	13
Carton (18 lbs)	18
Carton (20 lbs)	20
Carton (23 lbs)	23
Carton (25 lbs)	25
Carton (30 lbs)	30
Carton (33 lbs)	33
Carton (38 lbs)	38
Carton (40 lbs)	40

Production Unit	Lbs Conversion
Carton (50 lbs)	50
Carton (55 lbs)	55
Carton (60 lbs)	60
Carton (85 lbs)	85
Carton of 30 (11-12 lbs)	12
Carton or Lug (22 lbs)	22
Carton/25 Bunches (8 lbs)	8
Crate (30 lbs)	30
Crate (38 lbs)	38
Crate (40 lbs)	40
Crate (50 lbs)	50
Crate (50-60 lbs)	55
Crate (60 lbs)	60
Cwt (100 lbs)	100
Flat (4-6 lbs)	5
Flat (6 lbs)	6
Flat of 12 pots (10 lbs)	10
Lug Box (112 lbs)	112
Lug Box (12-15 lbs)	14
Lug Box (18 lbs)	18
Lug Box (24 lbs)	24
Lug Box (25-30 lbs)	28
Lug Box (28 lbs)	28
Pounds	1
Sack (25 lbs)	25
Sack (50 lbs)	50
Sack (60 lbs)	60
Sacks (100 lbs)	100
Sacks of 8, 5-pound bags (40 lbs)	40
SX (100 lbs)	100
Tons (2000 lbs)	2000
Units	1

Crop Classification

The statistical analysis of NMP SR data and the identification of outliers are strongly dependent on comparing NMP SR data from similar crops, necessitating an accurate classification of crops. In addition to the crop species (e.g., corn, alfalfa), many of the crops grown in the region can be harvested in very different ways (e.g., hay vs. silage) or from different varieties (e.g. corn grain vs. sweet corn). Some of these differences in harvest types and varieties have important implications for the analysis.

In field crops, different harvest types result in very different yields per acre. For example, field crops harvested as hay have lower moisture content (usually around 12%) than the same crop harvested as silage (usually around 70%). As a result, the yields reported for hay harvests are significantly lower than the yields reported for silage harvests, even if both harvests remove the same dry matter and nitrogen content from the field; therefore, hay and silage harvests cannot be compared to each other. Additionally, different types of harvest remove different amounts of N per pound of yield. For example, crops harvested as grain have a higher N content than the same crop harvested as silage. Therefore, for field crops the harvest type must be reported for the data to be useable in the analysis and correctly calculate A/R and A-R.

Some fruit crops are grown and harvested for different purposes (e.g., wine grapes vs. table grapes; or processing tomatoes vs. market tomatoes). These fruit varieties may differ in moisture content and N concentration, making the distinction important for the correct analysis of A/Y and identification of outliers. Current crop-specific nitrogen (C_N) coefficients and preliminary analysis of the yields suggest that these differences are not as large as the differences seen among field crop harvest types. However, as the quality of the data improves over time, some distinctions may become more apparent. Tree crops also have smaller yields per acre for younger trees that have not reached full maturity. Therefore, the summary statistics in Appendix I include an analysis of outliers by T-R based on the crop group and additional summary statistics based on crop age for perennial tree crops.

To account for those crop differences and facilitate an accurate analysis, the Coalition classifies crops using a specific crop type that includes the harvest type, crop variety, and crop age, when applicable. The Coalition is improving the list of specific crop types to best represent the growing practices in the region and the nitrogen management information required by the Regional Water Board. This is an ongoing process, and as a result, some of the crop classifications used in this report are slightly different from the ones used in the NMP SR Analysis of the 2015 crop year.

When a grower provided an ambiguous crop name for crops that could have very large differences in yields or N content depending on the harvest type, the Coalition excluded these MUs from the analysis. However, when a grower reported ambiguous crop names for crops that are less variable (e.g., tomatoes or peaches), the Coalition included them in the analysis. The Coalition expects that crop classification will become more accurate over time.

N Removal Calculations

All C_N coefficients were obtained from Dr. Daniel Geisseler's 2016 report[1] (with the single exception of berries). The C_N coefficients for blackberries, blueberries and raspberries are from CDFA, as no values were reported by Geisseler for these crops. In this report, Geisseler performed an extensive literature review of nitrogen concentrations for a wide variety of crops and summarized all data, providing an average N removal per crop. In addition, Geisseler provided a coefficient of variation to assess the variability of the data around each mean, and an assessment of the quality, completeness, and relevance of the dataset. By the author's own assessment, many of the values are poor or unreliable estimates for the Central Valley.

The Coalition is using the average C_N coefficients reported in Geisseler (2016) with the understanding that many of the values are poor estimates and will change in the future. After further review, the Coalition also considers the coefficient of variation provided by Geisseler not to be a proper statistic to estimate variability. Instead, to assess variability, the Coalition used the range of values from all studies reviewed by Geisseler for each crop. A summary of Geisseler's mean C_N coefficients, the range of values, and both Geisseler's and the Coalition's quality assessments, are provided in Table 5. The Coalition plans on updating and improving these values over time, as more, higher quality data become available.

In some cases, the crop types reported by Geisseler were more specific than those used by the Coalition. For example, while the Coalition reports on wheat as a single crop type, Geisseler has two separate (albeit similar) values for durum and common grain wheat. In such cases, the Coalition calculated an average of the multiple values provided by Geisseler. Averages calculated by the Coalition are presented in Table 6.

In some cases where the Coalition calculated average C_N coefficients for groups of similar crops, the Coalition's quality assessment of the average differed from Geisseler's assessment of the more specific crops used to calculate the average. For example, Geisseler considers that there are insufficient data for black-eyed and garbanzo beans from the Central Valley, and it is not possible to determine if the average he provides is a good estimate for the region. However, the Coalition observed that those values overlap substantially with values from lima beans, which are considered by Geisseler to be reasonable estimates for the region. Given the strong overlap in means and ranges, the Coalition considers that the average for dry beans is likely also a reasonable estimate for the region. The same group quality assessment was made for citrus based on their general overlap with each other and oranges from California, for market tomatoes based its overlap with processing tomatoes from California, and for oat grain based on its overlap with other small grains from California (Table 5).

[1] Geisseler, Daniel. 2016. Nitrogen concentrations in harvested plant parts – A literature overview. Prepared for the Central Valley ILRP Water Quality Coalitions.

The specific C_N coefficients that were applied to each specific crop type reported by Coalition growers are shown in Table 7. Crops with available C_N coefficients in this report cover 178,139 acres, 96% of the available data (based on the total number of received and complete reports).

Table 5. C_N coefficients reported by Geisseler (2016) with their range and quality assessment; this is a subset of crops based on SJCDWQC NMP SR results.

Commodity	C_N Coefficient			Units	Quality Assessment	
	Mean	Min	Max		Coalition	Geisseler Report (2016)
Alfalfa - Hay	0.03115	0.02465	0.04125	lbs N/lbs @ 12% moisture	Good	The dataset used for this report can be considered a very good estimate for alfalfa hay produced in California. However, the range probably includes sites outside the Central Valley.
Alfalfa - Haylage	0.012	0.00925	0.0138	lbs N/lbs @ 65% moisture	Good	The estimate can be considered a very good estimate of alfalfa silage produce in California. However, the dataset is small and more samples are needed.
Almonds	0.068	0.051	0.087	lbs N/lbs of marketable kernels	Good	The value is a good estimate for N removed from almond orchards in the Central Valley.
Apples	0.00054	0.0003	0.001615	lbs N/lbs of fruits	Poor	The value is only a rough estimate.
Apricots	0.00278	0.00224	0.00282	lbs N/lbs of fruits	Poor	The value is only a rough estimate.
Asparagus	0.002925	0.00196	0.00444	lbs N/lbs of fresh spears	Poor	The value may not be representative for contemporary asparagus in the Central Valley. More recent data needs to be collected from California.
Beans, dry - Blackeye	0.0365	0.02815	0.0403	lbs N/lbs of mature dry beans @ 12% moisture	Poor	It is not possible to determine the degree to which the average value is representative. Needs a more representative sample from the Central Valley. However, values overlap substantially with lima beans from California.
Beans, dry - Garbanzo	0.0336	0.0234	0.04785	lbs N/lbs of mature dry beans @ 12% moisture	Poor	It is not possible to determine the degree to which the average value is representative. Needs a more representative sample from the Central Valley. However, values overlap substantially with lima beans from California.
Beans, dry - Lima	0.03615	0.03165	0.045	lbs N/lbs of mature dry beans @ 12% moisture	Reasonable	The value in the table may be a reasonable estimate of N in lima beans harvested in California.
Beans, green (Snap beans)	0.00289	0.002225	0.0036	lbs N/lbs of harvested pods	Reasonable	It is not possible to determine how well the average value represents green beans harvested in the Central Valley. More data needs to be collected from fields in the Central Valley.
Broccoli	0.0056	0.00374	0.0095	lbs N/lbs of fresh weight	Poor	The average value may not be a good estimate of the N concentration in broccoli in the Central Valley. Samples need to be collected from the Central Valley.
Carrots	0.001645	0.000855	0.003675	lbs N/lbs of carrot root	Poor	No recent values are available from California. It is not possible to determine the degree to which the value is representative of the Central Valley.
Cherries	0.00221	0.00135	0.003335	lbs N/lbs of fruits	Poor	The value is only a rough estimate.
Corn - Grain	0.012	0.003	0.0268	lbs N/lbs of grain @ 15.5% moisture	Poor	More corn grain samples from Central Valley fields are necessary to determine whether the value is a good estimate for the region.
Corn - Silage	0.00378	0.0025	0.0052	lbs N/lbs @ 70% moisture	Good	This value can be considered a very good estimate of Central Valley corn silage.
Corn - Sweet	0.003585	0.002415	0.0053	lbs N/lbs of fresh ears	Reasonable	It is not possible to determine whether the values in the table are a good estimate for N concentrations in sweet corn in California.

Commodity	C_N Coefficient			Units	Quality assessment	
	Mean	Min	Max		Coalition	Geisseler Report (2016)
Cotton	0.02185	0.01165	0.0316	lbs N/lbs lint & seed	Good	The value can be considered a very good estimate of the N concentration in cotton from the Central Valley.
Cucumbers	0.00108	0.0008	0.00142	lbs N/lbs of fresh weight	Reasonable	It is not possible to determine how well the average value represents the N concentration of cucumbers in California. More recent data from the Central Valley is needed.
Garlic	0.00755	0.004705	0.01024	lbs N/lbs of bulb weight	Poor	The variability within and among studies is high. With no recent values from California, it is not possible to determine how well the values in the table represent N concentrations in garlic harvested in California.
Grapes - Table	0.00113	0.00089	0.001405	lbs N/lbs of grapes	Reasonable	The value is a good estimate of N removed with 'Thompson Seedless' grapes from California vineyards. However, it likely underestimates the variability of grape N concentrations in commercial vineyards.
Grapes - Wine	0.0018	0.00098	0.0026	lbs N/lbs of grapes	Poor	It cannot be determined if value is representative for wine grapes from California.
Melons - Cantaloupe	0.002435	0.000985	0.00351	lbs N/lbs of melons	Poor	The variability within and among the studies is large, indicating samples need to be collected from fields in California to generate a more robust estimate.
Melons, Water	0.000695	0.000475	0.00102	lbs N/lbs of melons	Poor	With no recent data from California, it is not possible to determine if the value is a good estimate of watermelon harvested from the Central Valley.
Nectarines	0.00182	0.000825	0.002775	lbs N/lbs of fruits	Reasonable	The value may be a reasonable estimate of N in nectarines form the Central Valley. However, the dataset may not fully capture the variability.
Oat - Grain	0.01885	0.01325	0.02535	lbs N/lbs of grain @ 12% moisture	Poor	With no oat grain data from California, values may not be representative of oats grown in California. However, means and ranges overlap substantially, with other small grains from the Central Valley.
Oat - Hay	0.01085	0.0073	0.01465	lbs N/lbs @ 12% moisture	Good	The value is a good estimate of the average N concentration in oat hay produced in the Central Valley.
Olives	0.00314	0.002	0.00555	lbs N/lbs of olives	Reasonable	The dataset may provide a reasonable estimate of N removed with olives. However, the dataset needs more samples from orchards in the Central Valley.
Onions	0.00197	0.0008	0.0031445	lbs N/lbs of bulb weight	Poor	The value may not be representative of N concentrations in onions harvested in the Central Valley.
Peaches	0.00113	0.00069	0.001845	lbs N/lbs of fruits	Reasonable	The average N concentration may be a reasonable estimate of N in California peaches. However, needs more data from the Central Valley.
Pepper - Bell	0.001655	0.00109	0.003065	lbs N/lbs of fresh weight	Poor	It is not possible to determine whether the value is a good estimate of bell peppers grown in the Central Valley.
Pistachios	0.02805	0.02705	0.0288	lbs N/lbs dry yield (CPC)	Good	The value is a good estimate for N removed from pistachio orchards in the Central Valley.
Plums	0.001415	0.0012	0.00165	lbs N/lbs of fruits	Poor	It is not possible to determine how well the dataset represents N concentrations in the Central Valley.
Pomegranate	0.0076	0.00605	0.00935	lbs N/lbs of fruits	Poor	It is not possible to determine the degree to which the value is representative of pomegranates harvested in the Central Valley.

Commodity	C_N Coefficient			Units	Quality assessment	
	Mean	Min	Max		Coalition	Geisseler Report (2016)
Potatoes	0.00312	0.00204	0.00461	lbs N/lbs of fresh weight	Poor	It is not possible to determine how well the dataset represents N concentrations in potatoes harvested in the Central Valley.
Pumpkin	0.00368	0.002135	0.00453	lbs N/lbs of fresh weight	Poor	The value is likely not representative of N concentration of pumpkins in the Central Valley.
Safflower	0.0284	0.0169	0.05465	lbs N/lbs of seed @ 8% moisture	Poor	The variability within and among studies was uncharacteristically large. With only one study from California, the average may not be representative of N concentrations from California.
Squash	0.001835	0.00032	0.0032	lbs N/lbs of fresh weight	Poor	Some N concentrations refer to the edible part of the fruit, and may not represent the N removed with the whole fruit.
Sweet potatoes	0.00237	0.001715	0.003185	lbs N/lbs of fresh weight	Good	The value is a good estimate for N removed with sweet potatoes from Central Valley fields.
Tomatoes - Fresh market	0.001305	0.000945	0.001695	lbs N/lbs of fresh weight	Poor	It is not possible to determine the degree to which the dataset is representative of tomatoes harvested in the Central Valley. However, means and ranges overlap substantially, with processing tomatoes from the Central Valley.
Tomatoes - Processing	0.001365	0.00095	0.0018	lbs N/lbs of fresh weight	Good	The average value can be considered a very good estimate for the Central Valley.
Walnuts	0.01595	0.012	0.0232	lbs N/lbs with shells	Reasonable	The value can be considered a good estimate of N removed with walnuts in the Central Valley. However, the data range may not fully capture the variability.
Wheat - Silage	0.00525	0.00335	0.00725	lbs N/lbs @ 70% moisture	Reasonable	The dataset likely provides a good estimate of the average N concentration in wheat silage produced in the Central Valley. However, the data may not fully capture the variability.

Table 6. C_N coefficients calculated by the Coalition by averaging coefficients from similar crops evaluated separately by Geisseler (2016).

COMMODITY	C_N COEFFICIENT			UNITS	DESCRIPTION AND QUALITY ASSESSMENT	
	Mean	Min	Max			
Beans, dry - average	0.0354	0.0234	0.0479	lbs N/lbs of mature dry beans @ 12% moisture	Reasonable	This is an average of black-eyed, garbanzo and lima beans. As means and ranges overlap substantially for the different beans, and some values were obtained in California, this is likely a reasonable estimate for the Central Valley. The Coalition applied this value to cases when the growers did not specify the type of bean reported.
Citrus, average	0.00138	0.0008	0.00243	lbs N/lbs of fruits	Reasonable	This value is an average of grapefruit, lemons, oranges, and tangerines. Means and ranges for the different citrus overlap substantially. The Coalition used this citrus average C_N coefficient in cases when the grower reported other citrus fruits not included in that list. As means and ranges overlap substantially, this average can be considered a reasonable estimate for citrus.
Foragegrass - Hay, average	0.0267	0.0169	0.0382	lbs N/lbs @ 12% moisture	Poor	Geisseler evaluated tall fescue, orchard grass and ryegrass separately. The Coalition created a forage grass average C_N coefficient and applied that to cases when the grower did not specify the kind of grass hay reported. Means and ranges for the different grass C_N coefficients overlap substantially. However, they are all from the same trial, and may overestimate the N concentrations in the Central Valley.
Grapes - average	0.00147	0.00089	0.0026	lbs N/lbs of grapes	Reasonable	This value is an average of wine and table grapes. Although N removal might be higher in wine grapes, there is substantial overlap, and this mean value may be reasonable for grapes in the Central Valley. The Coalition applied this value to cases when the grower did not specify the kind of grapes reported.
Lettuce - average	0.00156	0.000875	0.00256	lbs N/lbs of fresh weight	Reasonable	Geisseler evaluated iceberg and romaine lettuce separately. Means and ranges for the two C_N coefficients overlap substantially. The Coalition created a lettuce average C_N coefficient and applied that to all salad greens reported by the growers. Geisseler believes the value is likely a reasonable estimate of N concentrations in the Central Valley, even though most of the data are from the Salinas Valley.
Small grains - Grain, average	0.0197	0.0098	0.027	lbs N/lbs of grain @ 12% moisture	Good	This is an average of barley, triticale, oats, common wheat and durum wheat. The Coalition applied this value to cases when the grower did not specify the kind of small grain reported. As means and ranges overlap substantially among the different small grains, this is likely a reasonable estimate of N Removal with small grains grain in the Central Valley.
Small grains - Silage, average	0.00488	0.00335	0.00725	lbs N/lbs @ 70% moisture	Good	This is an average of triticale and wheat. The Coalition applied this value to all other small grains, and to cases when the grower did not specify the kind of small grain reported. As means and ranges overlap substantially among the two small grains, this is likely a reasonable estimate of N Removal with small grains silage in the Central Valley.

Commodity	C_N Coefficient			Units	Description and Quality Assessment	
	Mean	Min	Max			
Tomatoes - average	0.00134	0.000945	0.0018	lbs N/lbs of fresh weight	**Good**	Geisseler evaluated market and processing tomatoes separately. Means and ranges for the two C_N coefficients overlap substantially. The Coalition created a tomato average C_N coefficient and applied that to cases when the grower did not specify the kind of tomato reported. As values overlap substantially, and there is good representation for processing tomatoes in the Central Valley, this is likely a reasonable estimate for tomato N removal in the region.
Wheat - Grain, average	0.0213	0.0161	0.027	lbs N/lbs of grain @ 12% moisture	**Good**	Geisseler evaluated grains from common wheat and durum wheat separately. Coalition growers did not differentiate between the two types of wheat. The Coalition applied this average to all wheat reported by the growers. Both values overlap substantially and results are highly representative of wheat grown in Central Valley.

Table 7. C_N coefficients applied to each of the Specific Crop Types used by the Coalition.
Some of the values used are not good estimates. The quality assessment of C_N coefficients sourced from Geisseler (2016) is provided in Table 5 for crops in the Coalition region. Coalition averages and their quality assessment are explained in Table 6.

Coalition Specific Crop type	C_N Coefficient Commodity	C_N Coefficient Source	Quality Assessment	C_N Coefficient	Units
ALFALFA, HAY	Alfalfa - Hay	Geisseler (2016)	Good	0.0311	lbs N/lbs @ 12% moisture
ALFALFA, HAYLAGE	Alfalfa - Haylage	Geisseler (2016)	Good	0.012	lbs N/lbs @ 65% moisture
ALMONDS	Almonds	Geisseler (2016)	Good	0.068	lbs N/lbs of marketable kernels
APPLES	Apples	Geisseler (2016)	Poor	0.0005	lbs N/lbs of fruits
APRICOTS	Apricots	Geisseler (2016)	Poor	0.0028	lbs N/lbs of fruits
ASPARAGUS	Asparagus	Geisseler (2016)	Poor	0.0029	lbs N/lbs of fresh spears
BEANS, DRY	Beans, dry - average	Coalition average	Reasonable	0.0354	lbs N/lbs of mature dry beans @ 12% moisture
BEANS, DRY, BLACK-EYED	Beans, dry - Blackeye	Geisseler (2016)	Poor	0.0365	lbs N/lbs of mature dry beans @ 12% moisture
BEANS, DRY, GARBANZO	Beans, dry - Garbanzo	Geisseler (2016)	Poor	0.0336	lbs N/lbs of mature dry beans @ 12% moisture
BEANS, DRY, LIMA	Beans, dry - Lima	Geisseler (2016)	Reasonable	0.0362	lbs N/lbs of mature dry beans @ 12% moisture
BEANS, GREEN	Beans, green (Snap beans)	Geisseler (2016)	Reasonable	0.0029	lbs N/lbs of harvested pods
BERRY, BLACKBERRY	Strawberries	CDFA FREP[1]	--	0.0013	lbs N/lbs of fruit
BERRY, BLUEBERRY	Strawberries	CDFA FREP[1]	--	0.0013	lbs N/lbs of fruit
BERRY, RASPBERRIES	Strawberries	CDFA FREP[1]	--	0.0013	lbs N/lbs of fruit
BROCCOLI	Broccoli	Geisseler (2016)	Poor	0.0056	lbs N/lbs of fresh weight
CARROT	Carrots	Geisseler (2016)	Poor	0.0016	lbs N/lbs of carrot root
CHARD	Lettuce - average	Coalition average	Reasonable	0.0016	lbs N/lbs of fresh weight
CHERRY	Cherries	Geisseler (2016)	Poor	0.0022	lbs N/lbs of fruits
CITRUS, MANDARINS	Citrus, average	Coalition average	Reasonable	0.0014	lbs N/lbs of fruits
CORN, GRAIN	Corn - Grain	Geisseler (2016)	Poor	0.012	lbs N/lbs of grain @ 15.5% moisture
CORN, SILAGE	Corn - Silage	Geisseler (2016)	Good	0.0038	lbs N/lbs @ 70% moisture
CORN, SWEET	Corn - Sweet	Geisseler (2016)	Reasonable	0.0036	lbs N/lbs of fresh ears
COTTON	Cotton	Geisseler (2016)	Good	0.0219	lbs N/lbs lint & seed
CUCUMBERS	Cucumbers	Geisseler (2016)	Reasonable	0.0011	lbs N/lbs of fresh weight
FORAGE GRASS, HAY	Foragegrass - Hay, average	Coalition average	Poor	0.0267	lbs N/lbs @ 12% moisture

Coalition Specific Crop type	C_N Coefficient Commodity	C_N Coefficient Source	Quality Assessment	C_N Coefficient	Units
GARLIC	Garlic	Geisseler (2016)	Poor	0.0076	lbs N/lbs of bulb weight
GRAPES, NR	Grapes - average	Coalition average	Reasonable	0.0015	lbs N/lbs of grapes
GRAPES, TABLE	Grapes - Table	Geisseler (2016)	Reasonable	0.0011	lbs N/lbs of grapes
GRAPES, WINE	Grapes - Wine	Geisseler (2016)	Poor	0.0018	lbs N/lbs of grapes
GREENS, COLLARD	Lettuce - average	Coalition average	Reasonable	0.0016	lbs N/lbs of fresh weight
KALE	Lettuce - average	Coalition average	Reasonable	0.0016	lbs N/lbs of fresh weight
LETTUCE	Lettuce - average	Coalition average	Reasonable	0.0016	lbs N/lbs of fresh weight
MELONS, CANTALOUP	Melons - Cantaloupe	Geisseler (2016)	Poor	0.0024	lbs N/lbs of melons
MELONS, WATERMELON	Melons, Water	Geisseler (2016)	Poor	0.0007	lbs N/lbs of melons
MUSTARD, GREENS	Lettuce - average	Coalition average	Reasonable	0.0016	lbs N/lbs of fresh weight
NECTARINES	Nectarines	Geisseler (2016)	Reasonable	0.0018	lbs N/lbs of fruits
OATS, GRAIN	Oat - Grain	Geisseler (2016)	Poor	0.0189	lbs N/lbs of grain @ 12% moisture
OATS, HAY	Oat - Hay	Geisseler (2016)	Good	0.0109	lbs N/lbs @ 12% moisture
OATS, SILAGE	Small grains - Silage, average	Coalition average	Good	0.0049	lbs N/lbs @ 70% moisture
OLIVES	Olives	Geisseler (2016)	Reasonable	0.0031	lbs N/lbs of olives
ONIONS, BULB	Onions	Geisseler (2016)	Poor	0.002	lbs N/lbs of bulb weight
PEACHES, FRESH MARKET	Peaches	Geisseler (2016)	Reasonable	0.0011	lbs N/lbs of fruits
PEACHES, NR	Peaches	Geisseler (2016)	Reasonable	0.0011	lbs N/lbs of fruits
PEACHES, PROCESSING	Peaches	Geisseler (2016)	Reasonable	0.0011	lbs N/lbs of fruits
PEAS, GREEN	Beans, green (Snap beans)	Geisseler (2016)	Reasonable	0.0029	lbs N/lbs of harvested pods
PEPPERS, BELL	Pepper - Bell	Geisseler (2016)	Poor	0.0017	lbs N/lbs of fresh weight
PEPPERS, CHILE	Pepper - Bell	Geisseler (2016)	Poor	0.0017	lbs N/lbs of fresh weight
PISTACHIOS	Pistachios	Geisseler (2016)	Good	0.0281	lbs N/lbs dry yield (CPC)
PLUM-APRICOT HYBRIDS	Plums	Geisseler (2016)	Poor	0.0014	lbs N/lbs of fruits
PLUMS	Plums	Geisseler (2016)	Poor	0.0014	lbs N/lbs of fruits
POMEGRANATES	Pomegranate	Geisseler (2016)	Poor	0.0076	lbs N/lbs of fruits
POTATOES	Potatoes	Geisseler (2016)	Poor	0.0031	lbs N/lbs of fresh weight
PUMPKINS	Pumpkin	Geisseler (2016)	Poor	0.0037	lbs N/lbs of fresh weight
SAFFLOWER	Safflower	Geisseler (2016)	Poor	0.0284	lbs N/lbs of seed @ 8% moisture

Coalition Specific Crop type	C_N Coefficient Commodity	C_N Coefficient Source	Quality Assessment	C_N Coefficient	Units
SMALL GRAIN (EXCL WHEAT AND OATS), GRAIN	Small grains - Grain, average	Coalition average	Good	0.0197	lbs N/lbs of grain @ 12% moisture
SPINACH	Lettuce - average	Coalition average	Reasonable	0.0016	lbs N/lbs of fresh weight
SQUASH, NR	Squash	Geisseler (2016)	Poor	0.0018	lbs N/lbs of fresh weight
SQUASH, SUMMER	Squash	Geisseler (2016)	Poor	0.0018	lbs N/lbs of fresh weight
SQUASH, WINTER	Squash	Geisseler (2016)	Poor	0.0018	lbs N/lbs of fresh weight
STRAWBERRIES	Strawberries	CDFA FREP[1]	--	0.0013	lbs N/lbs of fruit
SWEET POTATOES	Sweet potatoes	Geisseler (2016)	Good	0.0024	lbs N/lbs of fresh weight
TOMATOES, FRESH MARKET	Tomatoes - Fresh market	Geisseler (2016)	Poor	0.0013	lbs N/lbs of fresh weight
TOMATOES, NR	Tomatoes - average	Coalition average	Good	0.0013	lbs N/lbs of fresh weight
TOMATOES, PROCESSING	Tomatoes - Processing	Geisseler (2016)	Good	0.0014	lbs N/lbs of fresh weight
WALNUTS	Walnuts	Geisseler (2016)	Reasonable	0.016	lbs N/lbs with shells
WHEAT, GRAIN	Wheat - Grain, average	Coalition average	Good	0.0213	lbs N/lbs of grain @ 12% moisture
WHEAT, SILAGE	Wheat - Silage	Geisseler (2016)	Reasonable	0.0053	lbs N/lbs @ 70% moisture

[1] CDFA FREP values were obtained from http://apps.cdfa.ca.gov/frep/docs/N_Strawberry.html. No data quality assessment exists for this value.

Statistical Methods

All analyses were performed using R software for statistical computing[2]. The Coalition calculated summary statistics on the NMP SR values by crop. Summary statistics included the minimum, the maximum, and the 10th, 25th, 50th, 75th, and 90th percentiles of A/Y, A-R, and A/R (if the C_N coefficient was known). Percentiles were calculated using the R function "quantile" per the default method in R. This is a quantile method for continuous variables, where the quantiles are obtained by linear interpolation between data points. For example, if only two data points were available, the median is interpolated half way between them, and the 90th percentile is one ninth of the way from the highest value. All data points (NMP MUs) with A/Y values > the 90th percentile within each group were flagged as outliers.

Summary statistics were also calculated by T-R to comply with the Order requirements. Each T-R represents 36 sections (23,040 acres). The NMP data were associated with a T-R location using ArcGIS by overlaying the TRS layer with the county parcel layers. There were 37 MUs associated with APNs that could not be associated to a T-R. These were labeled as T-R unknown and treated as a single T-R in the analysis. Some NMP MUs were associated with more than one T-R because different parcels or parts of a parcel overlapped with multiple T-Rs. To avoid having the MUs duplicated in the T-R outlier analysis, these NMP MUs were assigned to the T-R that included most of the MU area.

As indicated in the Order, the Coalition used standard box and whisker plots to visualize data grouped by crop and T-R (Appendix I). In the box and whisker plots, the "boxes" indicate the 25th, 50th, and 75th percentiles, and "whiskers" the data range. The default box and whisker plot method in R calculates the percentiles as described above for the quantile calculation. The data range are the most extreme data point, which are no more than 1.5 times the length of the box away from the box. In addition to the box and whisker plots, the Coalition generated standard scatter plots of A vs. Y to visualize the range of nitrogen applications and yields for each crop (Appendix I).

[2] R Core Team 2016. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

RESULTS

The analysis was performed at the level of NMP MUs, which represents field level management of nitrogen by Coalition members. After QC, there were 3,242 NMP MUs with complete data (Table 8). Of these, 362 MUs from non-yield (NY) or nonbearing (NB) crops that have no A/Y due to zero yield. The NY/NB crops cover 15,177 acres and reported applications of 13,954 lbs of nitrogen (Table 8. In addition, there were 61 MUs (3,964 acres, Table 8) that had ambiguous crop types. This occurred when members did not provide enough specific crop information on their NMP SRs (e.g. only reporting "Corn" without a harvest type). While MUs with ambiguous crop types had valid A/Y values, the Coalition determined that these could not be used to reliably calculate summary statistics and estimate outliers (See Crop Classification Section). With the exclusion of MUs with NY/NB crops or with ambiguous crop types, this analysis reflects the A/Y values of 3,242 NMP MUs.

Table 8. List of crop groups used in the Appendix I and Specific Crop Types (not including tree age) reported by growers in the Coalition region.
Additional information includes the total number of MUs reported, total nitrogen applied, yield, and acreage for each Specific Crop Type.

Crop Group	Specific Crop Type[1]	Number of MUs	Total N Applied (lbs)	Total Yield Harvested (lbs)	Total Acres
Almonds	ALMONDS	986	158,387	5,817,655	42,796
Apples	APPLES	12	435	311,831	616
Apricots	APRICOTS	6	288	87,668	227
Asparagus	ASPARAGUS	4	151	6,655	73
Beans	BEANS, DRY	13	792	25,682	1,956
Beans	BEANS, DRY, BLACK-EYED	9	435	17,487	593
Beans	BEANS, DRY, GARBANZO	4	131	9,639	262
Beans	BEANS, DRY, LIMA	15	1,296	38,795	1,678
Beets	BEETS	2	155	35,491	9
Berries	BERRY, BLACKBERRY	2	72	100	31
Berries	BERRY, BLUEBERRY	4	39	16,800	45
Berries	BERRY, RASPBERRIES	1	114	700	2
Berries	STRAWBERRIES	9	607	158,500	51
Bok Choy	BOK CHOY	1	0	--	0.2
Broccoli	BROCCOLI	2	40	7,978	3
Cabbage	CABBAGE	3	231	84,667	51
Carrots	CARROT	9	1,183	485,947	1,085
Celery	CELERY	1	0	--	0.2
Cherries	CHERRY	280	12,745	1,848,559	7,683
Chestnuts	CHESTNUTS	1	0	--	1
Citrus	CITRUS, MANDARINS	1	0	2,240	3
Corn, sweet	CORN, SWEET	18	3,677	1,392,145	1,142
Cotton	COTTON	3	420	3,500	229
Cucumbers	CUCUMBERS	6	410	243,953	477
Eggplant	EGGPLANT	2	107	8,255	4
Forage	FORAGE GRASS, FORAGE	5	295	59,937	806
Forage	OATS, FORAGE	5	558	125,398	283
Forage	SMALL GRAIN (EXCL WHEAT AND OATS), FORAGE	1	84	3,000	65

Crop Group	Specific Crop Type[1]	Number of MUs	Total N Applied (lbs)	Total Yield Harvested (lbs)	Total Acres
Forage	WHEAT, FORAGE	1	100	39,063	30
Garlic	GARLIC	4	357	38,777	9
Grains	OATS, GRAIN	1	0	--	15
Grains	WHEAT, GRAIN	1	100	5,000	20
Grains, Corn	CORN, GRAIN	4	838	44,022	296
Grapes	GRAPES, NR	75	2,344	200,818,417	2,903
Grapes	GRAPES, TABLE	42	1,135	30,507,264	1,560
Grapes	GRAPES, WINE	806	32,193	54,103,571	41,087
Green Beans	BEANS, GREEN	3	107	2,050	12
Greens	CHARD	1	120	28,500	8
Greens	GREENS, COLLARD	1	120	35,251	2
Greens	LETTUCE	3	360	60,554	14
Greens	KALE	3	225	47,524	27
Greens	MUSTARD, GREENS	1	120	33,480	2
Greens	ONIONS, GREEN	1	225	40,000	82
Greens	SPINACH	2	80	22,320	9
Hay	SMALL GRAIN (EXCL WHEAT AND OATS), HAY	6	174	16,878	135
Hay	WHEAT, HAY	4	396	50,010	56
Hay	OATS, HAY	6	121	33,176	218
Hay	FORAGE GRASS, HAY	17	1,177	94,745	754
Hay, Alfalfa	ALFALFA, HAY	101	3,596	2,054,400	8,995
Herbs	CILANTRO	2	270	23,100	24
Herbs	DANDELION	1	120	28,500	0.8
Herbs	BASIL	6	675	18,378	172
Herbs	HERBS, FRESH CUT	1	35	5,000	1
Herbs	PARSLEY	1	0	--	0.1
Jujube	JUJUBE	1	38	20,000	3
Kiwis	KIWIFRUIT	2	124	27,094	35
Leeks	LEEKS	1	0	--	0.2
Melons	MELONS, CANTALOUP	2	85	19,500	48
Melons	MELONS, NR	1	100	12,000	208
Melons	MELONS, WATERMELON	17	2,949	1,403,897	1,034
Nectarines	NECTARINES	2	146	81,112	12
Olives	OLIVES	20	590	449,562	765
Onions	ONIONS, BULB	4	398	27,181	25
Peaches	PEACHES, FRESH MARKET	11	1,121	260,362	177
Peaches	PEACHES, NR	4	635	225,144	187
Peaches	PEACHES, PROCESSING	9	585	303,248	334
Peas	PEAS, GREEN	3	144	814	10
Peppers	PEPPERS, BELL	5	522	82,818	262
Peppers	PEPPERS, CHILE	3	55	7,549	4
Persimmons	PERSIMMONS	6	107	50,380	23
Pistachios	PISTACHIOS	2	361	4,959	47
Plums	PLUM-APRICOT HYBRIDS	1	67	17,632	1
Plums	PLUMS	2	62	40,250	5
Pomegranates	POMEGRANATES	2	50	25,894	42
Potatoes	POTATOES	1	35	9,722	2
Potatoes	SWEET POTATOES	2	72	400	30
Pumpkins	PUMPKINS	15	1,805	655,590	1,435
Radishes	RADISHES	1	0	--	0.2

Crop Group	Specific Crop Type[1]	Number of MUs	Total N Applied (lbs)	Total Yield Harvested (lbs)	Total Acres
Safflower	SAFFLOWER	12	675	22,744	1,451
Silage	OATS, SILAGE	18	1,476	419,406	1,684
Silage	WHEAT, SILAGE	2	213	50,548	108
Silage, Alfalfa	ALFALFA, HAYLAGE	3	188	34,799	175
Silage, Corn	CORN, SILAGE	49	9,130	130,805,545	4,599
Squash	SQUASH, NR	5	411	84,833	331
Squash	SQUASH, SUMMER	6	387	38,553	43
Squash	SQUASH, WINTER	1	100	1,500	85
Tomatoes	TOMATOES, FRESH MARKET	15	2,110	444,222	818
Tomatoes	TOMATOES, NR	16	3,191	1,381,631	1,473
Tomatoes	TOMATOES, PROCESSING	58	10,554	5,256,995	5,929
Turnips	TURNIPS	1	0	--	0.2
Walnuts	WALNUTS	452	60,196	14,088,592	21,508
Ambiguous Crop Types[2]	WHEAT, NR	28	2,828	219,471	1,826
	VEGETABLES, NR	5	315	3,750	35
	SMALL GRAIN (EXCL WHEAT AND OATS), NR	4	470	27,897	264
	SORGHUM/SUDAN, NR	1	35	4,000	55
	CORN, NR	11	1,929	549,681	1,035
	CLOVER, NR	1	0	--	74
	FORAGE GRASS, NR	1	0	8,000	20
	OATS, NR	10	570	57,000	655
NB[3]	NON-BEARING	269	10,959	0	11,633
NY[3]	NO YIELD	93	2,995	0	3,544

NR – Crop or crop age not reported.

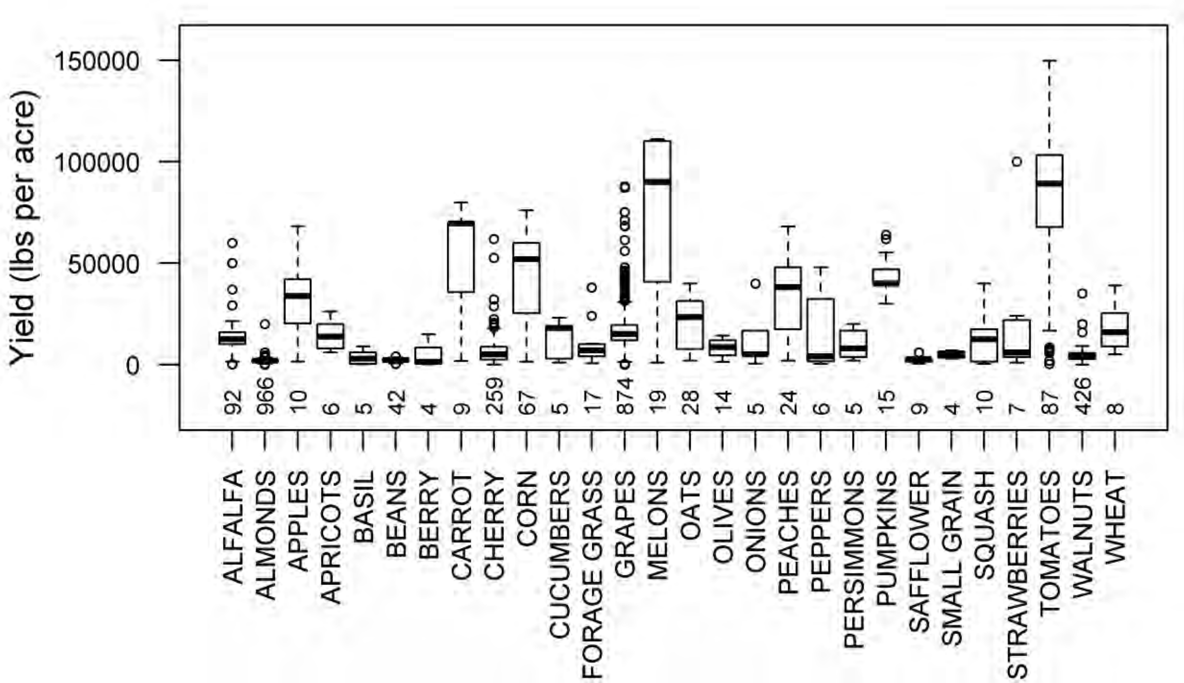
[1]Additional age categories are reported in Appendix I for perennial following crops.

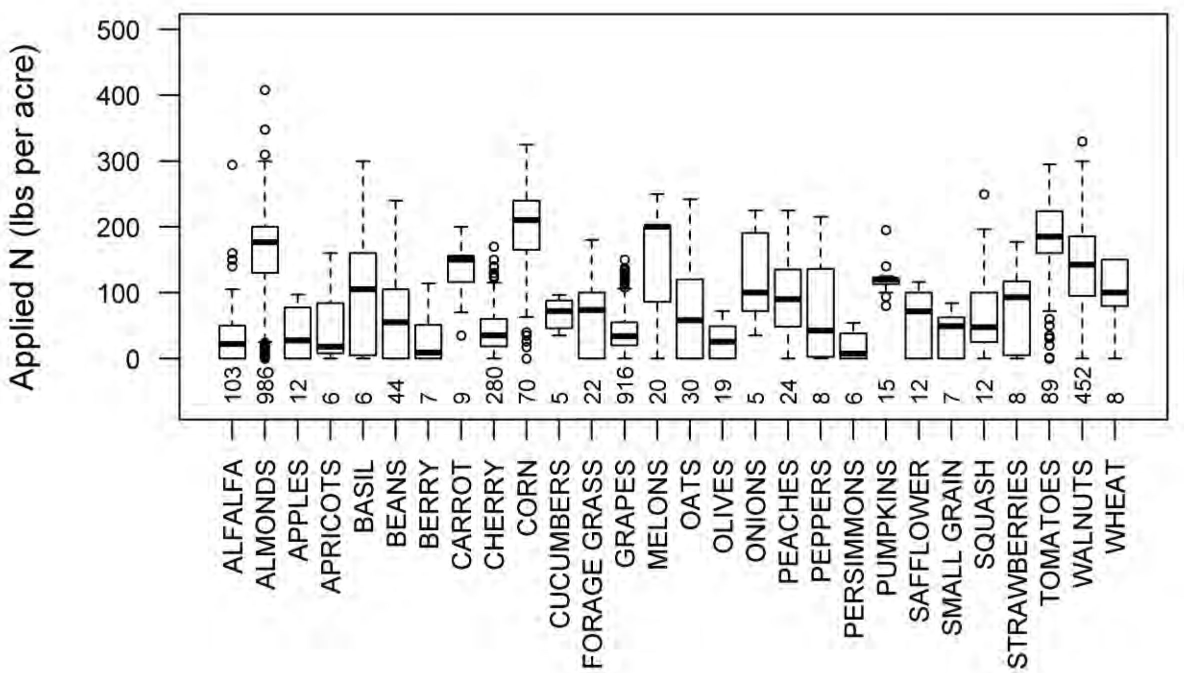
[2] Not included in the analysis because the harvest type is necessary to compare data appropriately.

[3] Not included in the analysis because these MUs have no A/Y.

Figure 2. Box and whisker plots showing the yield (Y) and nitrogen applied (A) per acre for the most common crop groups in the region.

Reporting yield in the NMP SR is optional when there are no N applications, as a result there are MUs that have no Yield values and there are fewer MUs in the yield plots.





Summary Statistics and Outliers by T-R

The Order requires the Coalition to report statistical summaries for parcels grouped by township, and "any outliers for similar soil conditions and similar crops in that township". In this analysis, the Coalition provides summary statistics and a count of outliers by similar crops and by T-R. However, further aggregation of the data by soil conditions, as suggested by the Order, would have limited the ability of the Coalition to calculate summary statistics. As such, this section reports statistical summaries only by similar crops and T-R, and the analysis by soil types is presented separately in the following section.

Even without grouping by soil conditions, the outlier identification by T-R is not reliable because, when grouping by crop type, most T-Rs have very small sample sizes. Any T-R with only one MU (or two MUs with identical A/Ys) will have no summary statistics and no outliers, even if the MU has a very large A/Y relative to neighboring T-Rs with more data points. If only two data points are available, the default method to calculate quantiles assumes that those are the range (e.g. 0% and 100% percentiles). All other percentiles are then calculated linearly, at the corresponding steps between those two points (i.e., the 90th percentile is one ninth of the way from the highest value). Thus, for any T-R with only two MUs in any particular crop type, the highest value will always be considered an outlier (>90th percentile). This would happen even if both points have very low A/Y values relative to neighboring T-Rs with more data points. The summary statistics are more meaningful when calculated from a larger sample size, and thus require the use of the region-wide data grouped by similar crop.

Box and whisker plots and summary statistics by specific crop type and by T-R are provided in Appendix I. For each crop group, the Coalition generated two sets of box plots and summary statistics: 1) plots and statistics by T-R (as requested by the Order), and 2) plots and statistics for the whole region (to provide a more robust estimate of outliers). In an attempt to increase the sample size to calculate summary statistics by T-Rs, the Coalition grouped similar crops within each crop group as listed in Table 8. To calculate summary statistics for the whole region, the Coalition used the appropriate specific crop type. Tables of summary statistics are also submitted with this report electronically as an Excel file.

The Regional Water Board also requested that the Coalition evaluate and provide an analysis of nitrogen applied relative to recommended fertilizer application rates. Fertilizer recommendations vary depending on factors such as age of crop, target yield, soil type, and irrigation method. The Coalition plotted a number of possible fertilizer recommendations as part of the scatter plots in Appendix I. Recommendations were obtained from the CDFA FREP (https://www.cdfa.ca.gov/is/ffldrs/frep/) and from the UC Cooperative Extension cost analysis (http://coststudies.ucdavis.edu/current/). Data from UC Davis are not recommendations but estimates of the amount of fertilizer used in a typical operation. The Coalition reviewed all available data from these two sources and, when possible, selected values from studies conducted within the SJCDWQC. A table explaining the source and applicability of each of the fertilizer recommendations for each crop is provided next to the corresponding scatter plot. It is important to note that this is not a comprehensive review of recommended application rates and should not be used to draw any conclusions regarding their accuracy or applicability to specific fields.

In scatter plots, each dot is an MU, and outliers (A/Y > 90% for the crop category) are highlighted in red. The NMP SRs do not include information that would explain very low yields (i.e., if a crop was lost or why), or application rates that are elevated due to irrigation with high nitrate concentration groundwater. However, these kinds of plots can be used to prioritize outreach to growers that have outlier MUs due to high nitrogen applications, as opposed to growers that are outliers due to reduced or lost yield.

Comparison of Outliers from 2015 and 2016 NMP SR Analyses

The Coalition compared the outliers obtained in this analysis to the outliers from the analysis of the 2015 NMP SR data. Because of the problems identifying outliers by T-R, the Coalition compared only outliers by crop type (for the whole Coalition region). Table 9 shows the number of Coalition members with at least one outlier in the 20 top crops in the region by acreage for the 2016 crop year. Table 9 suggests that relatively few members were identified as an outlier both years, with higher proportions occurring in the most abundant crops (almonds, wine grapes, cherries, and walnuts). Eleven of the top 20 crops had no members identified as outliers both years, while others, such as sweet corn and carrots, had the same single member identified as the crop's only outlier.

2017 was the first year the Coalition implemented outreach efforts to communicate the results of statistical analyses and an individual grower's status as an outlier based on results from the 2015 crop year. It is expected that as growers begin to incorporate the information in these outreach materials provided by the Coalition into their nitrogen planning and management practices, the amount of overlap between identified outliers over multiple years will decrease. Efforts to communicate the occurrence and significance of outlier status to growers are outlined in the Outreach and Education section below.

Table 9. Count of members having at least one outlier NMP MU in the top 20 crops in the region.
This count is by member only. Members can have outliers in more than one crop, or more than one MU per crop. This table does not indicate if outliers belong to the same MU.

Specific Crop Type	Number of members with at least one outlier MU		Number of members with outliers both years	Percent 2016 Outliers with an Outlier MU the Previous Year
	2015 Crop Year	2016 Crop Year	Both 2015 and 2016	
ALFALFA, HAY	9	10	3	30%
ALMONDS	79	100	14	14%
APPLES	1	1	0	0%
BEANS, DRY	1	2	0	0%
BEANS, DRY, LIMA	1	2	0	0%
CARROT	1	1	1	100%
CHERRY	24	30	6	20%
CORN, SILAGE	3	5	0	0%
CORN, SWEET	1	1	1	100%
FORAGE GRASS, HAY	1	2	0	0%
GRAPES, TABLE	10	4	0	0%
GRAPES, WINE	73	82	24	29%
MELONS, WATERMELON	1	2	1	50%
OATS, SILAGE	1	2	0	0%
OLIVES	2	2	1	50%
PUMPKINS	0	1	0	0%
SAFFLOWER	1	2	0	0%
TOMATOES, FRESH MARKET	1	2	0	0%

Specific Crop Type	Number of members with at least one outlier MU		Number of members with outliers both years	Percent 2016 Outliers with an Outlier MU the Previous Year
	2015 Crop Year	2016 Crop Year	Both 2015 and 2016	
TOMATOES, PROCESSING	6	5	0	0%
WALNUTS	39	46	12	26%

Evaluation of A/Y by Soil Type

The goal of this section is to determine if soil type groupings can be a useful category to calculate the summary statistics and identify outliers in a meaningful way. It is possible that farming operations in sandy soils may have higher A/Y values because of their lower nutrient retention capacity. When soil nutrient retention is low, farmers may apply larger amounts of fertilizer (increase A) to compensate for loss due to leaching, or may realize lower yields due to the lower availability of fertilizers (decrease Y), although these possible scenarios depend largely on management of nitrogen and irrigation water. To evaluate the possible effect of soil type on A/Y, the Coalition tested for differences in A/Y among NMP MUs with different soil types.

The analysis focused on the 12 most common crops in the region. These are almonds, wine grapes, walnuts, alfalfa hay, cherries, processing tomatoes, corn silage, undefined grapes, dry beans, oat silage, lima bean, and table grapes. By acreage, wheat was more abundant than the latter three crops. However, wheat could not be used for this analysis as most members reporting information on A and A/Y for wheat did not specify the crop type. The 12 crops analyzed comprise 88% of the acreage available for this report.

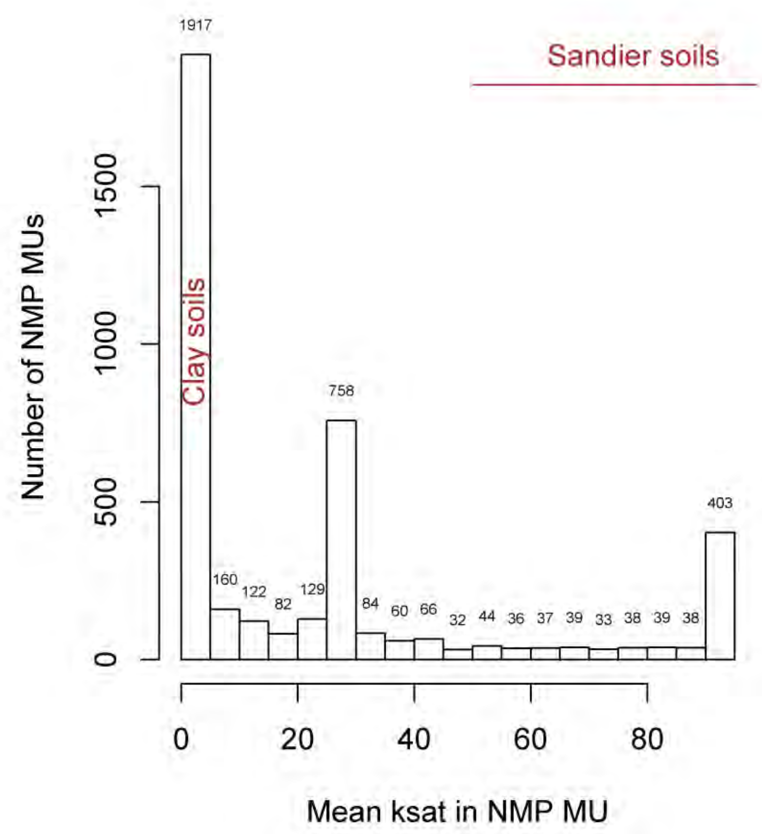
The Coalition characterized soil types within the SJCDWQC region based on the saturated hydraulic conductivity (K_{sat}) of the soils. The K_{sat} is a measure of the potential for water percolation and leaching of nutrients through the soil. The K_{sat} values are associated with the soil texture, which determines the rate at which water moves through the soil profile. Lower K_{sat} values are characteristic of clay soils, with low porosity, percolation, and low potential for leaching of nutrients to groundwater. Higher K_{sat} values are characteristic of sandy soils with high porosity, percolation, and potential for leaching of nutrients below the root zone and to the groundwater.

Soil data were obtained from the USDA Soil Survey Geographic Database (SSURGO: http://www.soils.usda.gov/survey/geography/ssurgo/). The "Gridded Soil Survey Geographic (gSSURGO) Database State-tile Package" product is derived from the Soil Survey Geographic (2.2) Database dated November 16, 2015. Parcel layer data were developed by the Coalition. Parcel layer data were overlaid on the SSURGO soil data using the 'Identify' processing tool; all soil map units present in each parcel were identified. Soil information was assigned to each NMP MU by linking the map unit from the soil data to each parcel within each NMP MU.

Soil K_{sat} in each parcel and NMP MU can vary vertically with soil depth, and horizontally among different soil types. Vertical variation in K_{sat} was summarized by selecting the minimum value among all horizons down to a 1 meter depth. The horizon with the minimum K_{sat} is the one that will limit the hydraulic conductivity of the soil profile. Summarizing horizontal variation in K_{sat} within a parcel or NMP MU was more challenging. Most NMP MUs had two or more soil types associated to them. Some NMP MUs contained over 20 different soil types. Soil types within one NMP MU could have similar properties or be dramatically different. For example, some NMP MUs had portions of clay and portions of sandy soils, resulting in K_{sat} ranges of 92 µm/s within a single NMP MU.

Due to the horizontal variability in soil types within each NMP MU, it was necessary to use summary statistics to obtain a K_{sat} value representative of each NMP MU. For this analysis, the Coalition calculated the weighted average K_{sat} in each NMP MU (from here on called *mean K_{sat}*). The mean K_{sat} is the average of all K_{sat} values from different soil types inside one NMP MU, weighted by the area of each soil type. This mean K_{sat} satisfactorily identifies NMP MUs with consistently large or small K_{sat} values. The NMP MUs with contrasting soil types produce intermediate mean K_{sat} that cannot be differentiated from soil types with intermediate conductivity. Figure 3 shows the frequency of different mean K_{sat} values among MUs in the Coalition region.

Figure 3. Distribution of mean K_{sat} values for MUs throughout the Coalition region based on parcels reported for the 2016 Crop Year.



For the purpose of this analysis, and based on the range of K_{sat} values in the SJCDWQC region, soils were classified as "Low" conductivity ($K_{sat} \leq 10$), "Medium" conductivity (K_{sat} from 10 to 30), and "High" conductivity ($K_{sat} \geq 30$). Most of the SJCDWQC NMP MUs are characterized by low conductivity soils (Figure 3).

The Coalition evaluated if A/Y differed among the K_{sat} categories described above using simple linear models for each of the major crops (Figure 4 and Figure 5). Linear models test the hypothesis that the mean A/Y differs among any of the soil type categories. One weakness of linear models is that, in skewed data such as A/Y, the mean A/Y is mostly influenced by the number and size of the outliers. To avoid cases where a few outlier values bias the test (by increasing the mean they exert an overly large impact on the results), the Coalition excluded some extremely large A/Y outliers (larger than two times the 90^{th} quantile of the data for that crop) from the analysis. Eliminated outliers are indicated in a cut y-axis in Figure 4 and Figure 5. The Coalition also determined if the frequency of outliers differed among K_{sat} categories using Chi-square tests (Table 10). Chi-squared tests are based on counts and are not affected by the size of the outliers. Hence, Chi-square analyses can use all the data, and are a good compliment to linear models.

Overall, there was no evidence that soil type influenced the mean A/Y in the SJCDWQC region (Figure 4 and Figure 5). Reported p-values ($p > 0.05$ for all crops) indicate that there is no difference in the mean A/Y among soil categories within each crop type.

The Coalition concludes that, for the crops that cover nearly 90% of the reported area, the average A/Y and frequency of outliers is mostly unaffected by the soil type. It is unlikely that differentiating by soil categories could generally improve the calculation or accuracy of the summary statistics and identification of outliers through the Coalition region.

The power and usefulness of the statistical tests decreases with the smaller sample size of the other crops. Lower power indicates a lower likelihood of detecting significant differences. Some of the crops included in this analysis have very small sample sizes. When evaluating multiple crops separately, as in this analysis, the probability of finding a significant result simply by chance (i.e., not real differences) increases. For instance, when using an $\alpha = 0.05$ as the threshold to indicate statistical significance, it is possible to find p-values < 0.05 in 1 in every 20 tests (5%) purely by chance.

The Coalition recognizes that soil type is important when understanding the potential for nitrogen to leach past the root zone. However, the available data suggests that soil type is not important to understand the frequency of A/Y outliers. This is probably because A/Y depends largely on the management of nitrogen and irrigation water. Properly managed operations in sandy soils are unlikely to differ much in their A/Y from properly managed operations in clay soils. The Coalition will continue to work with its members during grower outreach meetings and the MPEP to better understand the effectiveness of management practices in different soil types.

Figure 4. Evaluation of A/Y differences among major Ksat soil type categories for the top six Specific Crop Types in the SJCDWQC.

Each box represents the distribution of A/Y values within each soil category. The p-value tests the hypothesis that there are no differences in the mean A/Y among soil categories within each crop type.

Blue marks indicate the mean of each boxplot as tested in the model. Grey dotted lines show the 10, 50 and 90% quantiles for that crop through the whole Coalition region. Values above the 90% dotted line represent outliers.

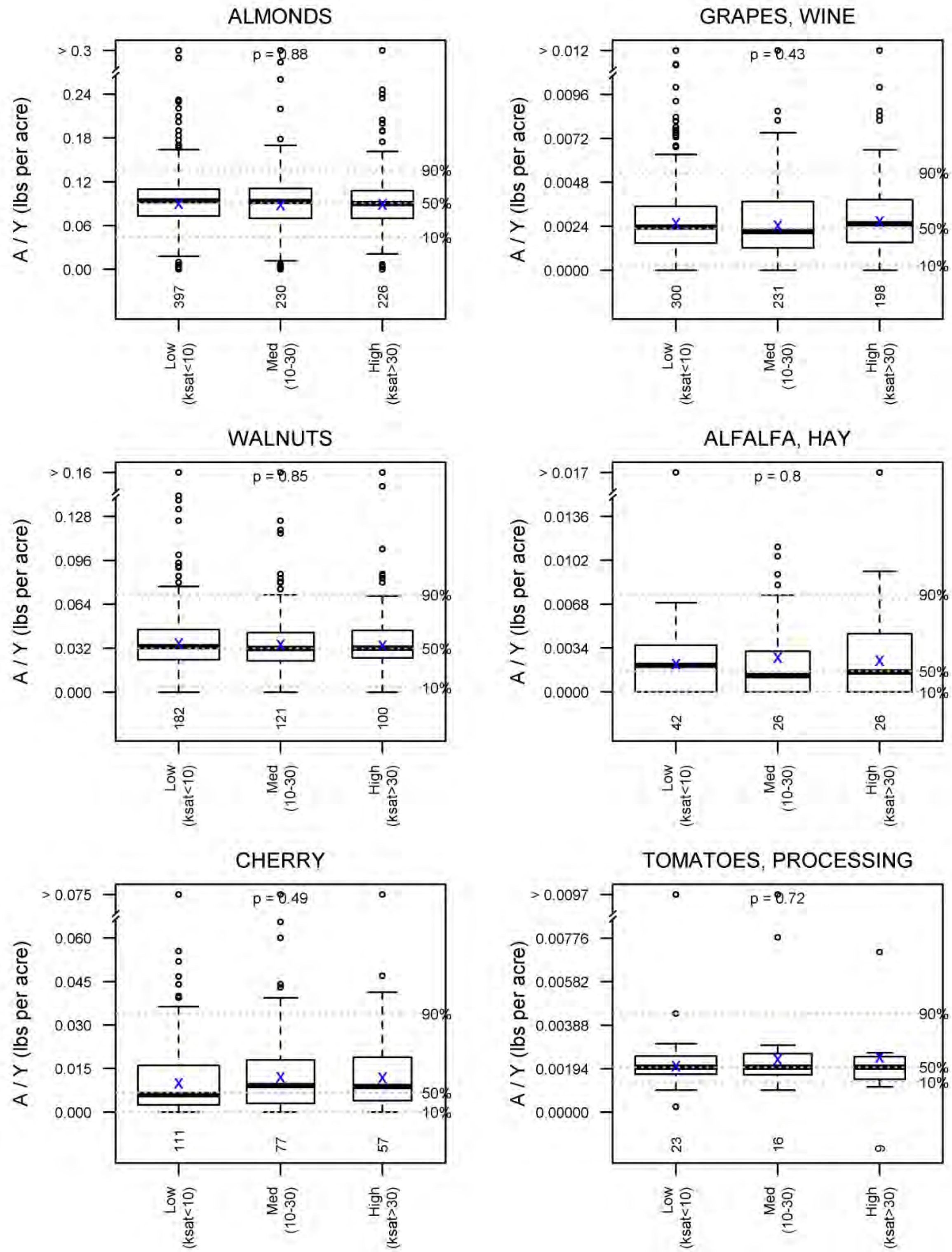


Figure 5. Evaluation of A/Y differences among major Ksat soil type categories for other major crops in the SJCDWQC.

Each box represents the distribution of A/Y values within each soil category. The p-value tests the hypothesis that there are no differences in the mean A/Y among soil categories within each crop type.

Blue marks indicate the mean of each boxplot as tested in the model. Grey dotted lines show the 10, 50 and 90% quantiles for that crop through the whole Coalition region. Values above the 90% dotted line represent outliers.

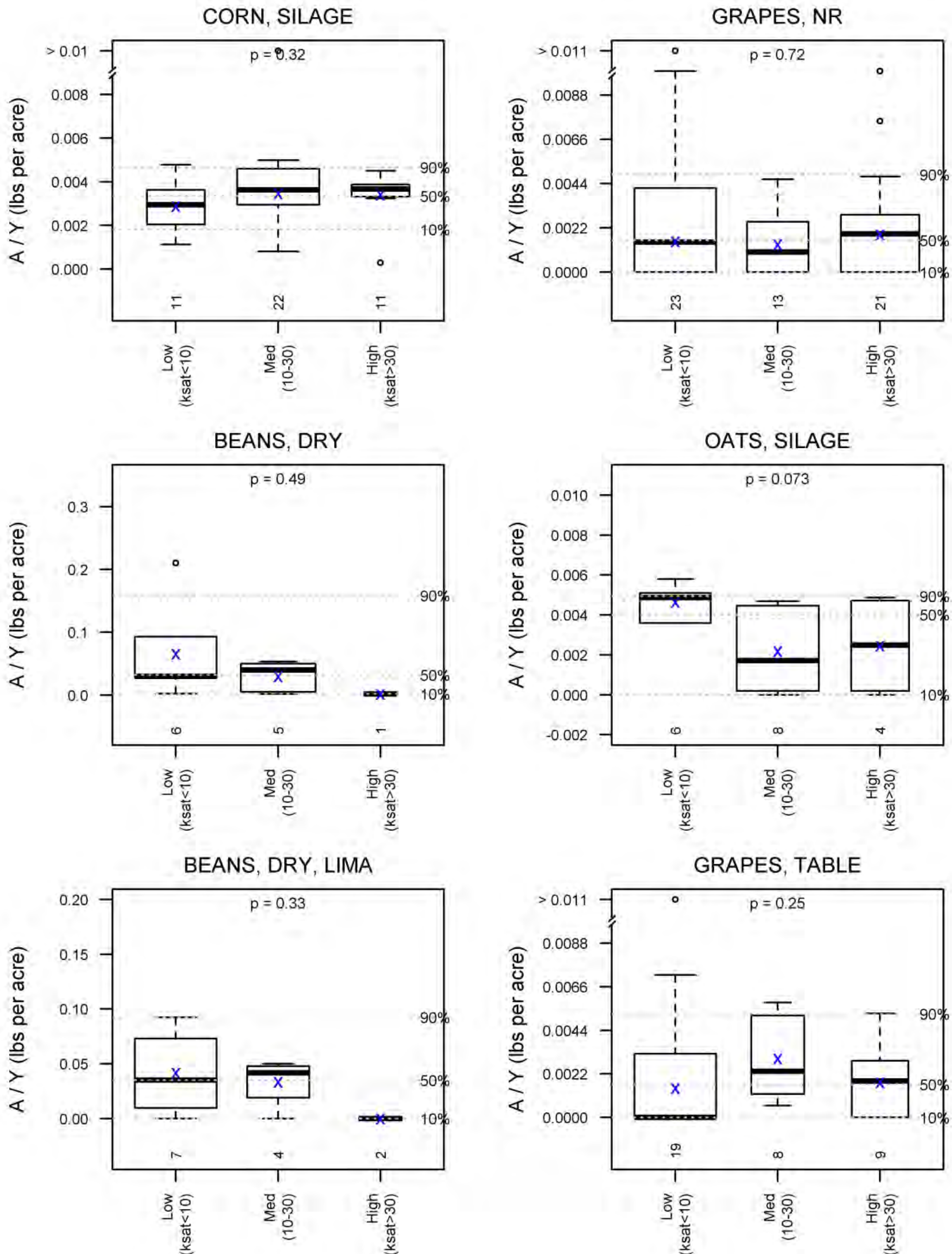


Table 10. Evaluation of the frequencies of A/Y outliers grouped by mean Ksat category for the 12 major crops in the Coalition region.

Outliers were identified grouping by specific crop for the whole Coalition region. Significant p-values are highlighted in bold.

Specific Crop Type	Soil Type	Contingency Table		Percent Outliers	P-value
		Non-outlier	Outlier		
ALMONDS	Low	352	45	13%	0.47
	Med	210	20	10%	
	High	206	20	10%	
GRAPES, WINE	Low	265	35	13%	0.51
	Med	209	22	11%	
	High	181	17	9%	
WALNUTS	Low	163	19	12%	0.95
	Med	109	12	11%	
	High	91	9	10%	
ALFALFA, HAY	Low	40	2	5%	0.32
	Med	22	4	18%	
	High	22	4	18%	
CHERRY	Low	98	13	13%	0.86
	Med	70	7	10%	
	High	51	6	12%	
TOMATOES, PROCESSING	Low	21	2	10%	1
	Med	14	2	14%	
	High	8	1	13%	
CORN, SILAGE	Low	10	1	10%	0.36
	Med	18	4	22%	
	High	11	0	0%	
GRAPES, NR	Low	18	5	28%	0.16
	Med	13	0	0%	
	High	19	2	11%	
BEANS, DRY	Low	5	1	20%	1
	Med	5	0	0%	
	High	1	0	0%	
OATS, SILAGE	Low	4	2	50%	0.14
	Med	8	0	0%	
	High	4	0	0%	
BEANS, DRY, LIMA	Low	6	1	17%	1
	Med	4	0	0%	
	High	2	0	0%	
GRAPES, TABLE	Low	17	2	12%	0.69
	Med	6	2	33%	
	High	8	1	13%	

Evaluation of A/Y by Irrigation Practices

For some crops, recommended nitrogen application rates can be different for flood vs. pressurized operations. In some cases, recommended application rates can be higher for flood-irrigated operations to compensate for the different efficiency of the delivery method and the greater potential for loss. As not all Coalition members are able to switch to more expensive, pressurized irrigation practices, irrigation type could be a useful grouping to compare A/Y in the region.

The Coalition obtained a list of management practices implemented by members from the Farm Evaluation (FE) Surveys. Coalition members in high vulnerability areas are required to submit FEs annually, to provide information regarding irrigation practices, nitrogen management practices, active and abandoned wells, pesticide practices and sediment/erosion control practices. The Coalition determined which irrigation practices were implemented in each NMP MU by linking the two datasets based on the parcel number. When one parcel included multiple NMP MUs, the corresponding FE data were identified by the specific crop type. In total, 3,192 NMP MUs (98% of the complete dataset) were satisfactorily associated with the respective parcel management practices from the FE surveys.

The Coalition grouped irrigation practices into two broad categories: flood irrigation (which includes flood and furrow) and pressurized irrigation (which includes drip, sprinkler, and micro-sprinkler). As with the soil analysis, the Coalition evaluated the 12 most abundant specific crop types in the region. The Coalition tested whether A/Y and the frequency of outliers vary depending on the primary irrigation practices.

As with the soil types, the Coalition tested if there were differences in average A/Y among NMP MUs with different irrigation types. Differences in average A/Y among the different irrigation types were evaluated using a simple linear model after excluding very large A/Y outliers (larger than two times the 90^{th} quantile of the data for that crop). The Coalition also evaluated if the frequency of outliers differed among MUs with different irrigation practices using Chi-square tests.

None of the 12 crops evaluated had significant differences in average A/Y in flood vs. pressurized irrigated fields (Figure 6 and Figure 7). There was a difference in the proportion of outliers between the different irrigation types for Almonds and Beans, Dry (Table 11). However, differentiating MUs by irrigation management is not useful when calculating or interpreting the summary statistics and identification of outliers for other crops.

Figure 6. Evaluation of A/Y differences among MUs with different irrigation practices for the top six major crops in the SJCDWQC.

Each box represents the distribution of A/Y values within each irrigation category. The p-value tests the hypothesis that there are no differences in the mean A/Y among irrigation categories within each crop type. Blue marks indicate the mean of each boxplot as tested in the model. Grey dotted lines show the 10, 50 and 90% quantiles for that crop through the whole Coalition region. Values above the 90% dotted line represent outliers.

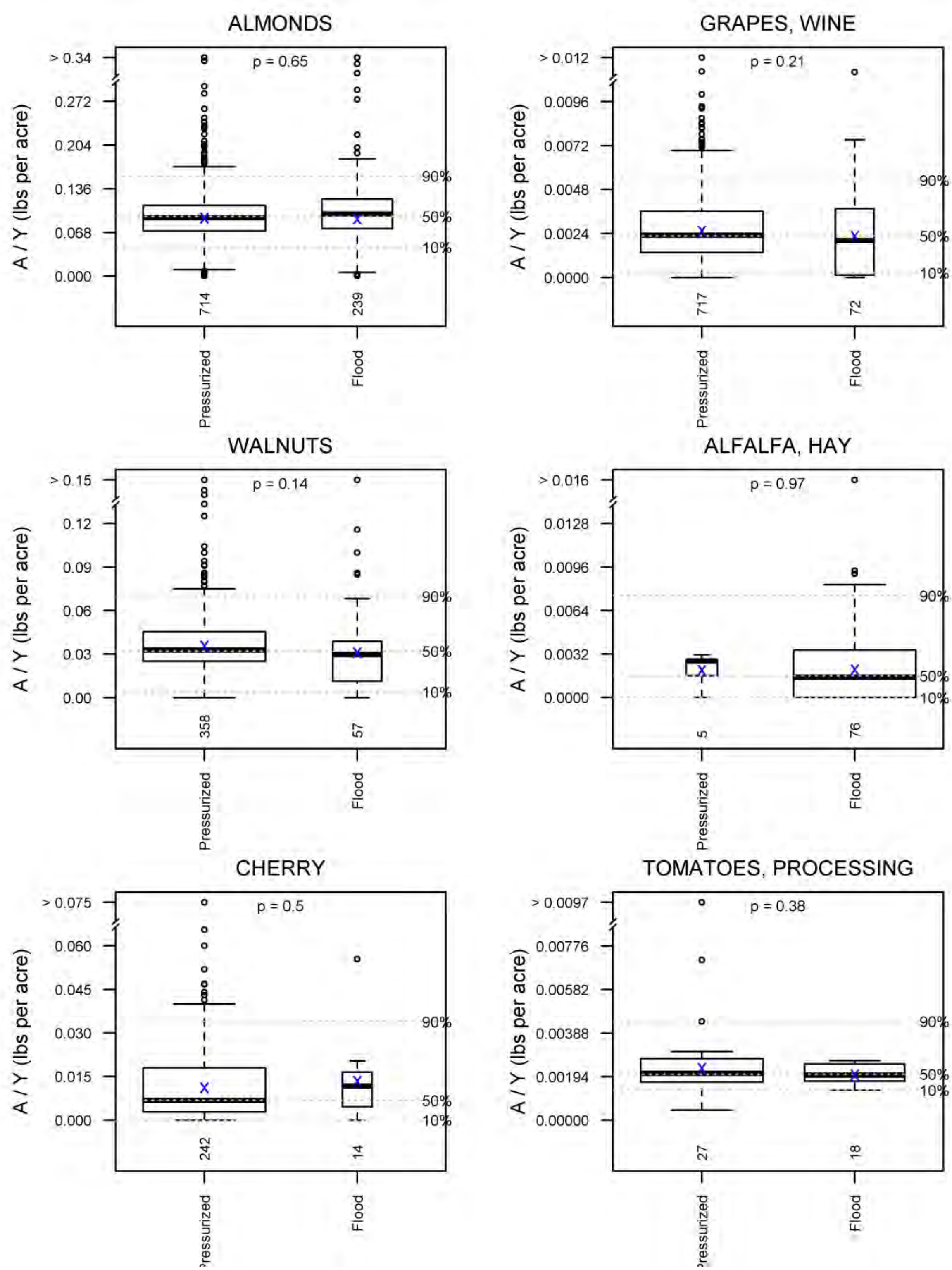


Figure 7. Evaluation of A/Y differences among MUs with different irrigation practices for the next six major crops in the SJCDWQC.

Each box represents the distribution of A/Y values within each irrigation category. The p-value tests the hypothesis that there are no differences in the mean A/Y among irrigation categories within each crop type. Blue marks indicate the mean of each boxplot as tested in the model. Grey dotted lines show the 10, 50 and 90% quantiles for that crop through the whole Coalition region. Values above the 90% dotted line represent outliers.

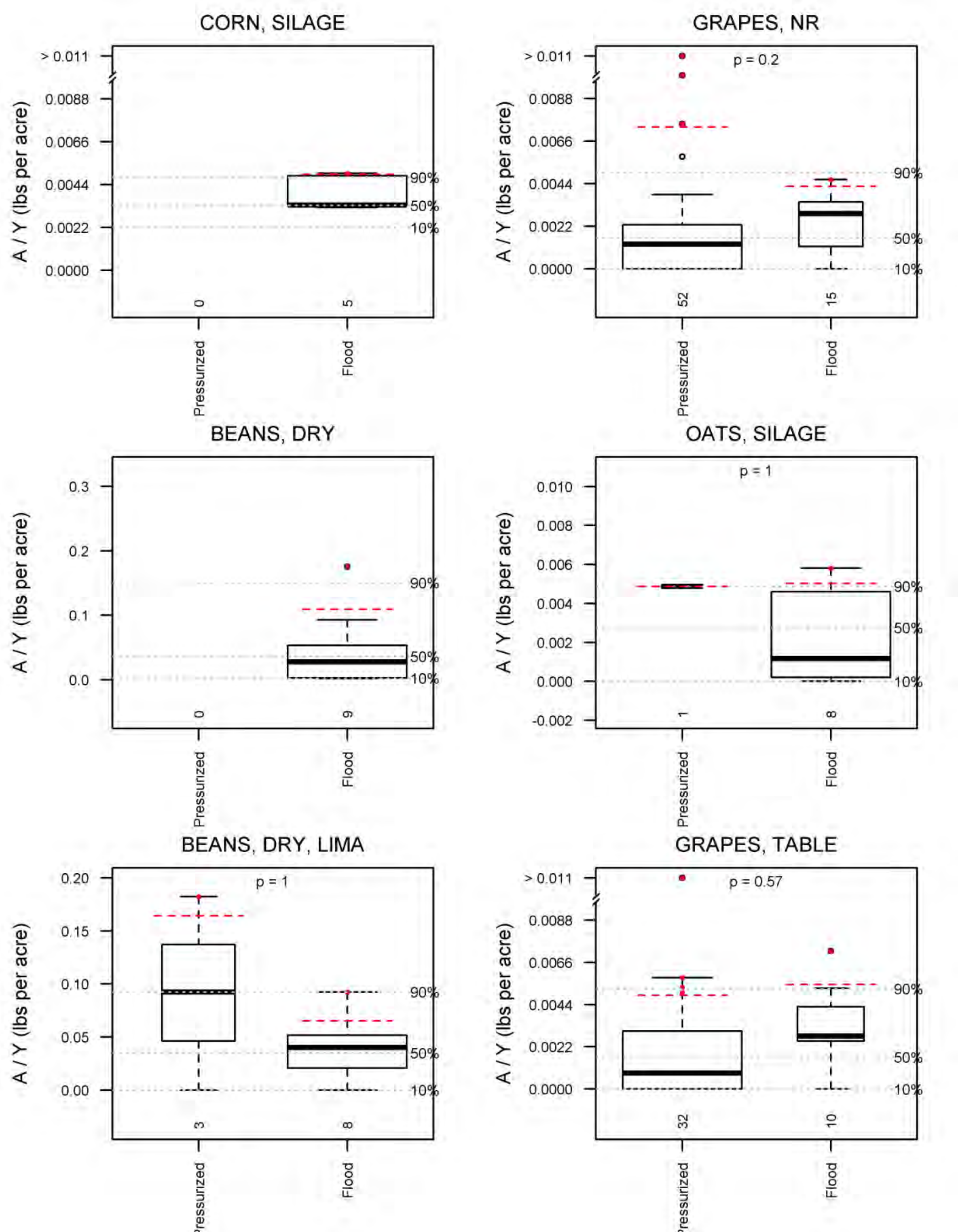


Table 11. Evaluation of the frequencies of A/Y outliers for the 12 major crops in the Coalition region by irrigation practices.

Outliers were identified by Specific Crop Type.

Specific Crop Type	Irrigation	Contingency Table		Proportion of Outliers	P-value
		Non-outlier	Outlier		
ALMONDS	**Pressurized**	**651**	**63**	**10%**	**0.02**
	Flood	**205**	**34**	**17%**	
GRAPES, WINE	Pressurized	648	69	11%	1
	Flood	65	7	11%	
WALNUTS	Pressurized	320	38	12%	1
	Flood	51	6	12%	
ALFALFA, HAY	Pressurized	5	0	0%	1
	Flood	68	8	12%	
CHERRY	Pressurized	215	27	13%	0.73
	Flood	13	1	8%	
TOMATOES, PROCESSING	Pressurized	23	4	17%	0.14
	Flood	18	0	0%	
CORN, SILAGE	Pressurized	0	0	NA	NA
	Flood	3	2	67%	
GRAPES, NR	Pressurized	45	7	16%	0.19
	Flood	15	0	0%	
BEANS, DRY	Pressurized	0	0	NA	NA
	Flood	8	1	13%	
OATS, SILAGE	Pressurized	1	0	0%	1
	Flood	7	1	14%	
BEANS, DRY, LIMA	Pressurized	2	1	50%	1
	Flood	7	1	14%	
GRAPES, TABLE	Pressurized	29	3	10%	0.58
	Flood	8	2	25%	

NA. -Not available, cannot be calculated

Nitrogen Management Practices

Implementation of some management practices can result in reduced nitrogen applications. To test if the implementation of N management practices reduces A/Y, the Coalition evaluated nitrogen management practices reported on the FEs. As a preliminary analysis, the Coalition evaluated the effect of nitrogen management practices on the A/Y values for almonds, the most common crop in the region.

The Coalition used a multiple generalized linear model to evaluate how the frequency of A/Y outliers in almonds changes as a function of the use of each individual N management practice (Table 12). The model evaluates the effect of each management practice by testing the null hypothesis that the effect of any one management practice is not significantly different from zero (i.e. a management practice does not impact the probability of being an outlier).

It is important to note that this method assumes each management practice is applied in isolation. In reality, however, growers often implement more than one management practice at the same time, and it is reasonable to expect that simultaneous implementation of more than one practice would also result in A/Y reductions. More elaborated linear models, outside the scope of this report, are required to evaluate such effects.

Table 12. Multiple linear model showing the effects of individual N management practices on A/Y in the absence of all other practices for almonds.
Bold numbers indicate significant effects and a rejection of the null hypothesis that the effect is not significantly different from zero. A negative effect indicates that the application of that management practice by itself decreases the probability of A/Y outliers. The standard error is the standard deviation of the estimate and is a measure of uncertainty of the estimate. The larger the standard error the larger the uncertainty of the estimate.

	Effect	Std. Error	P-value
Fertigation	**-2.590**	**0.638**	**0.010**
Foliar N Application	-1.505	0.623	0.205
Irrigation Water N Testing	-1.528	0.631	0.249
Soil Testing	-2.125	0.710	0.449
Split Fertilizer Applications	-1.783	0.751	0.864
Tissue Petiole Testing	-1.748	0.661	0.738
Variable Rate Applications using GPS	**-0.600**	**0.769**	**0.003**

The analysis shows that the implementation of N management practices reduced the frequency of A/Y outliers. MUs employing variable rate applications using GPS or fertigation have a lower probability of being an outlier compared to MUs where neither of these practices are used (Table 12). The Coalition believes that other N management practices also reduce A/Y, although this analysis indicates that their effect is not significant. In part this is likely due to the current method for designating outliers in which any MU with an A/Y in the upper 10% of the A/Y distribution of MUs for a given crop is considered an outlier. The analysis uses outlier status as a binary variable which does not take into account the true variability in A/Y within a dataset. One MU can be an outlier and a second MU may not be an outlier even though numerically, they have almost indistinguishable A/Y values. Two outliers can be vastly different numerically but both are seen as simply outliers. The binary nature of the response variable is insensitive to the actual outlier values and the arbitrary nature of the outlier category makes it difficult to detect effects.

A model to detect smaller changes in A/Y with management practices would need to evaluate changes in the average A/Y. However, this type of model cannot currently be run because the A/Y index is very non-normal. It is possible that, as the quality of the data improves over time, better models can be run that will allow the Coalition to identify in greater detail the factors responsible for changes in A/Y.

Caveats

There are several caveats that compromise our interpretation of the results (and particularly the correct identification of outliers) including:

1. Although the Coalition has achieved 92% response rate from members in high vulnerability areas for this report, a return rate of less than 100% of the NMP SRs results in potentially greater variability in the summary statistics relative to when more data are available. It is not possible to determine how the statistics will change, but it will certainly affect the less common

crops. The Coalition continues to receive NMP SRs that were not submitted in time to be incorporated into this report.

2. Even when all NMP SRs are returned, it is almost certain that many crops will still have only a few (ten or less) MUs in most T-Rs. The identification of outliers in these cases is compromised.
3. Some of the reported information is clearly in error. The Coalition made every effort to flag data with QC concerns. The Coalition excluded 150 MUs (5% of the total MUs with returned NMP SRs) from the analysis that had data quality concerns that could not be resolved with the grower. It is likely that some errors were not identified which now contribute to the variability and uncertainty of the data. All summary statistics, box and whisker plots, and outliers, are likely to change as better data become available over time.
4. The Coalition has made a concerted effort to verify the C_N coefficients used in this report. However, Dr. Daniel Geisseler, the author of the document from which the C_N coefficients were obtained, points out that a large number of the coefficients are only rough estimates, and it is unknown the extent to which some values are a good representation of N removal in the Central Valley. In addition, there are uncertainties in the reporting of the yield by the growers that make it difficult to apply appropriate C_N coefficients.
5. The association of soils characteristics to specific NMP MUs reported by the members is very inexact. Members can include within a single NMP MU different parcels located some distance from each other, provided they are managed the same way. Furthermore, soil types can vary substantially even within a single field. Thus, soils can vary considerably within MUs, and is difficult to assign representative soils properties to those MUs.
6. Similarly, the association of irrigation and nitrogen management practices to specific NMP MUs is also inexact. The FE MUs are recorded by the growers potentially at a different scale than NMP MUs. Every effort was done to associate NMP MUs to FE MUs based on the parcel number and crop name. However, not all MUs were associated satisfactorily, and errors in the association may have happened due to inconsistencies in crop naming.

OUTREACH AND EDUCATION

In an effort to inform Coalition members on the potential effects of nitrogen applications on groundwater quality, the Coalition prepared and mailed Nitrogen Use Evaluation Packets to each member for whom 2016 crop year data was received and analyzed.

In January of 2018, the Coalition mailed Nitrogen Use Evaluation Packets for 2016 crop year data to 1,774 growers. An example of the packet that these growers received can be found in Appendix II. These packets include the data reported to the Coalition for 2016, summary statistics by crop type for all MUs across the Coalition, nitrogen removal estimates for crops with available R values, bell curves comparing each grower's MUs to others reporting on the same crop across the Coalition, and identification of outlier status for growers with A/Y values above the 90th percentile.

Members may have MUs that are considered outliers due to various factors including high application rates or low yield. High application rates may be due to not accounting for nitrogen in their irrigation water or over-application of synthetic fertilizer, manure or compost. Low yield may have occurred for reasons outside of the grower's control, including pest damage or drought stress. Having a MU identified as an outlier in these packets will alert growers who reported A/Y values that were significantly different from their neighbors and they may need to re-evaluate their nitrogen application practices or practice diligence about providing correct information back to the Coalition.

The Nitrogen Use Evaluations are meant to illustrate nitrogen use efficiency for each grower with the potential to leach nitrates into groundwater and to place each of these grower's practices within the context of other growers in the Coalition. Additionally, reporting the data back to each grower provides the opportunity for growers to address any data quality concerns that may not have been identified in the quality control and follow-up processes outlined above. Growers are encouraged to contact the Coalition with data change requests, questions, and concerns with their Nitrogen Use Evaluation, and as such, the packets will aid in more accurate and comprehensive data over time.

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