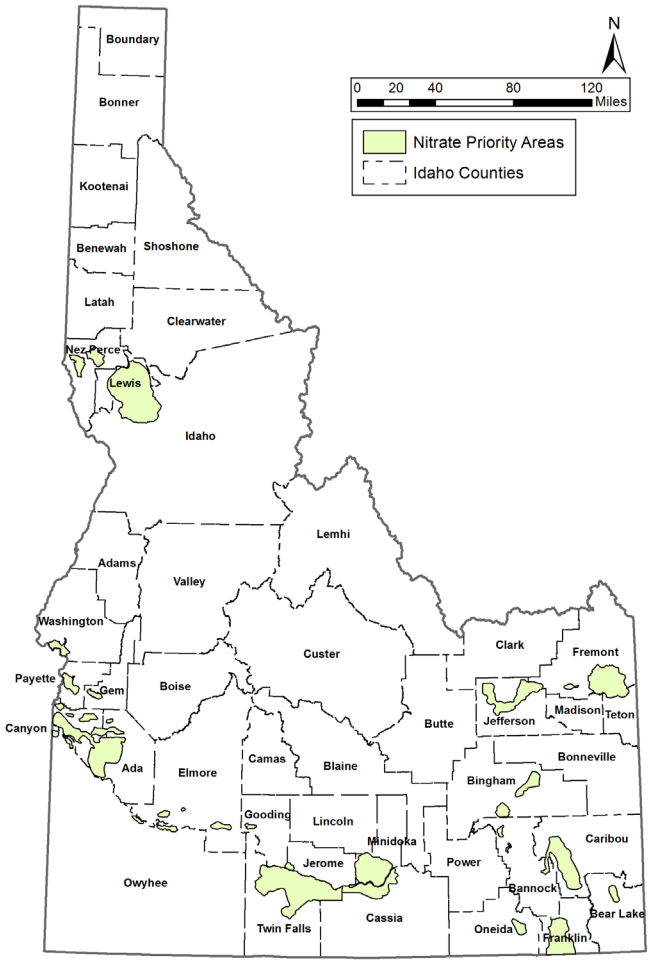
Nitrate Priority Area Trend Analysis

2007–2016



State of Idaho
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Abbreviations, Acronyms, and Symbols

DEQ	Idaho Department of Environmental Quality
GWMTC	Ground Water Monitoring Technical Committee
IDWR	Idaho Department of Water Resources
ISDA	Idaho State Department of Agriculture
L	liter
mg	milligrams
NPA	nitrate priority area
USGS	US Geological Survey

Introduction

Since 2000, the Idaho Department of Environmental Quality (DEQ) has maintained a statewide list of ground water areas degraded by nitrate concentrations. Degraded ground water areas, or nitrate priority areas (NPAs), are ranked according to severity by the NPA ranking process. The process identifies areas where additional investigation, evaluation, protection, and improvement efforts should be focused (DEQ 2014).

In 2002, DEQ cooperated with the Idaho Ground Water Monitoring Technical Committee (GWMTC) to publish the first NPA ranking, which included 25 NPAs. The NPA ranking process was updated in 2008, and the total number of NPAs increased to 32. The most recent NPA ranking process was updated 2014, yielding a total of 34 NPAs. In this iteration, the Southwest Jerome County NPA was added, resulting in 35 total NPAs (Figure 1).

As part of the NPA ranking process, water quality trends in each NPA are evaluated using nitrate concentration data. NPA nitrate concentrations are compared between time periods to determine any significant trends in nitrate concentrations within the NPA boundaries identified in 2014 (except for Southwest Jerome County, which used the proposed 2020 boundary).

Background

In 2002, the US Geological Survey (USGS) completed the first nitrate trend analysis for DEQ in support of the NPA ranking process. The USGS analyzed short-term and long-term trends in nitrate water quality data from 1961 to 2002. Trend analysis was conducted by comparing summary statistics and performing Mann-Whitney rank-sum tests. Long-term trends were assessed from 1970 to 2000 by comparing nitrate data from each decade (1970s, 1980s, and 1990s) while short-term trends were assessed using sampling time periods from the 1990s (1991–1994, 1995–1998, and 1999 –2000). Results showed long-term increasing trends for 6 NPAs, long-term decreasing trends for 4 NPAs, short-term increasing trends for 7 NPAs, and a short-term decreasing trend for 1 NPA. Additionally, seven NPAs had no long-term trends while 15 NPAs had no short-term trends (Parliman 2002).

In 2008, the Idaho Department of Water Resources (IDWR) conducted a nitrate trend analysis for the 2008 NPA ranking process. For this ranking, nitrate concentrations between 1994–2000 and 2001–2007 were compared using nonparametric, nonpaired statistical methods. For each time period, the dataset was reduced by selecting the maximum nitrate concentration for each sample site for the respective time period. Results showed increasing trends for five NPAs and a decreasing trend at one NPA (Neely 2008).

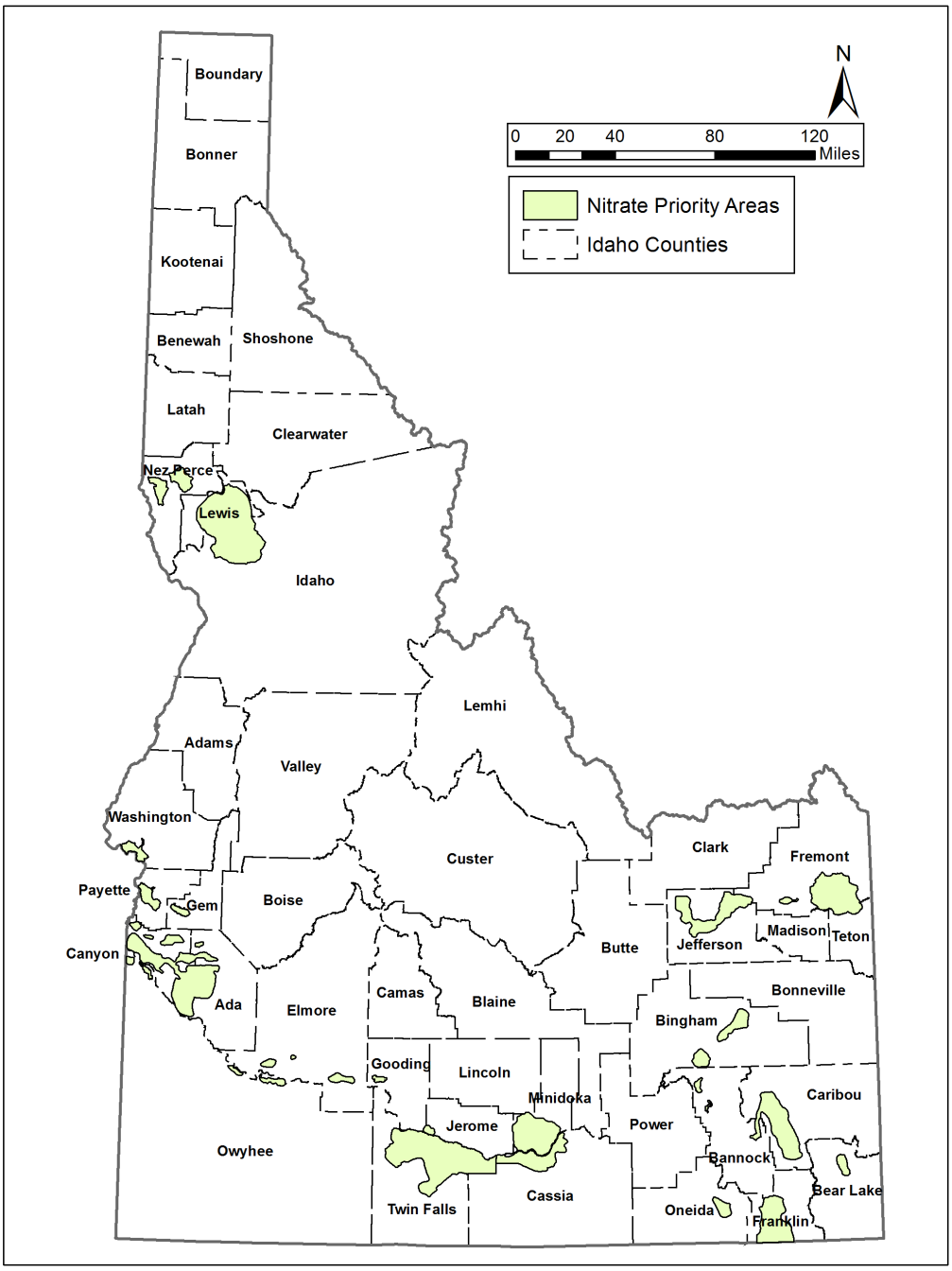


Figure 1. Idaho Nitrate Priority Areas.

In 2013, IDWR again conducted a nitrate trend analysis. For the 2014 NPA ranking, nitrate concentrations between 2002–2006 and 2007–2011 were compared using nonparametric statistical methods. Since previous analyses revealed temporal variability in maximum nitrate concentrations, the most recent nitrate samples were selected from each sample site for each time period to provide a more representative dataset, as determined by the GWMTC. Additionally, the trend analysis was updated to include nonparametric paired statistical analysis and a threshold criteria analysis. Threshold criteria are derived from statistically significant test results and the ratio of paired sites with nitrate increases and decreases. The threshold analysis classifies nitrate

trends in NPAs into five categories: increasing trend, decreasing trend, increasing tendency, decreasing tendency, and no trend (DEQ 2014, Neely 2013). The 2013 analysis found 3 NPAs with increasing trends, 1 NPA with an increasing tendency, 2 NPAs with decreasing tendencies, 4 NPAs with decreasing trends, and 11 NPAs with no trend (Neely 2013). Out of the 34 NPAs, 13 lacked sufficient data for statistical and trend analysis.

For this iteration, NPA nitrate concentrations between 2007–2011 and 2012–2016 were compared using previously-established statistical methods and the threshold criteria analysis (DEQ 2014, Neely 2013). The methods and results of this nitrate trend analysis are presented below.

Methods

Data Compilation

Nitrate water quality data were sourced from the DEQ regional nitrate monitoring projects, the DEQ Drinking Water Program, the Idaho State Department of Agriculture (ISDA), the IDWR, and the USGS. Water quality data from these sources were combined into a statewide dataset organized by site identification, sample date, sample nitrate concentration, and site geographic coordinates. The resulting database included 94,074 entries with sample dates from 1990 to 2016.

The statewide database was imported into ArcMap (ESRI 2017) and joined with the DEQ 2014 NPA boundary shapefile and the Southwest Jerome NPA boundary shapefile. This joined dataset was reduced by excluding any data points plotting outside NPA boundaries. This NPA nitrate dataset was then imported into R Statistical Programming (R 2017) for further analysis, including: summary statistics, nonparametric tests, and boxplot comparisons. The dataset was separated into two 5-year periods: Time Period 1 (T1, 2007–2011) and Time Period 2 (T2, 2012–2016). From each time period, the most recent nitrate sample was selected for each sample site. The resulting dataset, comprised of the most recent nitrate concentrations for T1 and T2, was used in the nonpaired, nonparametric data analysis. Lastly, the most recent dataset removed all nonpaired sample sites (i.e., only selecting sites sampled in both time periods). This dataset was used in the paired, nonparametric data analysis. The most recent nitrate dataset is available upon request.

Prior to analysis, summary statistics for T1 were compared to the results of the previous NPA ranking analysis (Neely 2013). T1 coincides with the second time period in the 2014 NPA ranking analysis (2007–2011). The 2018 statewide database has more than double the entries of the 2013 database (94,074 vs. 41,708) from the inclusion of additional data sources and sample sites. NPAs where medians differed between the two datasets (2013 and 2018) were examined to determine the cause of median differences. While continuity was desired, the 2018 dataset was generally not modified to match the 2013 dataset, as differences between the two datasets resulted from the inclusion of legitimate data sites or the exclusion of missing, improperly located, or duplicative data sites.

Trend Analysis

NPA nitrate concentration trends between T1 and T2 were analyzed using two nonparametric statistical tests; 1) the rank-sum test and 2) the signed-rank test. The rank-sum test was developed separately by Wilcoxon and Mann and Whitney (Mann and Whitney 1947, Wilcoxon 1945). Commonly referred to as the "Mann-Whitney," the rank-sum test compares differences in independent, or nonpaired samples, and is often applied to independent water quality datasets (Gilbert 1987, Helsel and Hirsh 2002, Neely 2013). The Mann-Whitney was used to test for changes in median values in the most recent, nonpaired nitrate concentrations for each NPA.

For dependent or paired samples, the Wilcoxon signed-rank test was applied (Wilcox 1945). The Wilcoxon test is used to determine whether the median difference between paired observations equals zero and is often applied to dependent water quality datasets (Ayotte et al. 2005, Helsel and Hirsh 2002, Lindsey and Rupert 2012, Neely 2013, Rupert 2008). While paired tests provide more robust results, a minimum number of paired sites are required for a valid statistical comparison. The minimum number of paired sites for this analysis was ten (Neely 2013, Rupert 2008). Fifteen NPAs lacked enough paired sites and were excluded from this statistical analysis.

The application of these statistical tests to water quality datasets may require test modification. As rank tests, these tests convert reported nitrate concentrations to ranks; which approximate the data distribution. This becomes a consideration when ties, or repeat values occur, requiring the average of ranks to be applied to duplicate ranks (Gilbert 1987). This commonly occurs in NPAs with larger datasets which have a higher chance of duplicate nitrate concentrations and with nondetect nitrate concentrations, which are preserved in the dataset at the nondetect concentration (i.e. <0.01 mg/L = 0.01 mg/L). For the Mann-Whitney, rank averaging has minimal effect on test results (Gilbert 1987). Thus, the Mann-Whitney test was performed using the base R statistical package and the "wilcox.test(paired = FALSE)" command.

However, in the original form of the Wilcoxon analysis, ties can reduce the sample size. As a sign-rank test, the difference in concentration between time periods is used at each site—repeat concentrations from the same site receive a zero. Zeros are common in NPAs with lower concentrations, or multiple sites with repeat nondetect concentrations. Zeros are discarded in the original Wilcoxon (Wilcox 1945). However, Pratt (1955) modified the Wilcoxon to include zeros, thus preserving nondetect or repeat concentrations. Following Lindsey and Rupert (2012), the Wilcoxon with the Pratt modification test was performed using the "sign_test(zero.method = "Pratt") command in the "coin" library R statistical package (Hothorn et al. 2008).

Each of these tests produces a probability value (p-value) which is used as an indication of statistical significance. For this analysis, a p-value of less than 0.15 or an 85% confidence level was considered a statistically significant difference between the two datasets (DEQ 2014, Neely 2013). This minimum confidence level was set by the GWMTC and allows more conservative prediction of nitrate concentration trends for adaptive management (Lindsey and Rupert 2012).

In addition to statistical tests, ratios were calculated for each NPA. Ratios were derived from the number of paired sites in each NPA that had increases or decreases in nitrate concentrations from T1 to T2 that exceeded 1.0 mg/L. Depending on the number of increases versus decreases greater than 1.0 mg/L, the ratio was calculated by dividing either the number of increases by the number of decreases or the number of decreases by the number of increases, so that the resulting ratio

was always greater than one. The resulting ratio was combined with nonparametric test results to further analyze NPA trends in a threshold analysis. A ratio greater than 1.5 was considered a significant indicator of nitrate concentration trends between the two time periods.

Threshold Analysis

The results from the three analyses, the Mann-Whitney test, the Wilcoxon test, and the calculated ratio were used in a threshold analysis to determine nitrate concentration trends for each NPA. For each analysis result, a threshold criterion was exceeded if the analysis result was significant. For the nonparametric test results, a threshold was exceeded if the test result was statistically significant at the 85% confidence level or greater. For the ratio analysis, a threshold was exceeded if the calculated ratio was greater than 1.5. Additionally, the direction of nitrate trends from T1 to T2 for all thresholds must agree. Any disagreement in nitrate trends (increase vs. decrease) between the three analyses would negate the results of the threshold analysis, resulting in no trend. The following threshold criteria determine if a NPA had an increasing or decreasing trend, an increasing or decreasing tendency, or no trend in nitrate concentrations:

1. If two or three thresholds were exceeded, and were in agreement, then a trend existed.
2. If only one threshold was exceeded and other criteria were in agreement without exceeding thresholds, then a tendency existed.
3. If two thresholds were exceeded, but they were not in agreement, then no trend existed.
4. If no thresholds were exceeded, then no trend existed.

Results

Of the total 35 NPAs, 20 NPAs had enough paired sample sites to allow for statistical trend analysis. Through the threshold analysis, the following trends were found in nitrate concentrations at NPAs:

1. Five NPAs had an increasing trend.
2. Zero NPAs had an increasing tendency.
3. Three NPAs had a decreasing tendency.
4. Four NPAs had a decreasing trend.
5. Eight NPAs had no trend.
6. 15 NPAs lacked enough paired sample sites for statistical analysis.

Table 1 and Table 2 summarize median trends in NPAs for nonpaired and paired datasets. Table 3 summarizes threshold criteria results based on statistical and ratio results for each NPA. Specific results for each NPA are discussed below, specifically differences in nonpaired and

paired nitrate trends and reversals of nitrate trends from the previous analysis. Appendix I contains summary statistic boxplots of nonpaired and paired data for each NPA.

Table 1. Nonpaired sites and nitrate medians for Nitrate Priority Areas between 2007–2011 (T1) and 2012–2016 (T2).

NPA	Number of Nonpaired Sites T1/T2	T1 Nitrate Median	T2 Nitrate Median	Median Nitrate Change (T2 - T1)
Ada Canyon	378/404	3.5	3.8	0.3
Ashton-Drummond	73/37	5.8	5.5	-0.3
Black Cliffs	13/0	16.8	NA	NA
Blackfoot	21/15	4.1	3.2	-0.9
Bliss	18/11	3.6	6.4	2.8
Bruneau	4/7	15.0	5.7	-9.3
Clearwater Plateau	99/78	3.8	3.7	-0.1
Emmett North Bench	37/57	2.3	2.3	0.0
Fort Hall	6/4	9.3	5.5	-3.8
Georgetown-Bennington	20/9	4.9	2.1	-2.8
Glenns Ferry	13/11	1.5	7.0	5.5
Grace	50/28	2.7	2.3	-0.4
Grand View	11/23	8.2	6.3	-1.9
Homedale	12/17	1.3	1.9	0.6
Lapwai Creek	14/22	4.9	8.1	3.2
Lindsay Creek	42/34	4.5	3.3	-1.2
Lower Payette	142/121	3.9	4.3	0.4
Malad	10/4	2.8	4.0	1.2
Marsh Creek	173/103	6.5	5.4	-1.1
Marsing	34/15	2.7	0.2	-2.5
Minidoka	153/112	3.9	4.3	0.4
Mink Creek	5/3	2.5	2.7	0.2
Mountain Home	37/21	8.7	5.1	-3.6
Mountain Home AFB	24/20	6.7	8.5	1.8
Mud Lake	73/59	3.5	4.0	0.5
North Pocatello	25/24	4.2	3.7	-0.5
Northeast Canyon Co. (Purple Sage)	75/86	4.3	6.1	1.8
Northeast Star	26/20	8.7	15.0	6.3
Notus	1/9	16.0	11.0	-5.0
Parma	9/15	0.5	2.6	2.1
Preston	68/45	4.8	3.3	-1.5
South Fremont	8/15	1.9	1.9	0.0
Southwest Jerome	20/17	4.8	5.6	0.8
Twin Falls	380/198	4.7	4.8	0.1
Weiser	92/82	12.0	9.1	-2.9

Table 2. Paired sites and nitrate medians for Nitrate Priority Areas between 2007–2011 (T1) and 2012–2016 (T2).

NPA	Number of Paired Sites	T1 Nitrate Median	T2 Nitrate Median	Median Nitrate Change (T2 - T1)
Ada Canyon	274	2.9	2.9	0.0
Ashton-Drummond	28	5.7	5.6	-0.1
Black Cliffs[1]	0	NA	NA	NA
Blackfoot	15	4.0	3.2	-0.8
Bliss[1]	9	3.6	6.4	2.8
Bruneau[1]	3	8.1	4.6	-3.5
Clearwater Plateau	70	4.2	3.6	-0.6
Emmett North Bench	19	2.3	1.3	-1.0
Fort Hall[1]	4	6.7	5.5	-1.2
Georgetown-Bennington[1]	9	4.5	2.1	-2.4
Glenns Ferry[1]	5	9.4	9.1	-0.3
Grace	26	2.7	2.3	-0.4
Grand View[1]	9	9.0	8.8	-0.2
Homedale[1]	7	5.5	1.3	-4.2
Lapwai Creek[1]	6	7.0	4.7	-2.3
Lindsay Creek	29	5.5	5.6	0.1
Lower Payette	82	4.5	4.3	-0.2
Malad[1]	3	4.3	3.3	-1.0
Marsh Creek	98	6.3	5.4	-0.9
Marsing	11	2.4	1.1	-1.3
Minidoka	96	3.5	4.0	0.5
Mink Creek[1]	3	2.2	2.7	0.5
Mountain Home[1]	8	13.0	9.2	-3.8
Mountain Home AFB	20	6.7	8.5	1.8
Mud Lake	35	3.8	4.0	0.2
North Pocatello	23	4.2	3.6	-0.6
Northeast Canyon Co. (Purple Sage)	23	4.5	4.8	0.3
Northeast Star	19	12.8	15.0	2.2
Notus[1]	1	16.0	16.0	0.0
Parma[1]	6	0.4	0.1	-0.3
Preston	38	4.5	3.8	-0.7
South Fremont[1]	4	3.4	13.0	9.6
Southwest Jerome	14	4.7	5.3	0.6
Twin Falls	169	4.8	4.8	0.0
Weiser	43	12.0	9.7	-2.3

Notes:

1. Nonparametric statistical analysis was not performed for Nitrate Priority Areas with less than 10 paired sites.

Table 3. Threshold analysis results for statistical and ratio tests of nitrate trends in Nitrate Priority Areas from 2007–2011 and 2012–2016.

NPA	Nonpaired P-value and Confidence Level[1]	Paired P-value and Confidence Level[1]	Ratio,[2] # of increases >1 / # of decreases >1	Ratio,[2] # of decreases >1 / # of increases >1	Threshold Trend Results[3]
Ada Canyon	0.605	0.368	1.2	–	No Trend
Ashton-Drummond	0.244	0.900	–	1.5	No Trend
Blackfoot	0.275	0.211	–	**2.5**	*Decreasing Tendency*
Clearwater Plateau	0.354	0.988	–	1.2	No Trend
Emmett North Bench	0.871	**0.125 (>85%)**	–	**3.0**	Decreasing Trend
Grace	0.393	**0.099 (>90%)**	–	**2.2**	Decreasing Trend
Lindsay Creek	0.690	**0.067 (>90%)**	–	**2.5**	No Trend
Lower Payette	0.286	0.693	1.3	–	No Trend
Marsh Creek	0.377	0.567	1.2	–	No Trend
Marsing	0.481	**0.067 (>90%)**	–	**4.0**	Decreasing Trend
Minidoka	0.976	**0.056 (>90%)**	**2.4**	–	Increasing Trend
Mountain Home AFB	0.646	**0.035 (>95%)**	**8.0**	–	Increasing Trend
Mud Lake	0.315	0.342	–	1.2	No Trend
North Pocatello	0.373	0.207	–	**2.5**	*Decreasing Tendency*
Northeast Canyon Co. (Purple Sage)	**0.018 (>95%)**	**0.043 (>95%)**	**7.0**	–	Increasing Trend
Northeast Star	0.303	**0.058 (>90%)**	**3.7**	–	Increasing Trend
Preston	**0.039 (>95%)**	0.384	–	**3.2**	Decreasing Trend
Southwest Jerome	0.175	**0.048 (>95%)**	**3.0**	–	Increasing Trend
Twin Falls	0.953	0.265	1.3	–	No Trend
Weiser	**0.096 (>90%)**	0.726	–	1.1	*Decreasing Tendency*

Notes:

1. Bold values indicate statistically significant results of nonparametric tests exceeding the minimum confidence level of 85%.
2. Bold values indicate significant ratio results exceeding the minimum criteria of 1.5.
3. Italic values indicate tendency threshold results and underlined values indicate trend threshold results.

NPA Site Results

1.1.1 Ada Canyon (No Trend)

In the Ada Canyon NPA nonpaired analysis, T1 had 378 sites and T2 had 404 sites. The paired analysis included 274 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration increased by 0.3 mg/L from T1 to T2 (Table 1, Figure A-2). This increase was not significant at the 85% confidence level (Table 3). In the paired analysis, the median nitrate concentration did not change from T1 to T2 (Table 2, Figure A-3). This lack of change was not significant at the 85% confidence level (Table 3). The ratio of sites with increases greater than 1.0 mg/L to sites with decreases greater than 1.0 mg/L was 1.2 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 2.

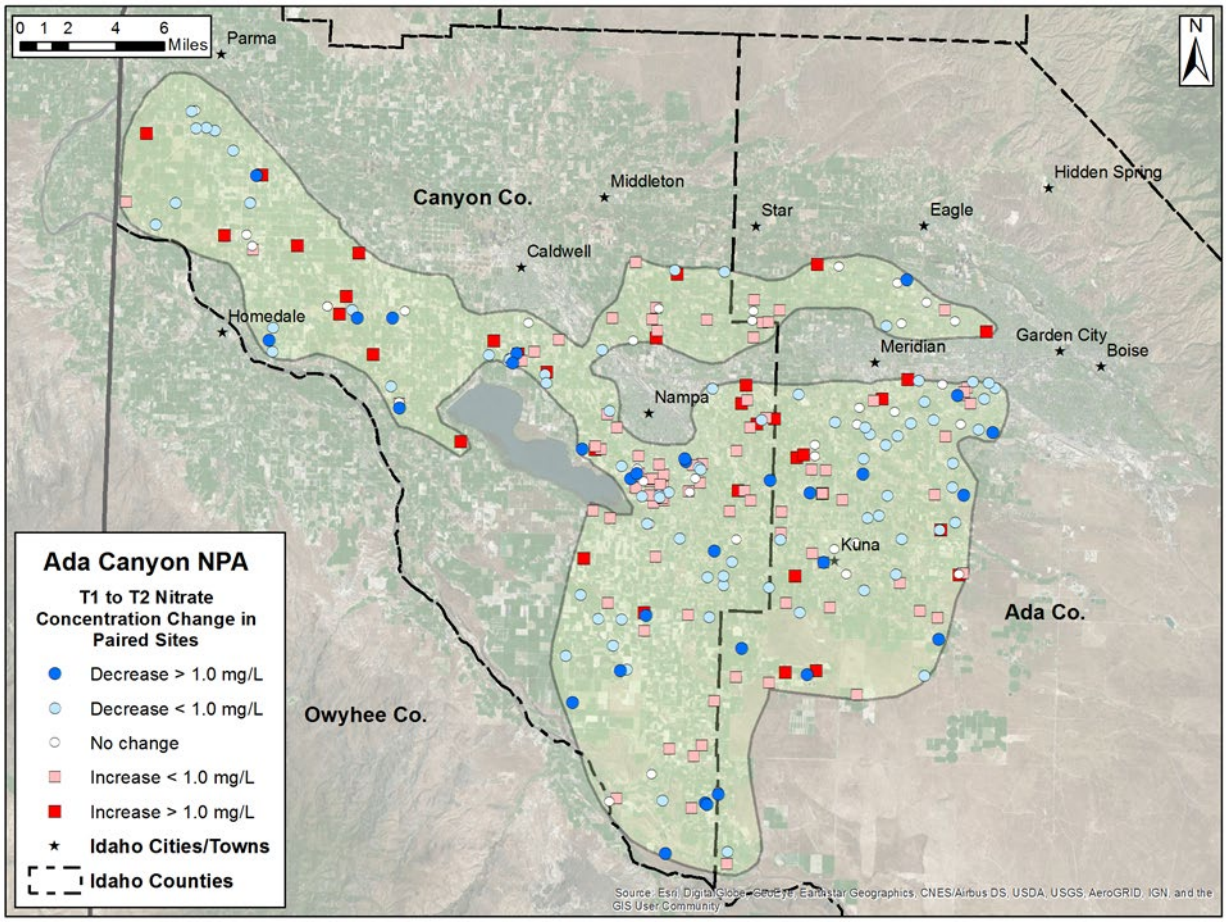


Figure 2. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Ada Canyon Nitrate Priority Area.

While the nonpaired median and ratio change agreed (increasing), no thresholds were exceeded for any of the significance criteria. Thus, the Ada Canyon NPA had no trend.

1.1.2 Ashton Drummond (No Trend)

In the Ashton Drummond NPA nonpaired analysis, T1 had 73 sites and T2 had 37 sites. The paired analysis included 28 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration decreased by 0.3 mg/L from T1 to T2 (Table 1, Figure A-4). This decrease was not significant at the 85% confidence level (Table 3). In the paired analysis, the median nitrate concentration decreased by 0.1 mg/L from T1 to T2 (Table 2, Figure A-5). This decrease was also not significant at the 85% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L was 1.5 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 3.

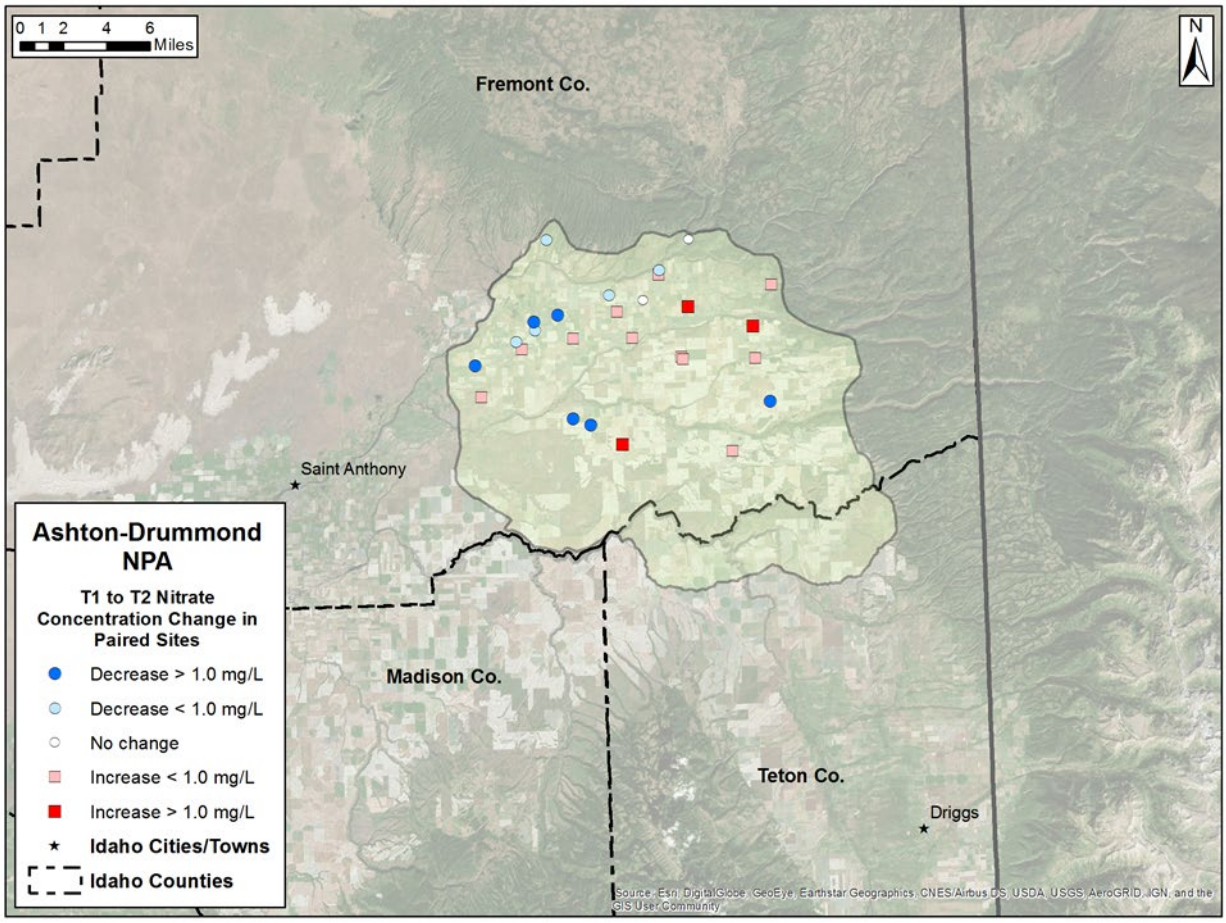


Figure 3. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Ashton-Drummond Nitrate Priority Area.

While the median and ratio change agree (decreasing), none of the threshold criteria were exceeded. Thus, the Ashton Drummond NPA had no trend.

1.1.3 Blackfoot (Decreasing Tendency)

In the Blackfoot NPA nonpaired analysis, T1 had 21 sites and T2 had 15 sites. The paired analysis included 15 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration decreased by 0.9 mg/L from T1 to T2 (Table 1, Figure A-6). This decrease was not significant at the 85% confidence level (Table 3). In the paired analysis, the median nitrate concentration decreased by 0.8 mg/L from T1 to T2 (Table 2, Figure A-7). This decrease was also not significant at the 85% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L was 2.5 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 4.

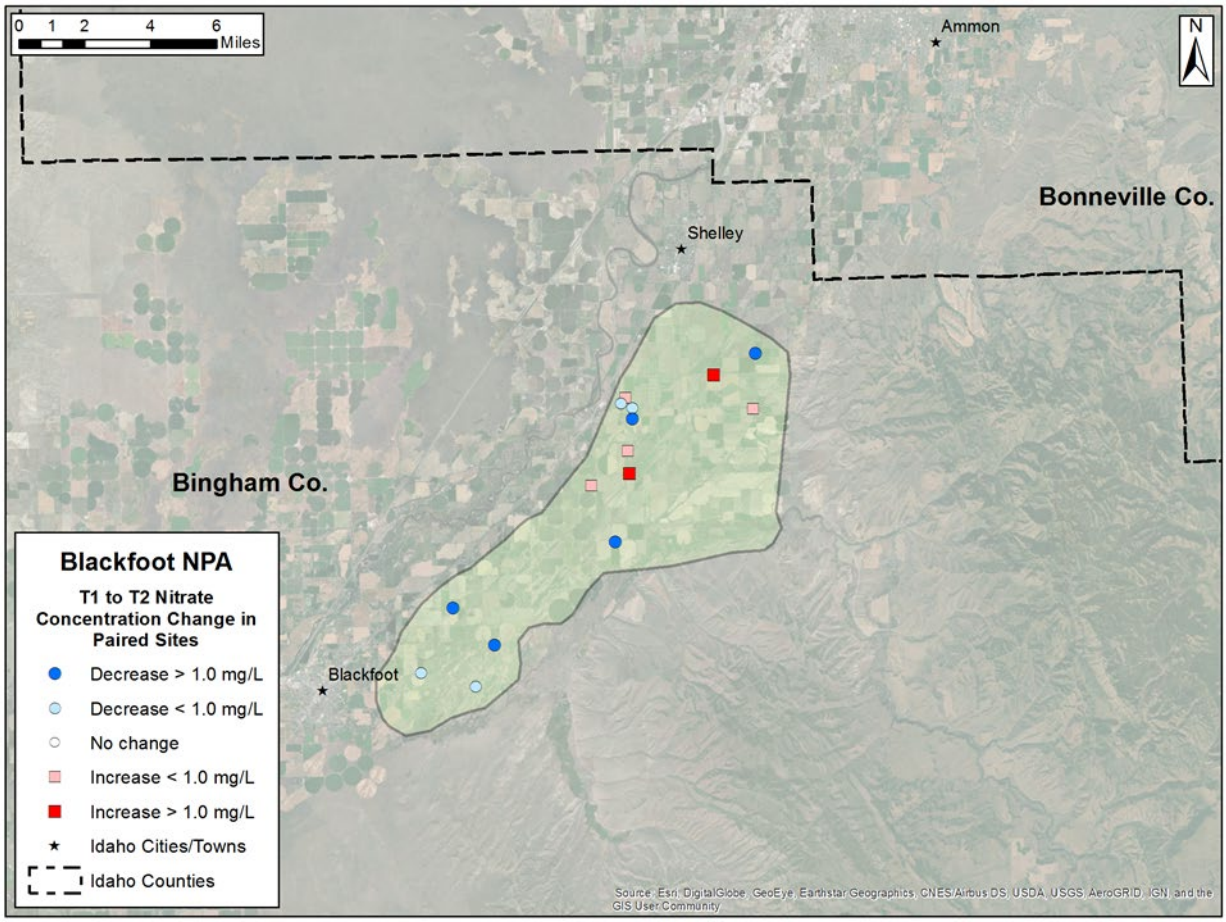


Figure 4. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Blackfoot Nitrate Priority Area.

Since the median and ratio changes agree (decreasing), and the decreasing ratio exceeded the threshold criteria, the Blackfoot NPA had a decreasing tendency.

1.1.4 Clearwater Plateau (No Trend)

In the Clearwater Plateau NPA nonpaired analysis, T1 had 99 sites and T2 had 78 sites. The paired analysis included 70 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration decreased by 0.1 mg/L from T1 to T2 (Table 1, Figure A-8). This decrease was not significant at the 85% confidence level (Table 3). In the paired analysis, the median nitrate concentration decreased by 0.6 mg/L from T1 to T2 (Table 2, Figure A-9). This decrease was also not significant at the 85% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L was 1.2 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 5.

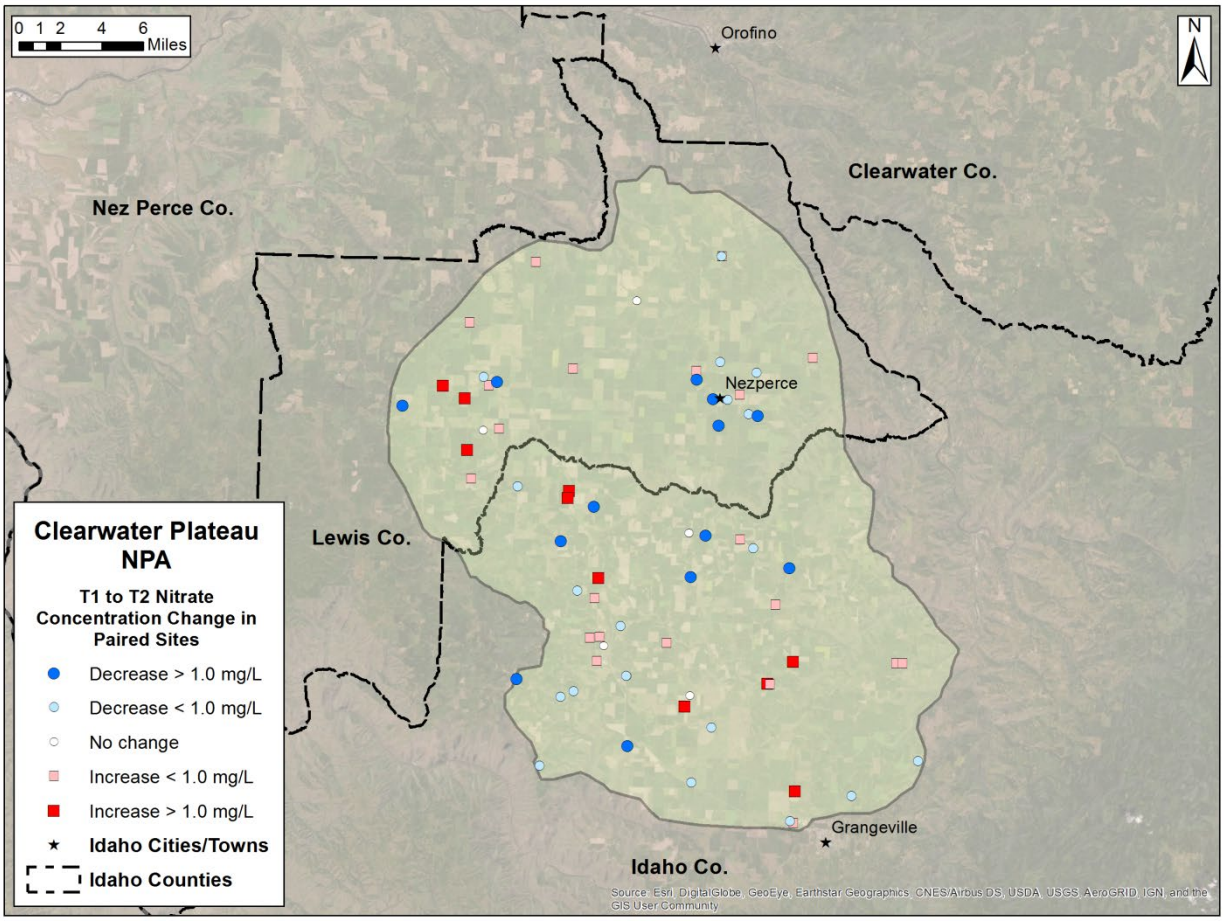


Figure 5. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Clearwater Plateau Nitrate Priority Area.

While the median and ratio change agree (decreasing), none of the threshold criteria were exceeded. Thus, the Clearwater Plateau NPA had no trend.

1.1.5 Emmett North Bench (Decreasing Trend)

In the Emmett North Bench NPA nonpaired analysis, T1 had 37 sites and T2 had 57 sites. The paired analysis included 19 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration did not change from T1 to T2 (Table 1, Figure A-10). This lack of change was not significant at the 85% confidence level (Table 3). In the paired analysis, the median nitrate concentration decreased by 1.0 mg/L from T1 to T2 (Table 2, Figure A-11). This decrease was significant at the 85% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1 mg/L was 3.0 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 6.

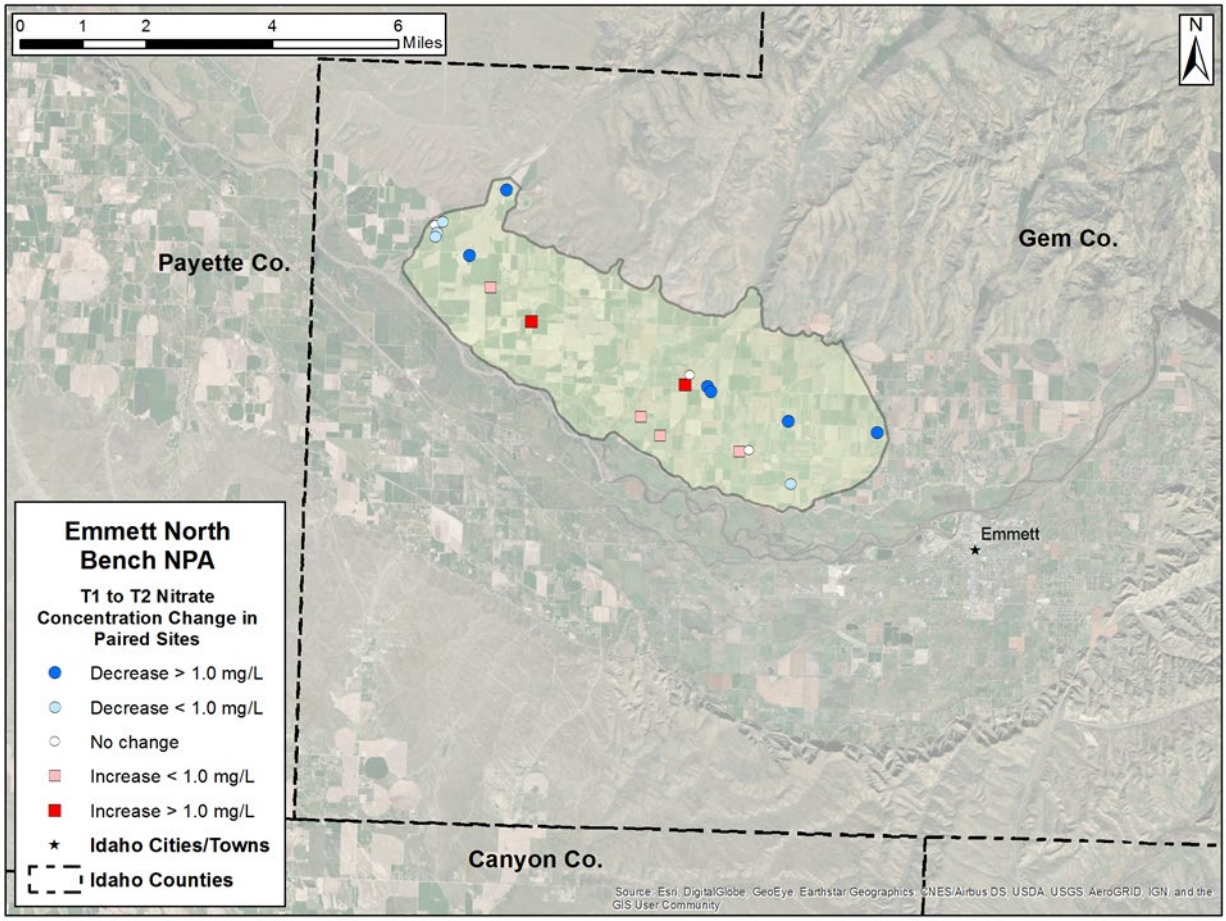


Figure 6. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Emmett North Bench Nitrate Priority Area.

While the median for the nonpaired analysis did not change between T1 and T2, the paired analysis and ratio were both decreasing and exceeded the threshold criteria. Thus, the Emmett North Bench NPA had a decreasing trend.

1.1.6 Grace (Decreasing Trend)

In the Grace NPA nonpaired analysis, T1 had 50 sites and T2 had 28 sites. The paired analysis included 26 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration decreased by 0.4 mg/L from T1 to T2 (Table 1, Figure A-12). This decrease was not significant at the 85% confidence level (Table 3). In the paired analysis, the median nitrate concentration decreased by 0.4 mg/L from T1 to T2 (Table 2, Figure A-13). This decrease was significant at the 90% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1 mg/L was 2.2 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 7.

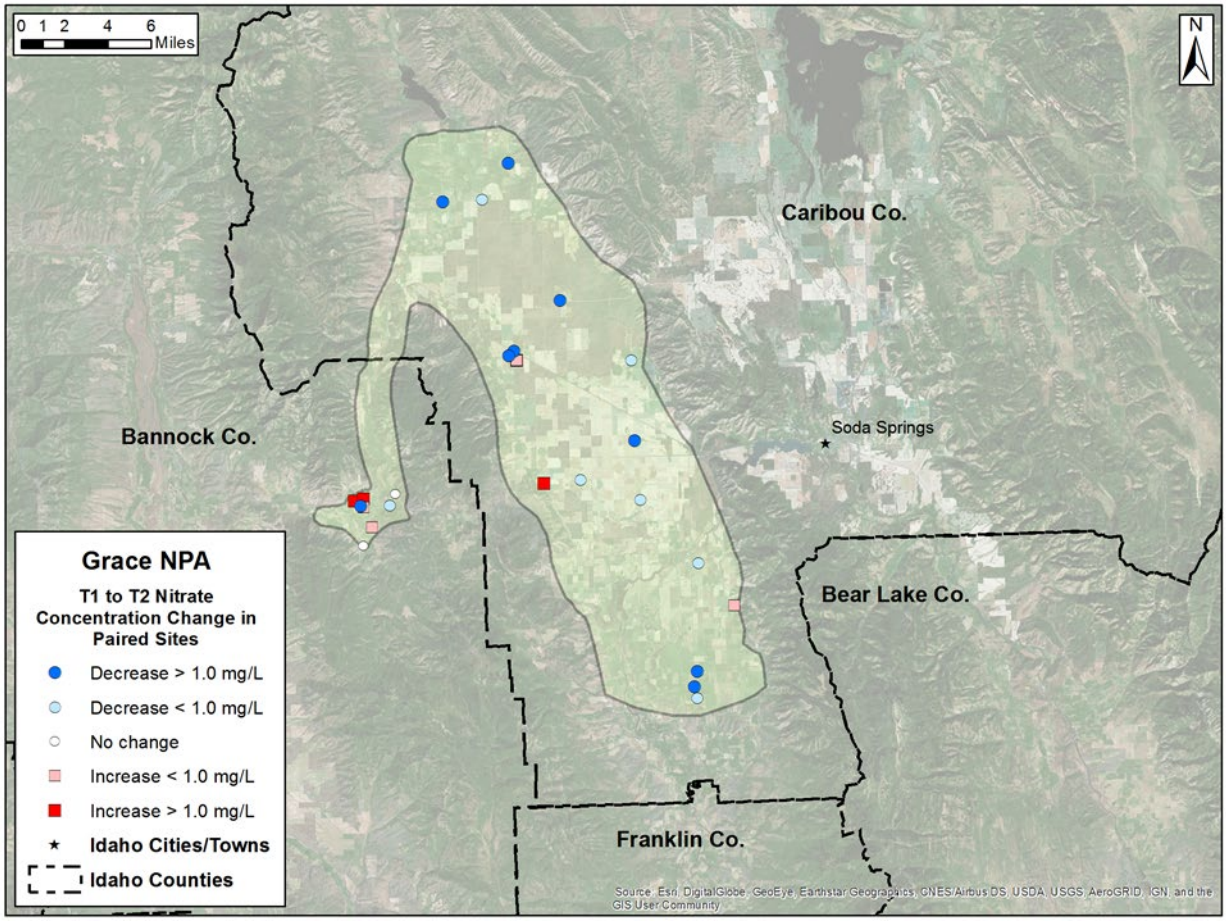


Figure 7. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Grace Nitrate Priority Area.

In this NPA, the median and ratio changes agreed (decreasing) and two threshold criteria were exceeded. Thus, the Grace NPA had a decreasing trend.

1.1.7 Lindsay Creek (No Trend)

In the Lindsay Creek NPA nonpaired analysis, T1 had 42 sites and T2 had 34 sites. The paired analysis included 29 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration decreased by 1.2 mg/L from T1 to T2 (Table 1, Figure A-14). This decrease was not significant at the 85% confidence level (Table 3). In the paired analysis, the median nitrate concentration increased by 0.1 mg/L from T1 to T2 (Table 2, Figure A-15). This increase was significant at the 90% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L was 2.5 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 8.

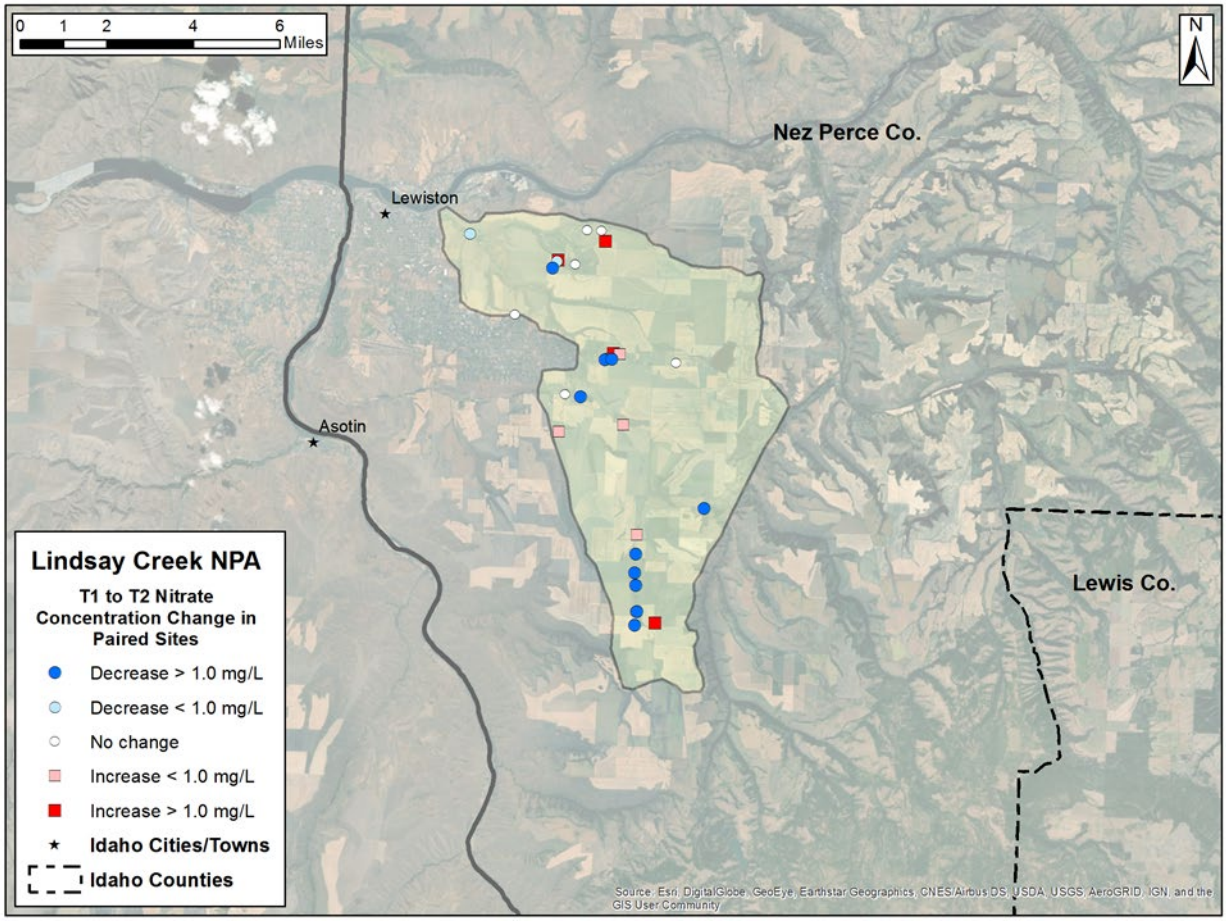


Figure 8. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Lindsay Creek Nitrate Priority Area.

While two of the threshold criteria were exceeded, the median changes disagreed. The paired data indicated an increase in nitrate concentrations while the nonpaired data indicated a decrease in nitrate concentrations. The difference in median changes between the nonpaired and paired data is because the paired dataset is a sub-set of the nonpaired dataset. Selection for paired sites reduces the dataset size, as not all nonpaired sites are sampled in both time periods. This sub-setting removes nonpaired data, which can affect nitrate summary statistics. In the case of Lindsay Creek, sub-setting for paired data removes a number of nonpaired sites with nitrate

concentrations less than 5 mg/L for T2. This increases the paired median nitrate concentration by approximately 2.0 mg/L for T2, from a nonpaired median concentration of 3.3 mg/L to a paired median concentration of 5.6 mg/L (Table 3 and Table 2).

Additionally, while the paired change in median concentration was significant at the 90% confidence level, the median only changed by 0.1 mg/L from T1 to T2. As discussed previously, the Wilcoxon test is a sign-rank test that compares the distribution of ranks between the two time periods. Therefore, significant p-values can result from datasets with similar medians if the ranks of the two datasets are sufficiently different. Regardless, because of the differences in median changes between the nonpaired and paired time periods, the Lindsay Creek NPA had no trend.

1.1.8 Lower Payette (No Trend)

In the Lower Payette NPA nonpaired analysis, T1 had 142 sites and T2 had 121 sites. The paired analysis included 82 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration increased by 0.4 mg/L from T1 to T2 (Table 1, Figure A-16). This increase was not significant at the 85% confidence level (Table 3). In the paired analysis, the median nitrate concentration decreased by 0.2 mg/L from T1 to T2 (Table 2, Figure A-17). This decrease was also not significant at the 85% confidence level (Table 3). The ratio of sites with increases greater than 1.0 mg/L to sites with decreases greater than 1.0 mg/L was 1.3 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 9.

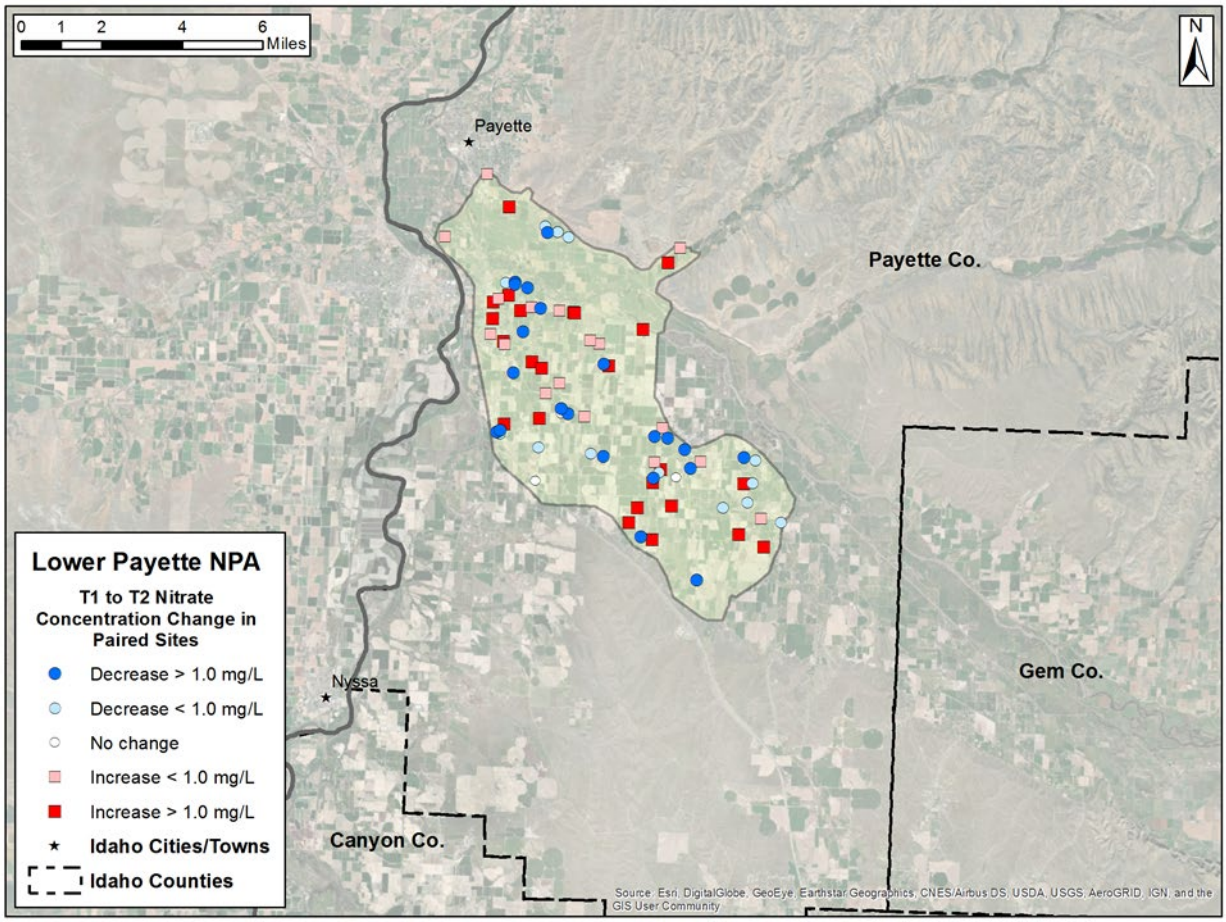


Figure 9. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Lower Payette Nitrate Priority Area.

For this NPA, the median changes disagreed and none of the threshold criteria were exceeded. Thus, the Lower Payette NPA had no trend.

1.1.9 Marsh Creek (No Trend)

In the Marsh Creek NPA nonpaired analysis, T1 had 173 sites and T2 had 103 sites. The paired analysis included 98 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration decreased by 1.1 mg/L from T1 to T2 (Table 1, Figure A-18). This decrease was not significant at the 85% confidence level (Table 3). In the paired analysis, the median nitrate concentration decreased by 0.9 mg/L from T1 to T2 (Table 2, Figure A-19). This decrease was not significant at the 85% confidence level (Table 3). The ratio of sites with increases greater than 1.0 mg/L to sites with decreases greater than 1.0 mg/L was 1.2 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 10.

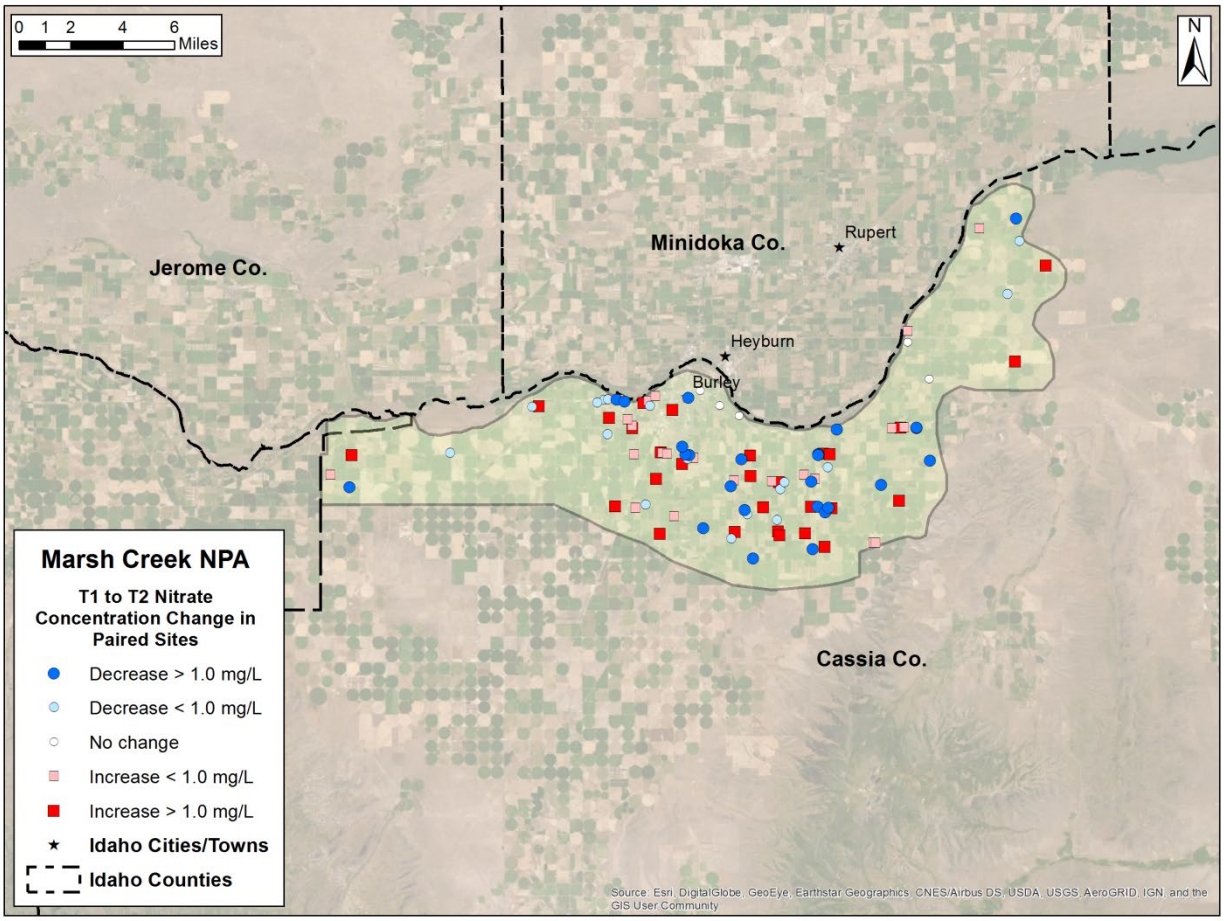


Figure 10. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Marsh Creek Nitrate Priority Area.

For this NPA, the median changes agreed. However, none of the threshold criteria were exceeded, and the number of sites with increase greater than 1.0 mg/L (31 sites) slightly exceeded the number of sites with decreases greater than 1.0 mg/L (25 sites). The resulting ratio, while not exceeding a threshold, does indicate an increasing trend in contrast to the decreasing medians. Thus, by the threshold criteria, the Marsh Creek NPA had no trend.

1.1.10 Marsing (Decreasing Trend)

In the Marsing NPA nonpaired analysis, T1 had 34 sites and T2 had 15 sites. The paired analysis included 11 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration decreased by 2.5 mg/L from T1 to T2 (Table 1, Figure A-20). This decrease was not significant at the 85% confidence level (Table 3). In the paired analysis, the median nitrate concentration decreased by 1.3 mg/L from T1 to T2 (Table 2, Figure A-21). This decrease was significant at the 90% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L was 4.0 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 11.

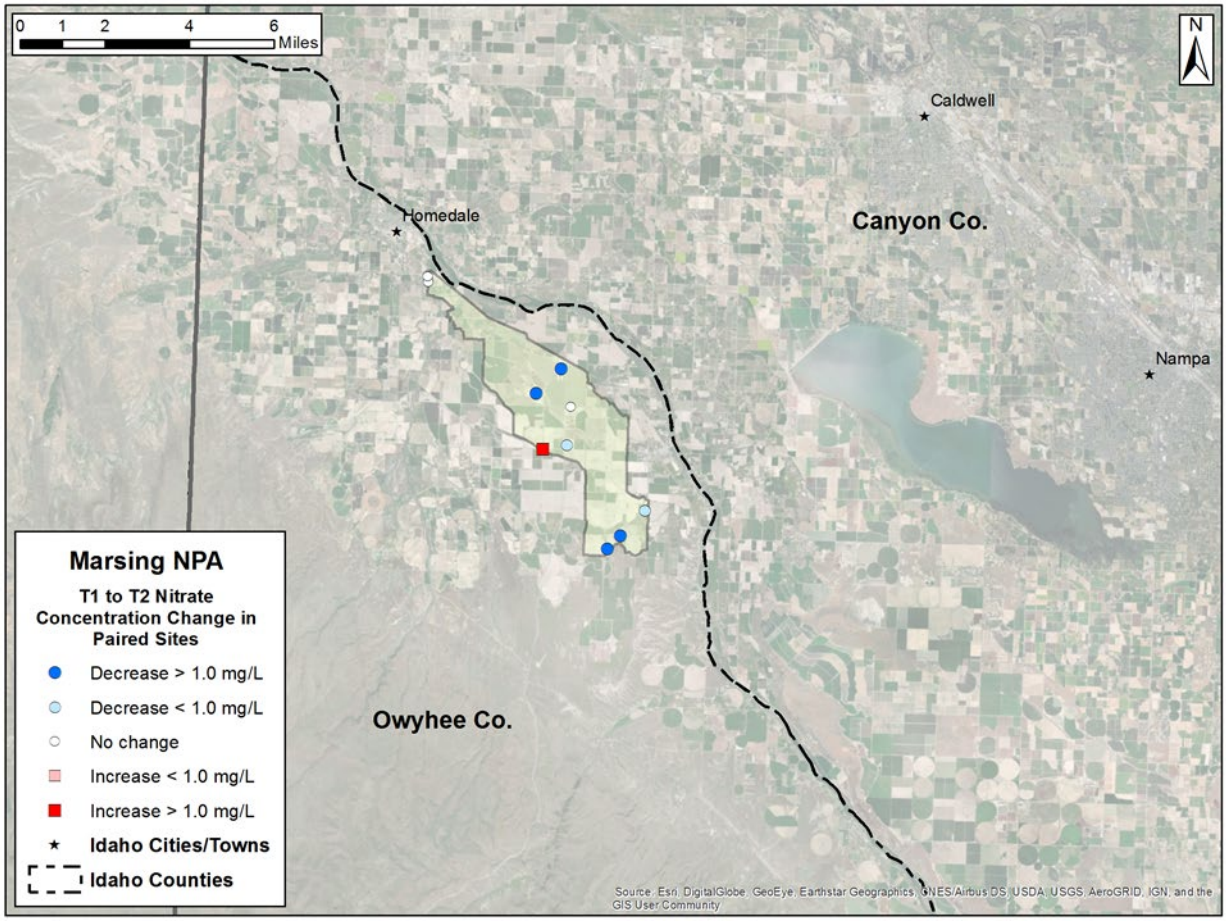


Figure 11. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Marsing Nitrate Priority Area.

For this NPA, the median and ratio changes agreed and two threshold criteria were exceeded. Thus, the Marsing NPA had a decreasing trend.

1.1.11 Minidoka (Increasing Trend)

In the Minikoka NPA nonpaired analysis, T1 had 153 sites and T2 had 112 sites. The paired analysis included 96 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration increased by 0.4 mg/L from T1 to T2 (Table 1, Figure A-22). This increase was not significant at the 85% confidence level (Table 3). In the paired analysis, the median nitrate concentration increased by 0.5 mg/L from T1 to T2 (Table 2, Figure A-23). This increase was significant at the 90% confidence level (Table 3). The ratio of sites with increases greater than 1.0 mg/L to sites with decreases greater than 1.0 mg/L was 2.4 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 12.

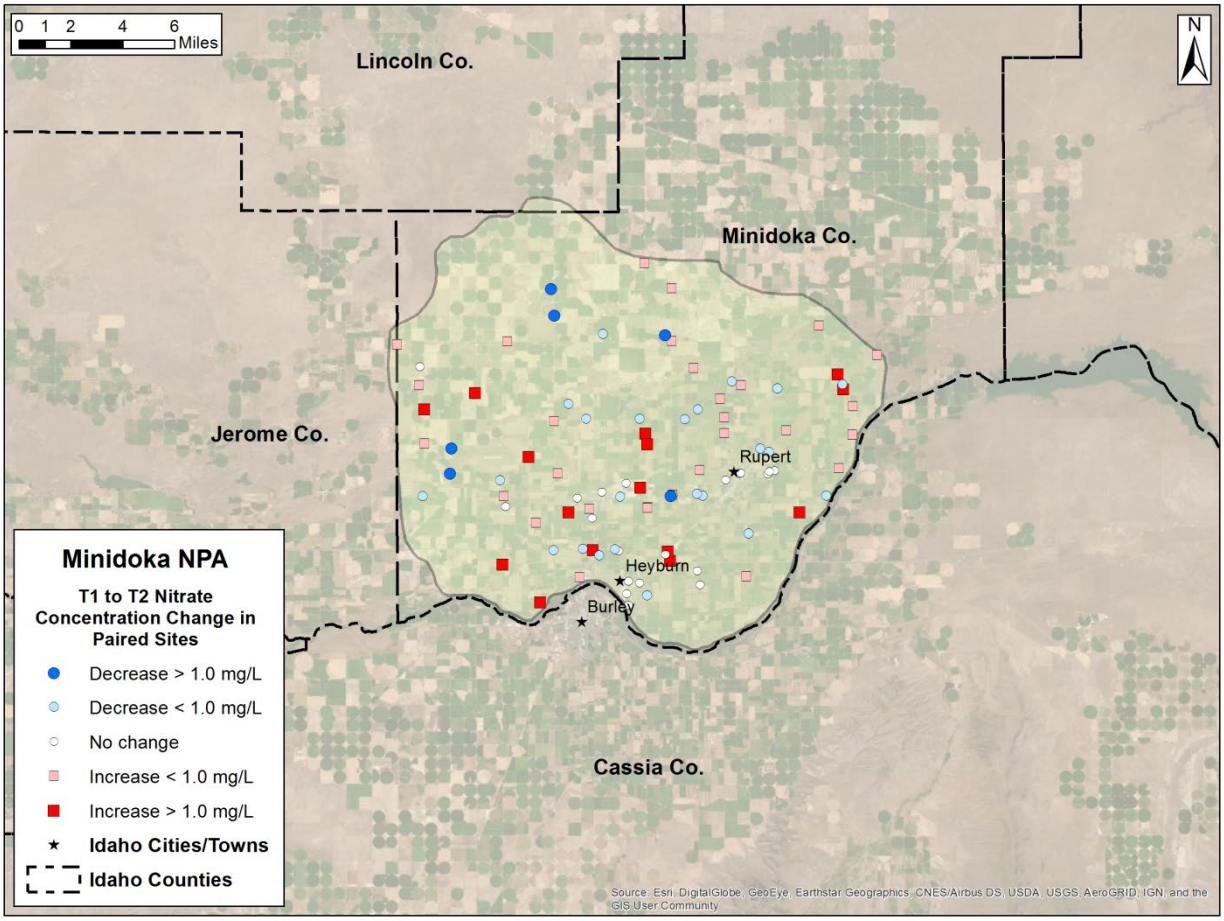


Figure 12. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Minidoka Nitrate Priority Area.

For this NPA, median and ratio changes agreed (increasing) and two threshold criteria were exceeded. Thus, the Minidoka NPA had an increasing trend.

1.1.12 Mountain Home AFB (Increasing Trend)

In the Mountain Home AFB NPA nonpaired analysis, T1 had 24 sites and T2 had 20 sites. The paired analysis included 20 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration increased by 1.8 mg/L from T1 to T2 (Table 1, Figure A-24). This increase was not significant at the 85% confidence level (Table 3). In the paired analysis, the median nitrate concentration increased by 1.8 mg/L from T1 to T2 (Table 2, Figure A-25). This increase was significant at the 95% confidence level (Table 3). The ratio of sites with increases greater than 1.0 mg/L to sites with decreases greater than 1.0 mg/L was 8.0 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 13.

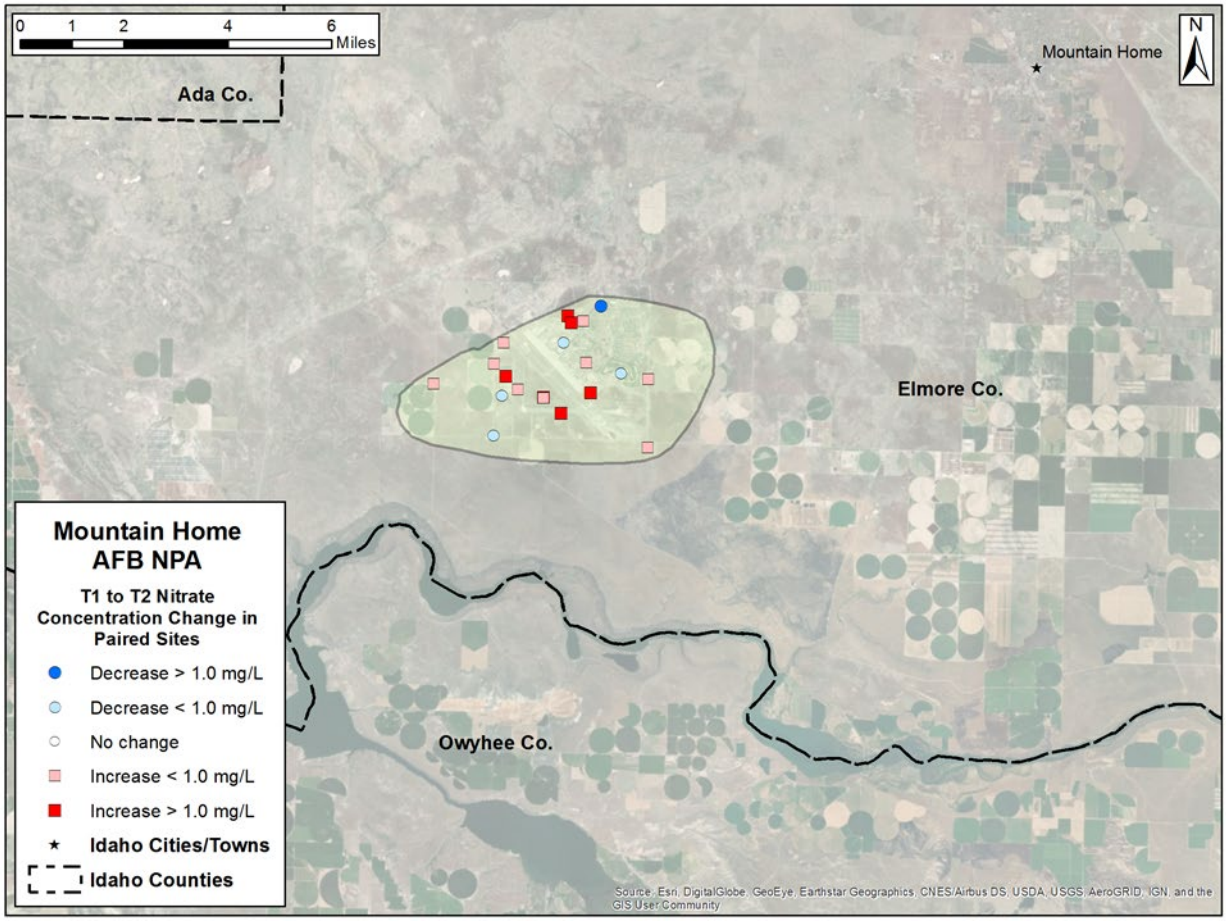


Figure 13. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Mountain Home AFB Nitrate Priority Area.

For this NPA the median and ratio change agreed (increase) and two threshold criteria were exceeded. Thus, the Mountain Home AFB NPA had an increasing trend.

1.1.13 Mud Lake (No Trend)

In the Mud Lake NPA nonpaired analysis, T1 had 73 sites and T2 had 59 sites. The paired analysis included 35 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration increased by 0.5 mg/L from T1 to T2 (Table 1, Figure A-26). This increase was not significant at the 85% confidence level (Table 3). In the paired analysis, the median nitrate concentration increased by 0.2 mg/L from T1 to T2 (Table 2, Figure A-27). This increase was also not significant at the 85% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L was 1.2 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 14.

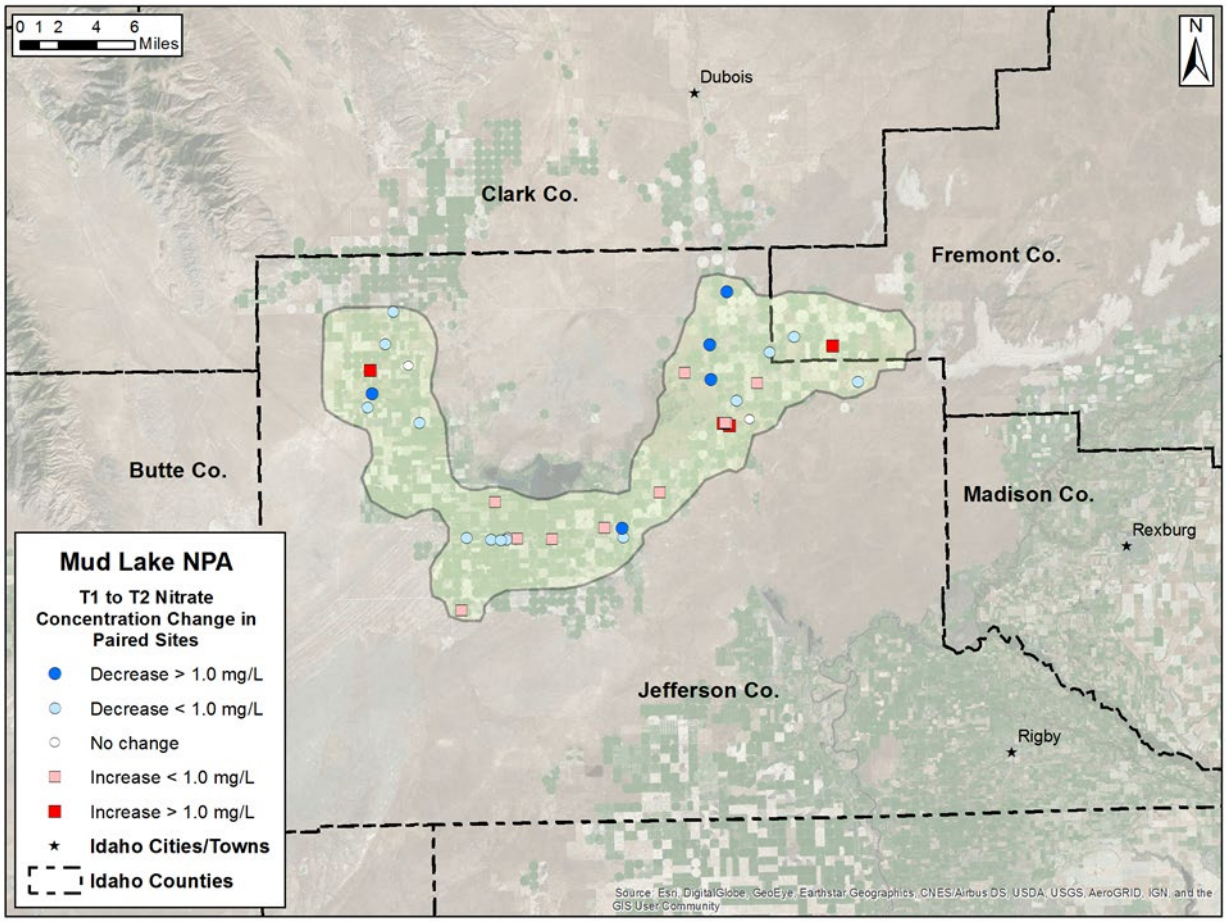


Figure 14. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Mud Lake Nitrate Priority Area.

For this NPA, the median and ratio change disagreed and no threshold criteria were exceeded. Thus, the Mud Lake NPA had no trend.

1.1.14 North Pocatello (Decreasing Tendency)

In the North Pocatello NPA nonpaired analysis, T1 had 25 sites and T2 had 24 sites. The paired analysis included 23 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration decreased by 0.5 mg/L from T1 to T2 (Table 1, Figure A-28). This decrease was not significant at the 85% confidence level (Table 3). In the paired analysis, the median nitrate concentration decreased by 0.6 mg/L from T1 to T2 (Table 2, Figure A-29). This decrease was also not significant at the 85% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L was 2.5 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 15.

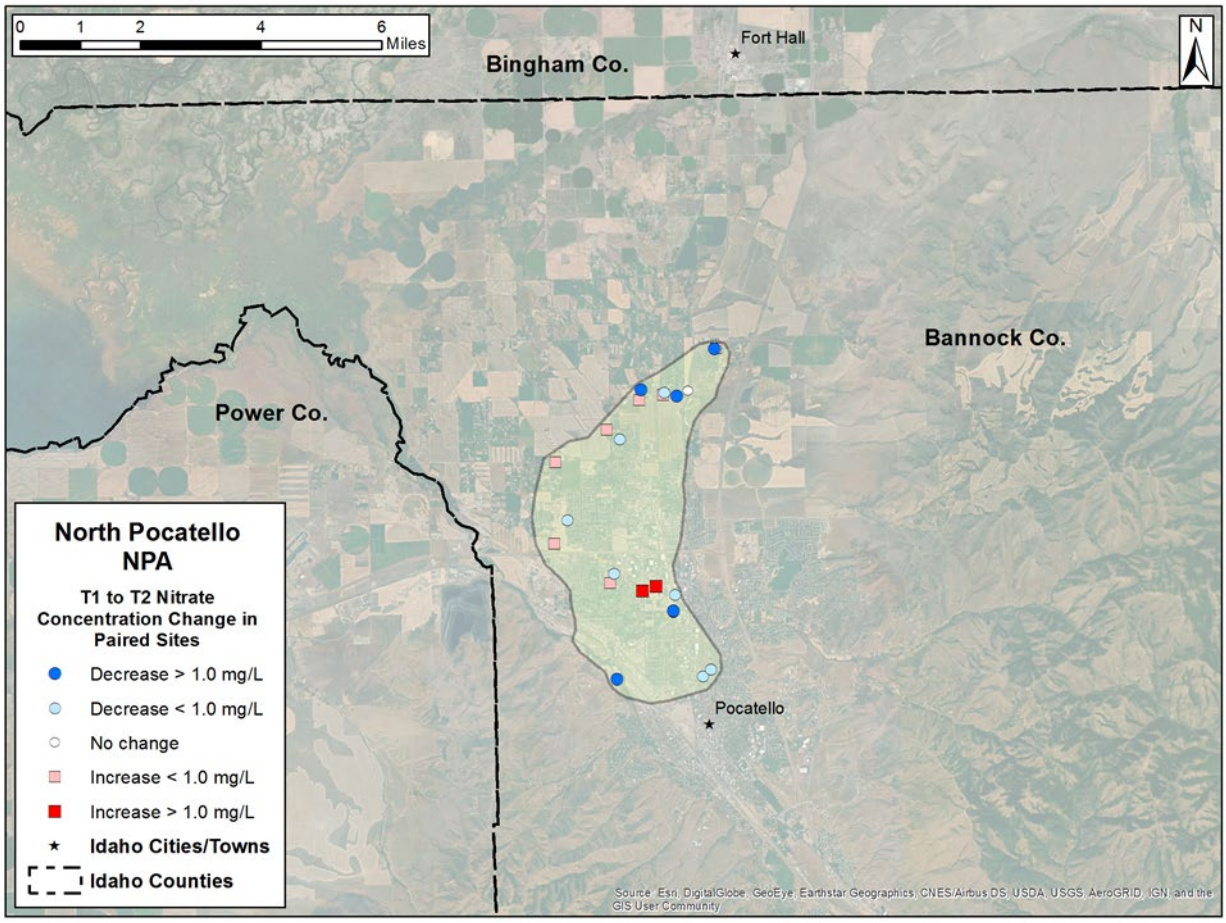


Figure 15. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in North Pocatello Nitrate Priority Area.

For this NPA, the median and ratio change were in agreement (decreasing) and one of the threshold criteria were exceeded. Thus, the North Pocatello NPA had a decreasing tendency.

1.1.15 Northeast Canyon County (Purple Sage) (Increasing Trend)

In the Northeast Canyon County (Purple Sage) NPA nonpaired analysis, T1 had 75 sites and T2 had 86 sites. The paired analysis included 23 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration increased by 1.8 mg/L from T1 to T2 (Table 1, Figure A-30). This increase was significant at the 95% confidence level (Table 3). In the paired analysis, the median nitrate concentration increased by 0.4 mg/L from T1 to T2 (Table 2, Figure A-31). This increase was also significant at the 95% confidence level (Table 3). The ratio of sites with increases greater than 1.0 mg/L to sites with decreases greater than 1.0 mg/L was 7.0 (Table 3). Changes in nitrate concentrations for paired sites are presented Figure 16.

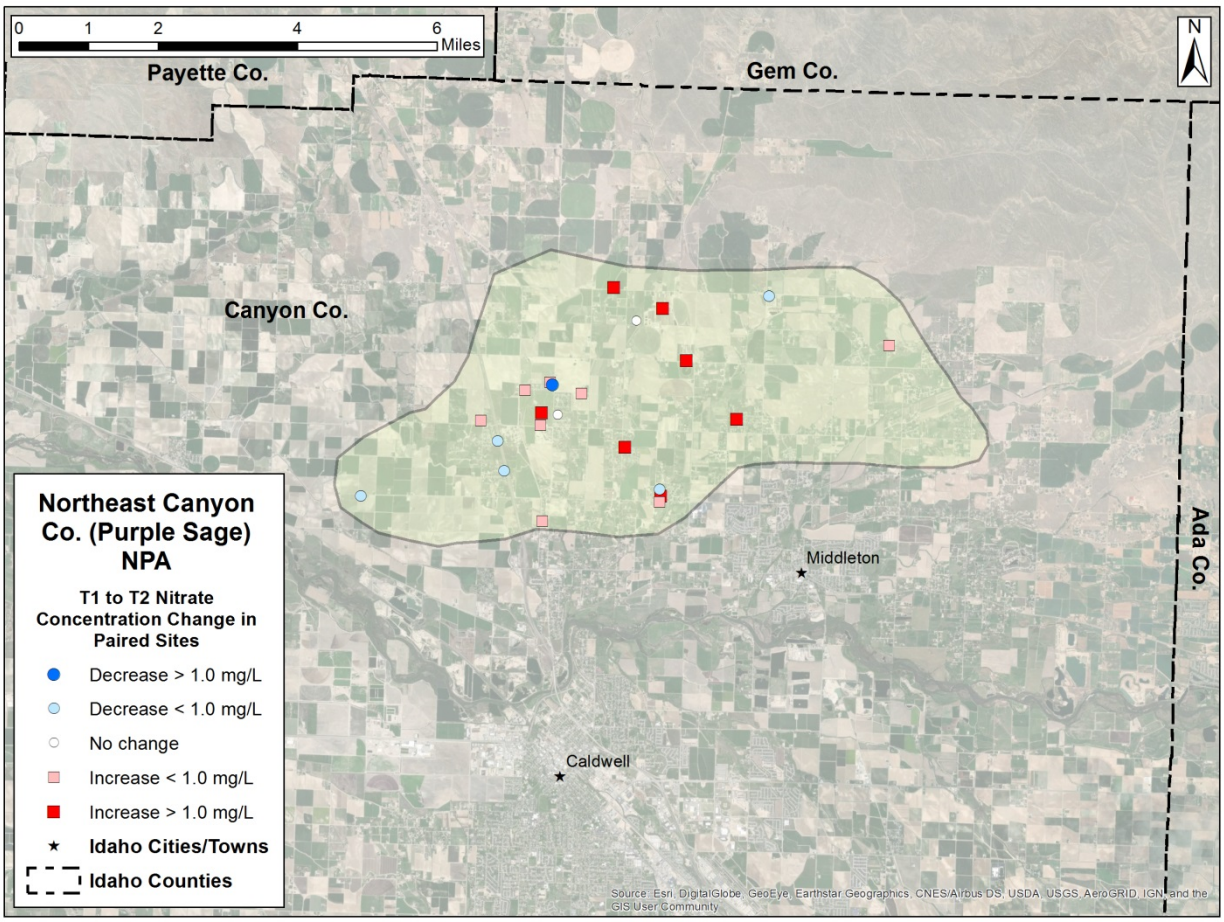


Figure 16. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Northeast Canyon Co. (Purple Sage) Nitrate Priority Area.

For this NPA, the median and ratio change agreed (increasing) and three threshold criteria were exceeded (Table 3). Thus, the Northeast Canyon County NPA had an increasing trend.

1.1.16 Northeast Star (Increasing Trend)

In the Northeast Star NPA nonpaired analysis, T1 had 26 sites and T2 had 20 sites. The paired analysis included 19 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration increased by 6.3 mg/L from T1 to T2 (Table 1, Figure A-32). This increase was not significant at the 85% confidence level (Table 3). In the paired analysis, the median nitrate concentration increased by 2.2 mg/L from T1 to T2 (Table 2, Figure A-33). This increase was significant at the 90% confidence level (Table 3). The ratio of sites with increases greater than 1.0 mg/L to sites with decreases greater than 1.0 mg/L was 3.7 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 17.

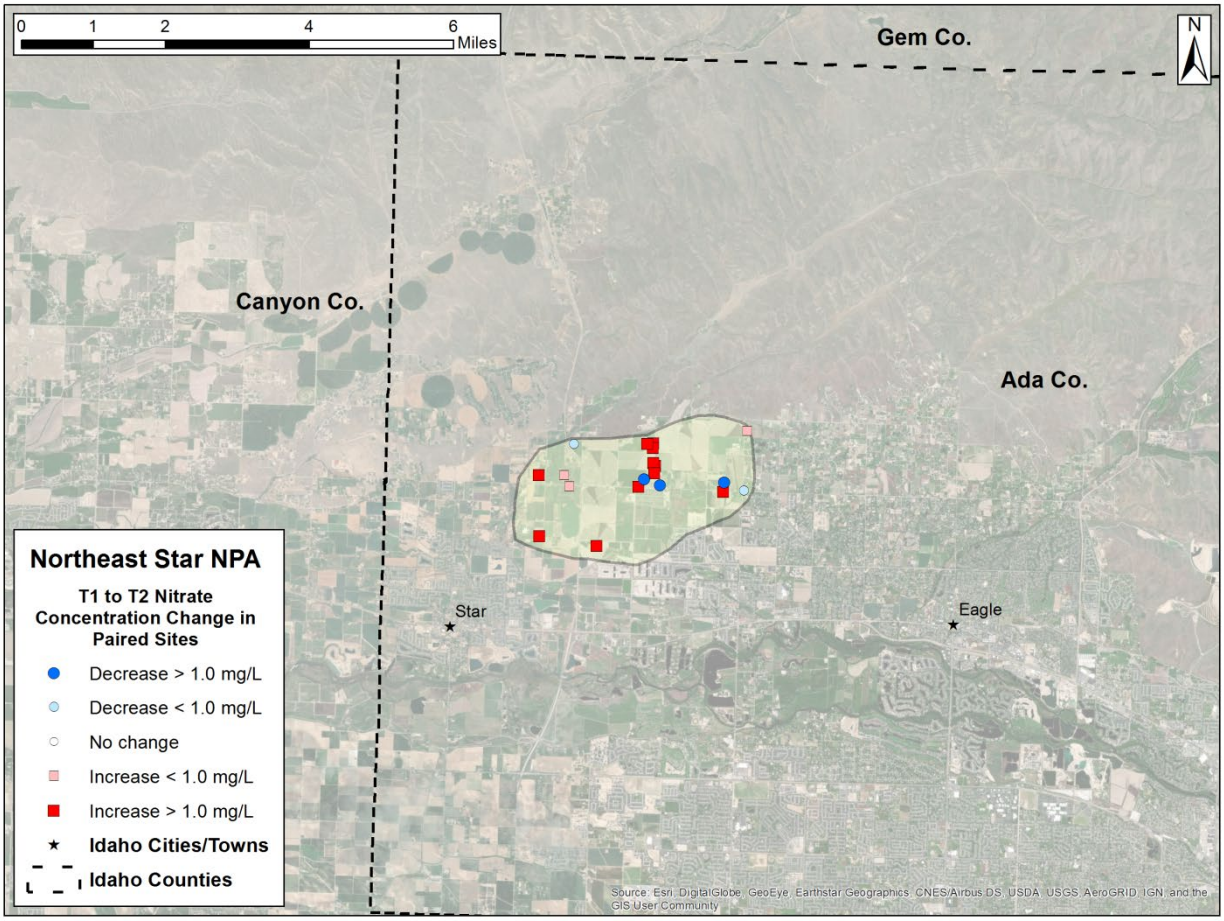


Figure 17. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Northeast Star Nitrate Priority Area.

For this NPA, the median and ratio change agreed (increasing) and two of the threshold criteria were exceeded. Thus, the Northeast Star NPA had an increasing trend.

1.1.17 Preston (Decreasing Trend)

In the Preston NPA nonpaired analysis, T1 had 68 sites and T2 had 45 sites. The paired analysis included 38 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration decreased by 1.5 mg/L from T1 to T2 (Table 1, Figure A-34). This decrease was significant at the 95% confidence level (Table 3). In the paired analysis, the median nitrate concentration decreased by 0.7 mg/L from T1 to T2 (Table 2, Figure A-35). This decrease was not significant at the 85% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L was 3.2 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 18.

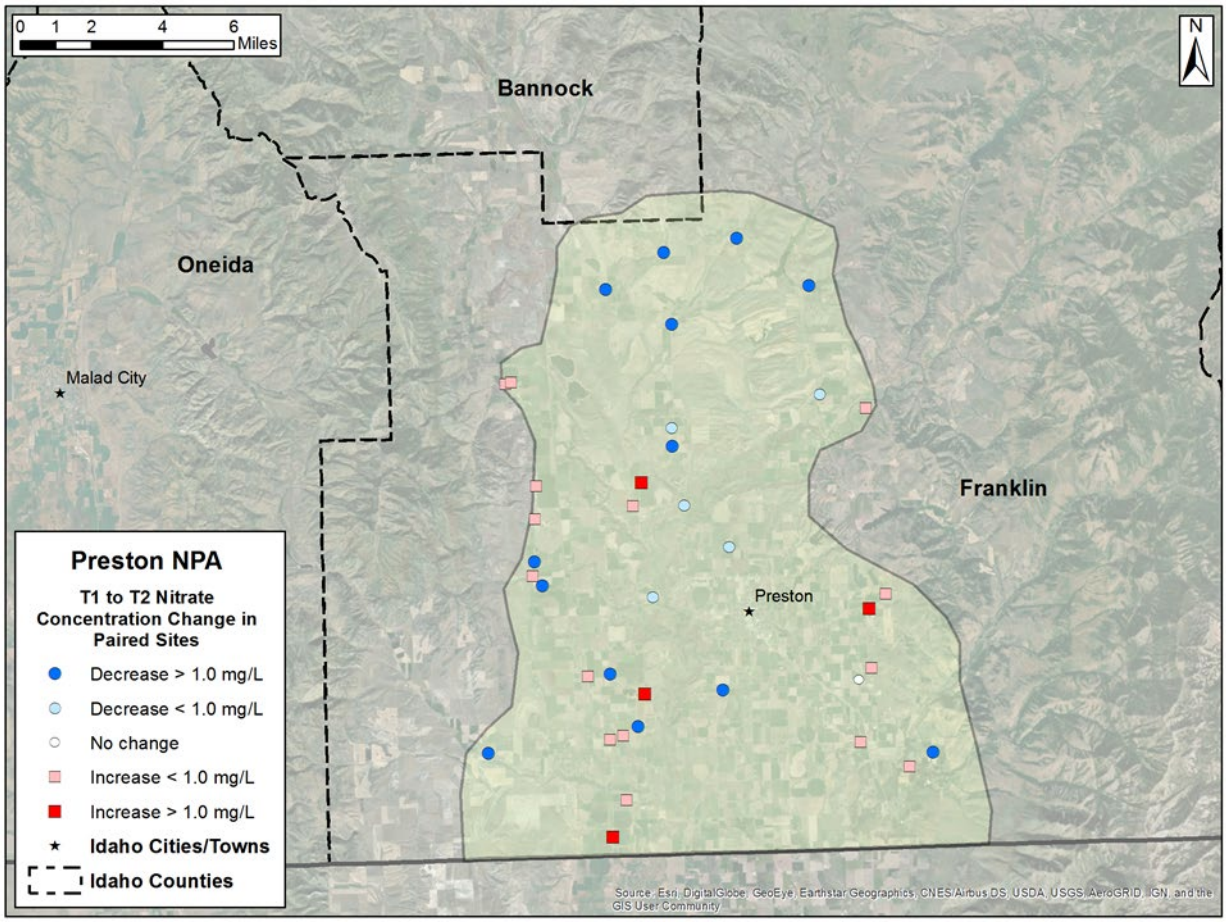


Figure 18. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Preston Nitrate Priority Area.

For this NPA, the median and ratio change agreed (decreasing) and two threshold criteria were exceeded (Table 3). Thus, the Preston NPA had a decreasing trend.

1.1.18 Southwest Jerome (Increasing Trend)

In the Southwest Jerome NPA nonpaired analysis, T1 had 20 sites and T2 had 17 sites. The paired analysis included 14 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration increased by 0.8 mg/L from T1 to T2 (Table 1, Figure A-36). This increase was not significant at the 85% confidence level (Table 3). In the paired analysis, the median nitrate concentration increased by 0.6 mg/L from T1 to T2 (Table 2, Figure A-37). This increase was significant at the 95% confidence level (Table 3). The ratio of sites with increases greater than 1.0 mg/L to sites with decreases greater than 1.0 mg/L was 3.0 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 19.

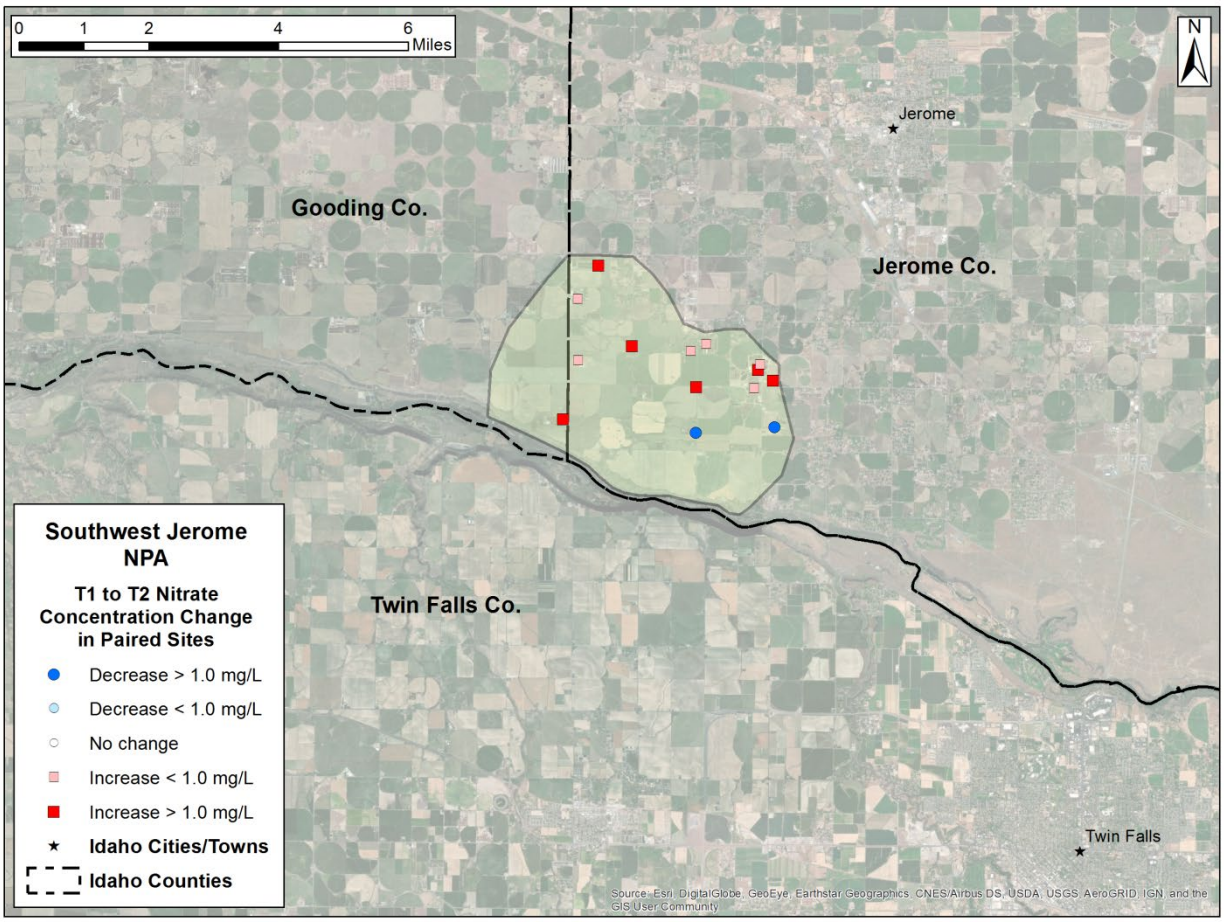


Figure 19. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Southwest Jerome Nitrate Priority Area.

For this NPA, the median and ratio change agreed (increasing) and two threshold criteria were exceeded (Table 3). Thus, the Southwest Jerome NPA had an increasing trend.

1.1.19 Twin Falls (No Trend)

In the Twin Falls NPA nonpaired analysis, T1 had 380 sites and T2 had 198 sites. The paired analysis included 169 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration increased by 0.1 mg/L from T1 to T2 (Table 1, Figure A-38). This increase was not significant at the 85% confidence level (Table 3). In the paired analysis, the median nitrate concentration did not change from T1 to T2 (Table 2, Figure A-39). This lack of change was also not significant at the 85% confidence level (Table 3). The ratio of sites with increases greater than 1.0 mg/L to sites with decreases greater than 1.0 mg/L was 1.3 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 20.

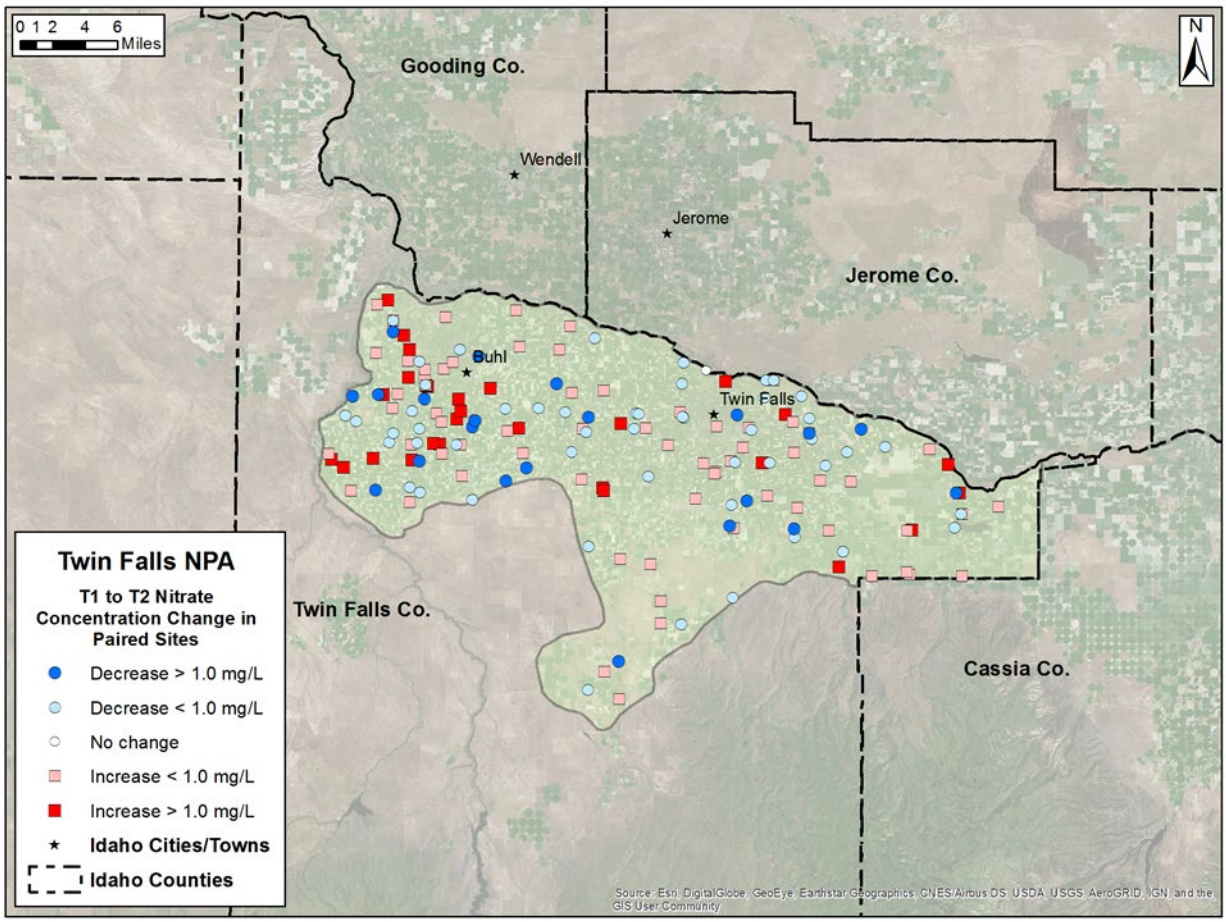


Figure 20. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Twin Falls Nitrate Priority Area.

While the median and ratio change were in agreement (increasing), none of the threshold criteria were exceeded. Thus, the Twin Falls NPA had no trend.

1.1.20 Weiser (Decreasing Tendency)

In the Weiser NPA nonpaired analysis, T1 had 92 sites and T2 had 82 sites. The paired analysis included 43 sites sampled in both time periods.

In the nonpaired analysis, the median nitrate concentration decreased by 2.9 mg/L from T1 to T2 (Table 1, Figure A-40). This decrease was significant at the 90% confidence level (Table 3). In the paired analysis, the median nitrate concentration decreased by 2.3 mg/L from T1 to T2 (Table 2, Figure A-41). This decrease was not significant at the 85% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L was 1.1 (Table 3). Changes in nitrate concentrations for paired sites are presented in Figure 21.

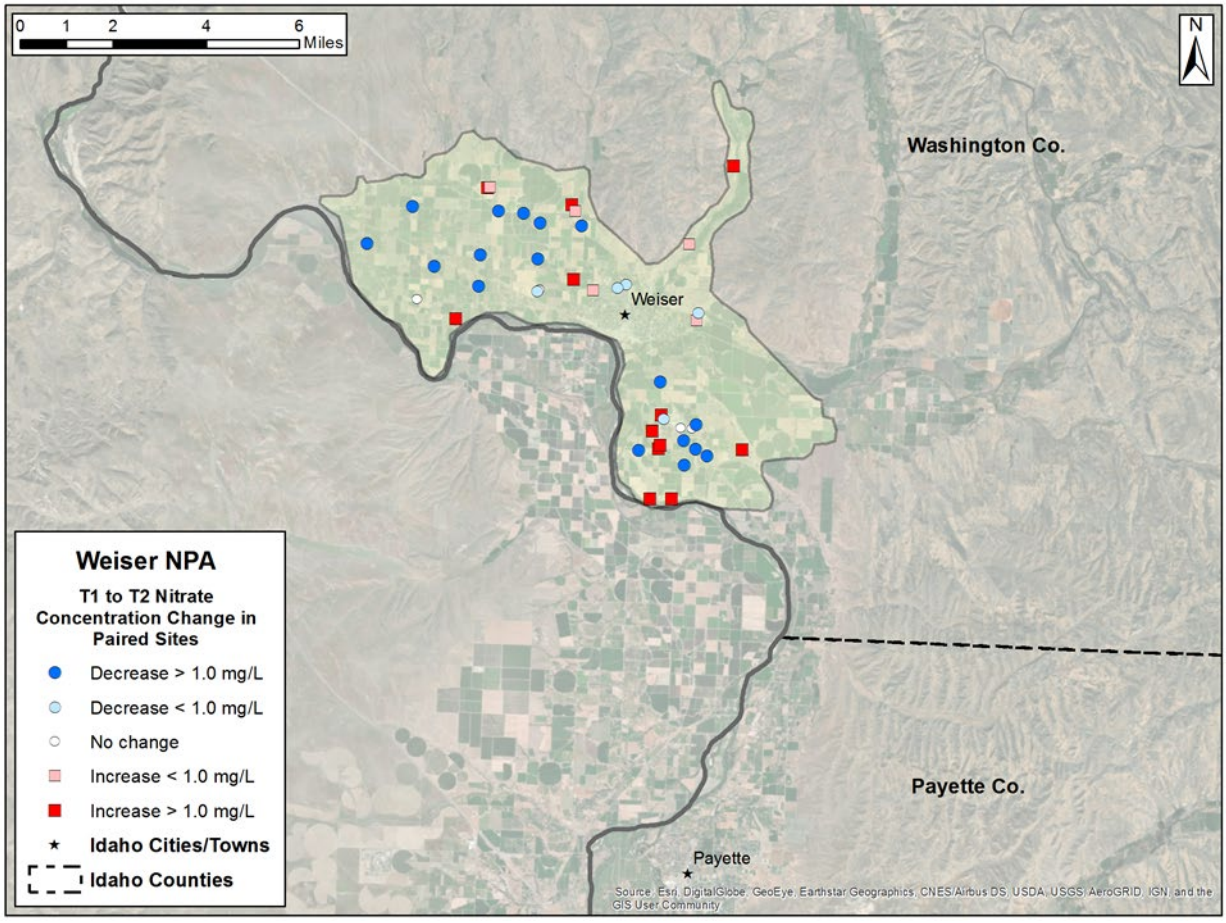


Figure 21. Nitrate concentration changes in paired sites from 2007–2011 (T1) and 2012–2016 (T2) in Weiser Nitrate Priority Area.

For this NPA, the median and ratio change were in agreement (decreasing) and one of the threshold criteria were exceeded. Thus, the Weiser NPA had a decreasing tendency.

References

DEQ (Idaho Department of Environmental Quality). 2014. *2014 Nitrate Priority Area Delineation and Ranking Process*. Boise, ID: DEQ.

ESRI (Environmental Systems Research Institute). 2017. ArcGIS Desktop: Release 10. Redlands, CA: ESRI.

Gilbert, R. 1987. *Statistical Methods for Environmental Pollution Monitoring*. New York, NY: Van Nostrand Reinhold.

Helsel, D. and R. W. Hirsch. 2002. *Statistical Methods in Water Resources: Techniques of Water-Resources Investigations of the U.S. Geological Survey, Book 4, Hydrologic Analysis and Interpretation, Chap. A3*. Reston, VA: US Geological Survey.

Hothorn, T., Hornik, K., van de Wiel, M., and A. Zeileis. 2008. "Implementing a Class of Permutation Tests: The Coin Package." *Journal of Statistical Software* 28 (8): 1–23.

Lindsey, B. and M.G. Rupert. 2012. *Methods for Evaluating Temporal Groundwater Quality Data and Results of Decadal-Scale Changes in Chloride, Dissolved Solids, and Nitrate Concentrations in Groundwater in the United States, 1988–2010*. Reston, VA: US Geological Survey. Scientific Investigations Report 2012-5049.

Mann, H. and D.R. Whitney. 1947. "On a Test of Whether one of Two Random Variables is Stochastically Larger than the Other." *Annals of Mathematical Statistics* 18 (1): 50-60.

Neely, K.W. 2008. *Trend Analyses for Idaho's Nitrate Priority Areas, 1994–2007*. Boise, ID: Idaho Department of Water Resources, Water Information Bulletin Number 50, Part 7.

Neely, K.W. 2013. *Trend Analyses for Idaho's Nitrate Priority Areas, 2002–2011*. Boise, ID: Idaho Department of Water Resources, Water Information Bulletin Number 50, Part 8.

Parliman, D. J. 2002. *Analysis of Nitrate (NO3-N) Concentration Trends in 25 Ground-Water-Quality Management Areas, Idaho, 1961-2001*. Boise, ID: US Geological Survey. Water-Resources Investigations Report No. 2002-4056.

Pratt, J.W. 1959. "Remarks on Zeros and Ties in the Wilcoxon Signed Rank Procedures." *American Statistical Association Journal* 54 (287): 655-667.

Rupert, M.G. 2008. "Decadal-Scale Changes of Nitrate in Ground Water of the United States, 1988–2004." *Journal of Environmental Quality* 37 (5): S-240.

R (R Core Team). 2017. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing.

Wilcoxon, F. 1945. "Individual Comparisons by Ranking Methods." *Biometrics* 1: 80-83.

Appendix I. Boxplots of nonpaired and paired Nitrate Priority Area nitrate data from 2007–2016.

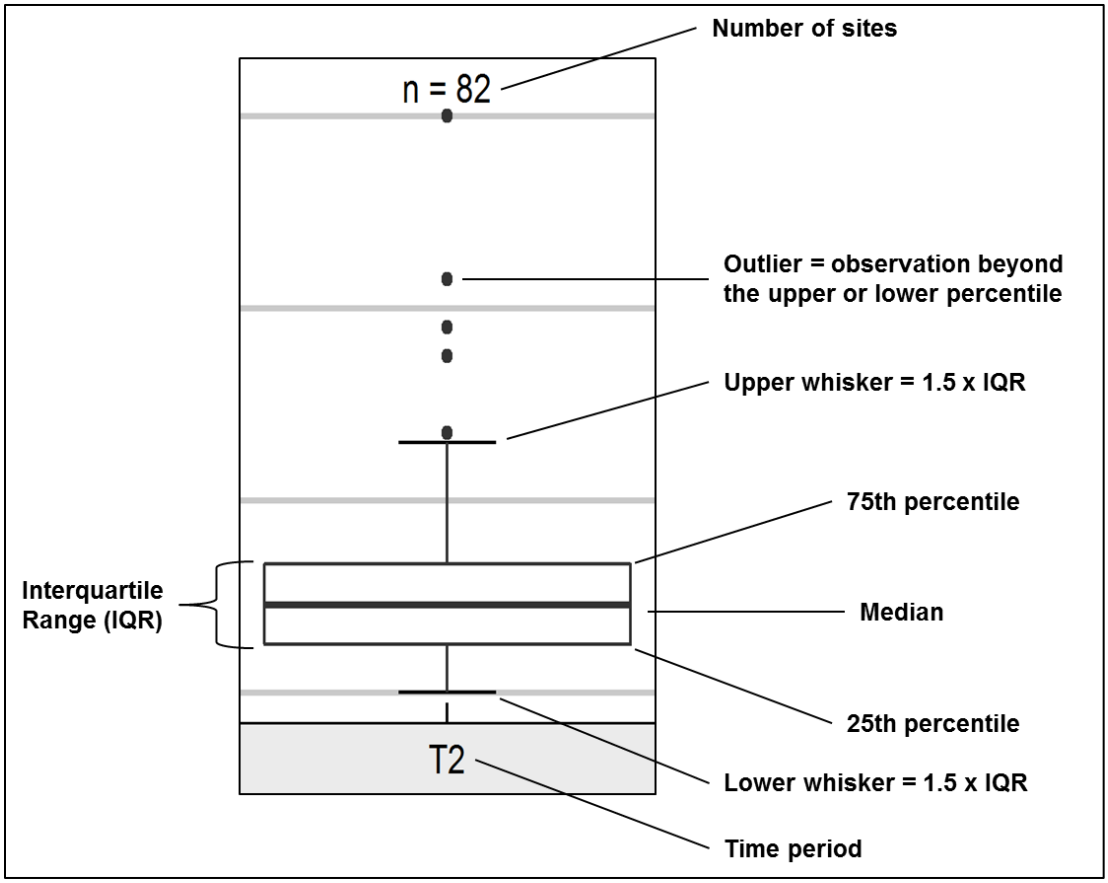


Figure A-1. Boxplot diagram explanation.

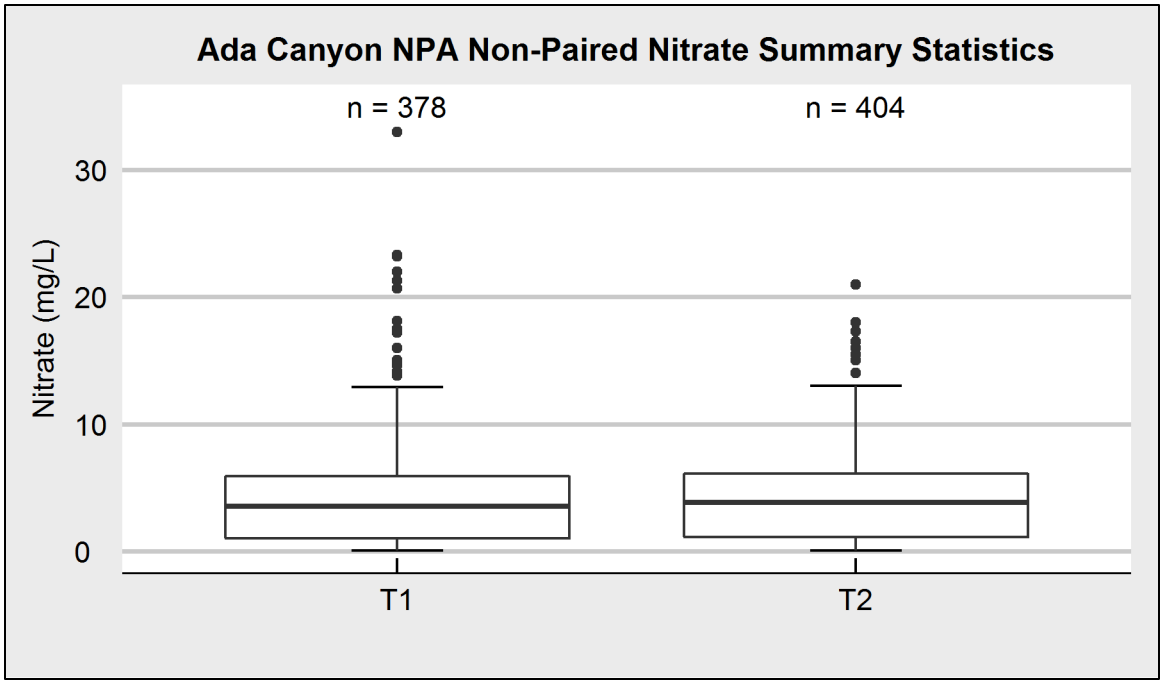


Figure A-2. Boxplots of Ada Canyon Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

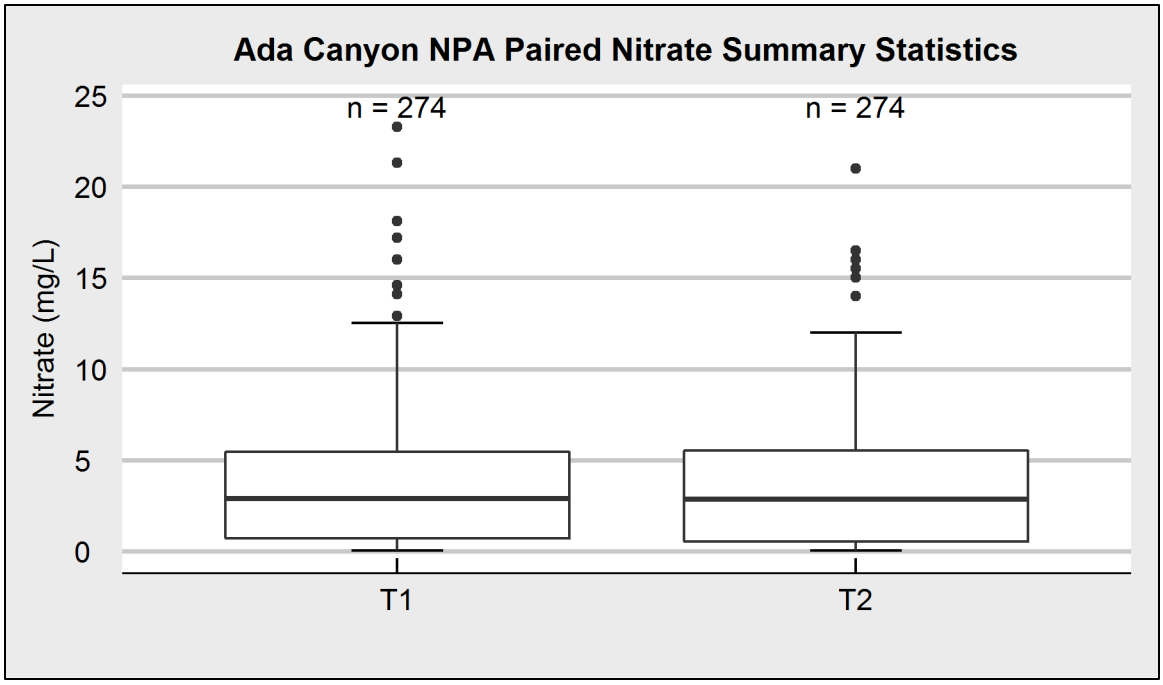


Figure A-3. Boxplots of Ada Canyon Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

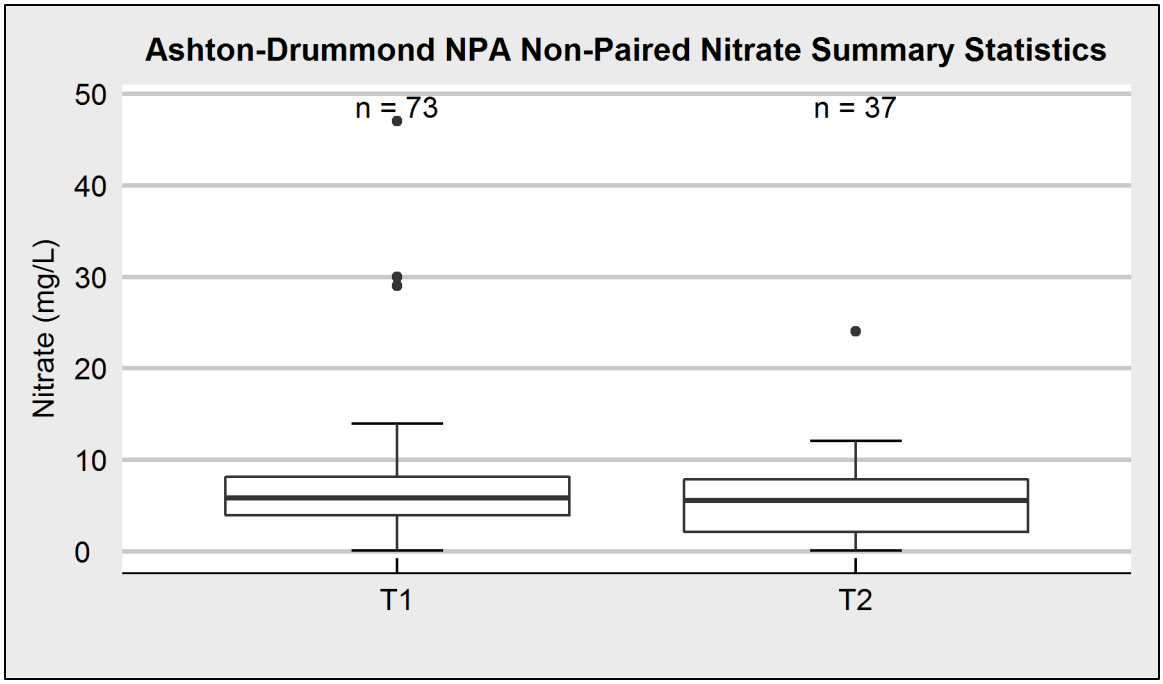


Figure A-4. Boxplots of Ashton-Drummond Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

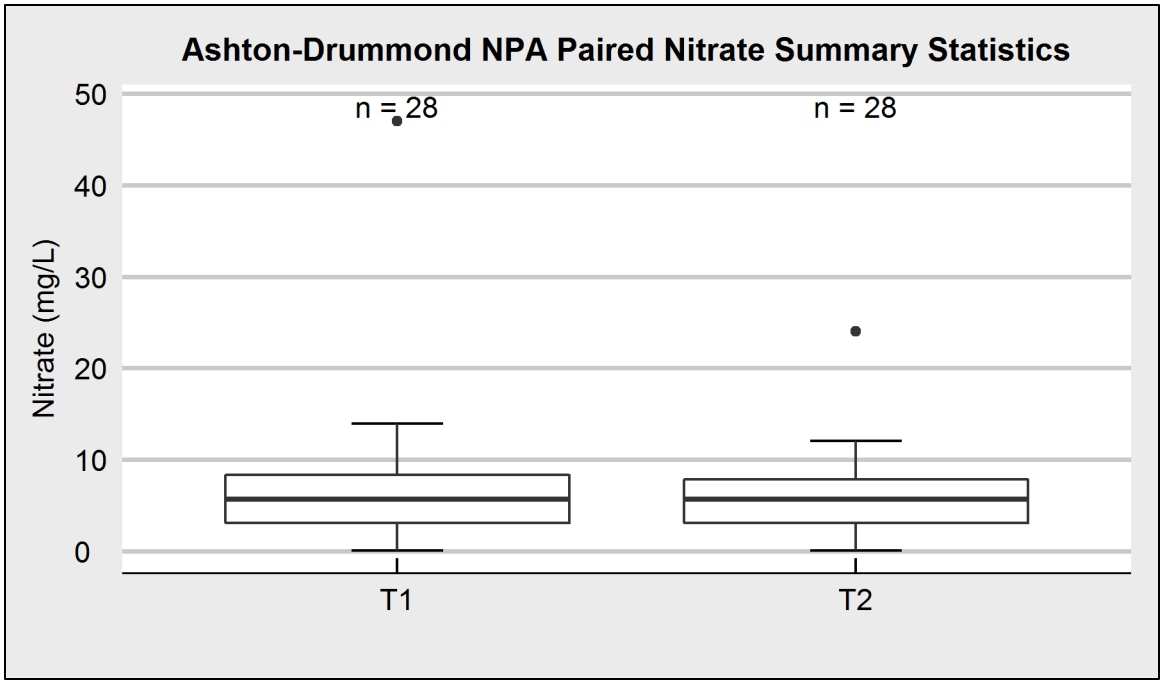


Figure A-5. Boxplots of Ashton-Drummond Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

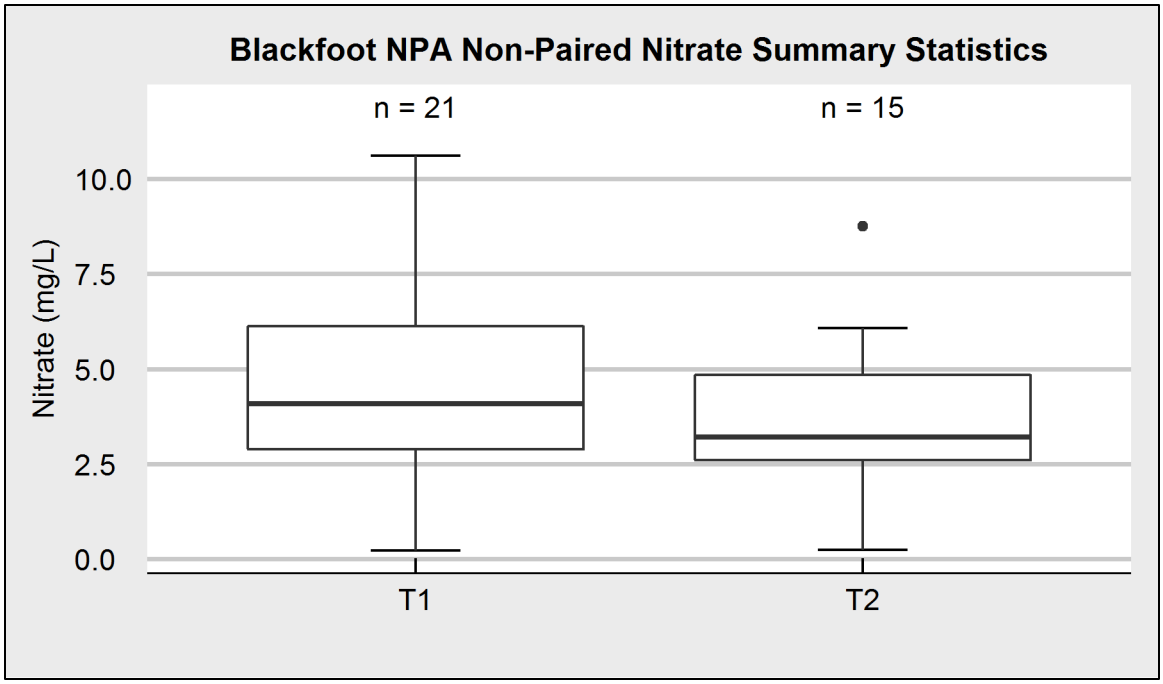


Figure A-6. Boxplots of Blackfoot Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

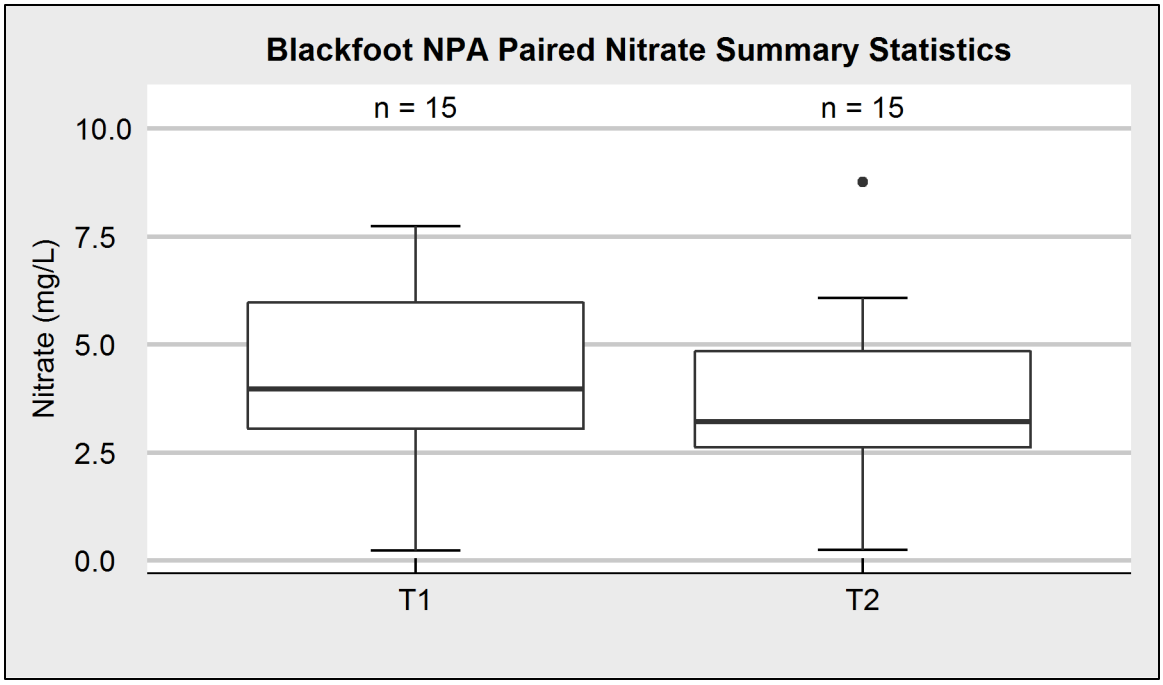


Figure A-7. Boxplots of Blackfoot Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

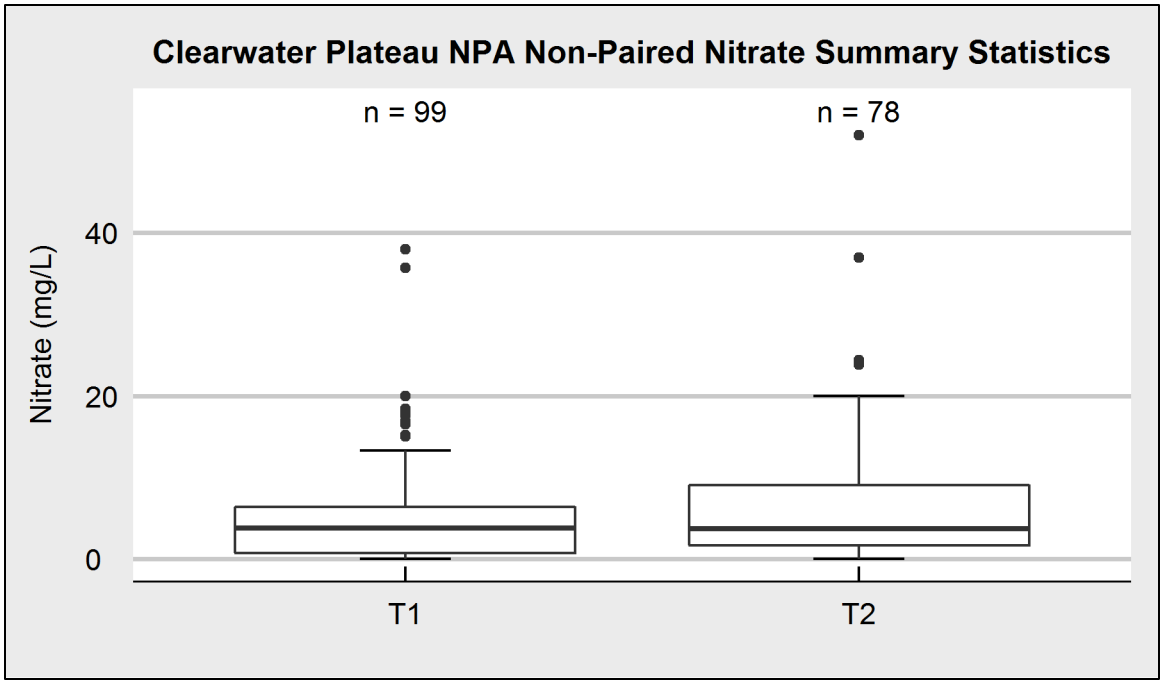


Figure A-8. Boxplots of Clearwater Plateau Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

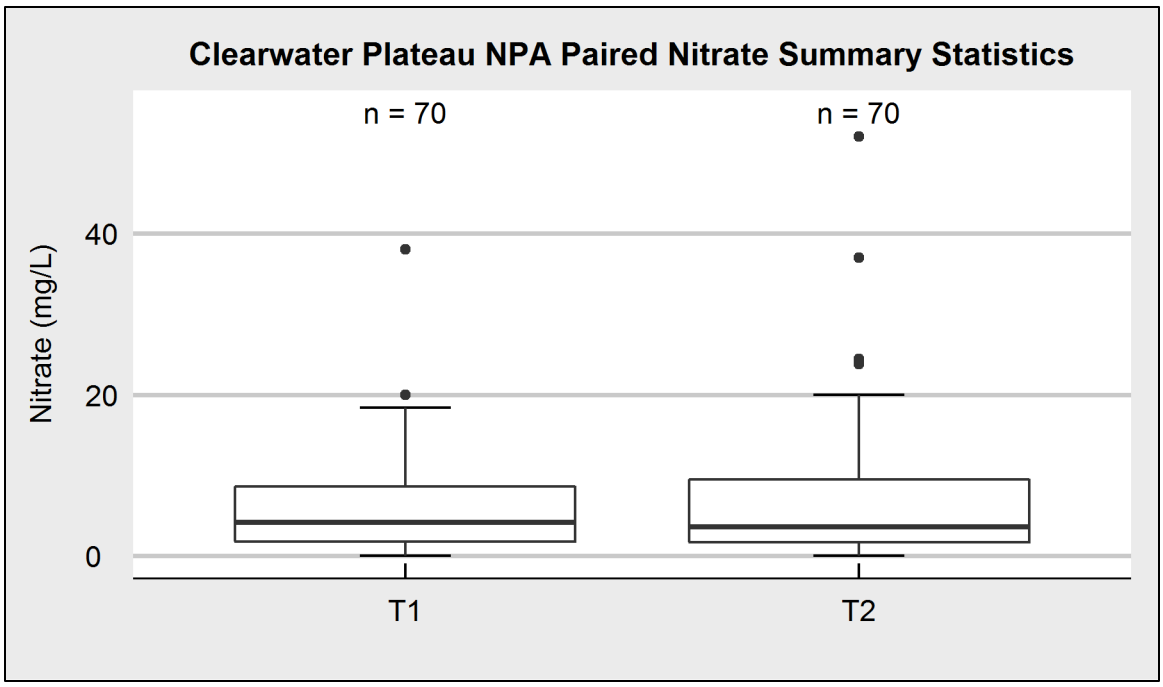


Figure A-9. Boxplots of Clearwater Plateau Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

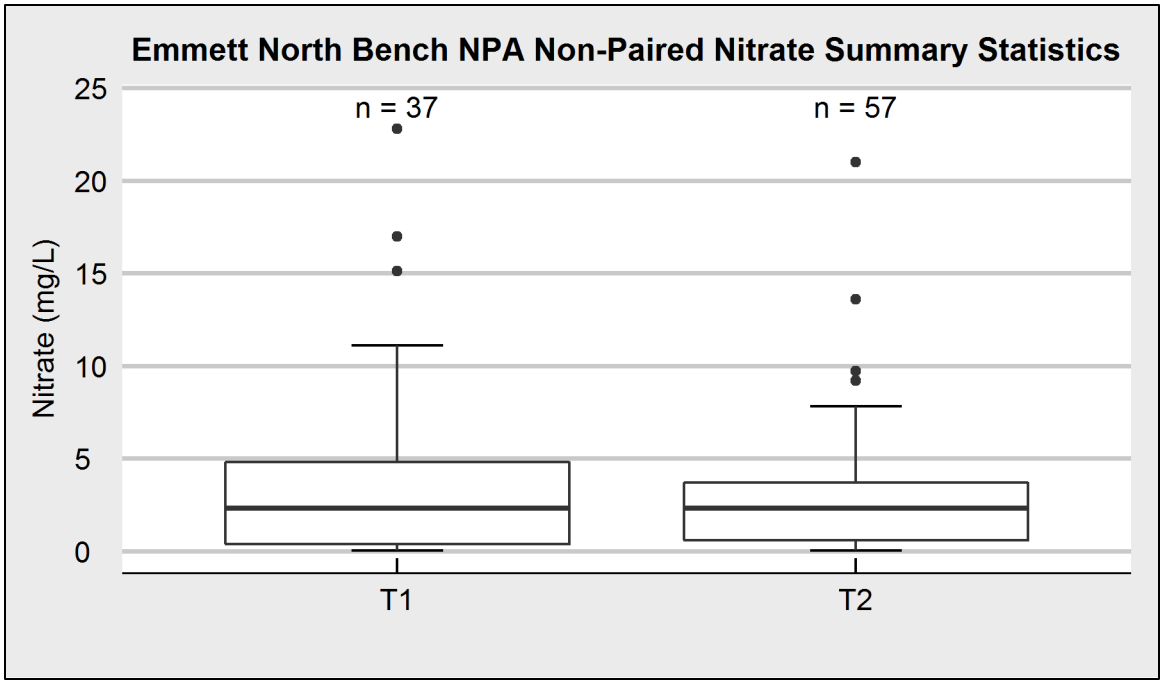


Figure A-10. Boxplots of Emmett North Bench Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

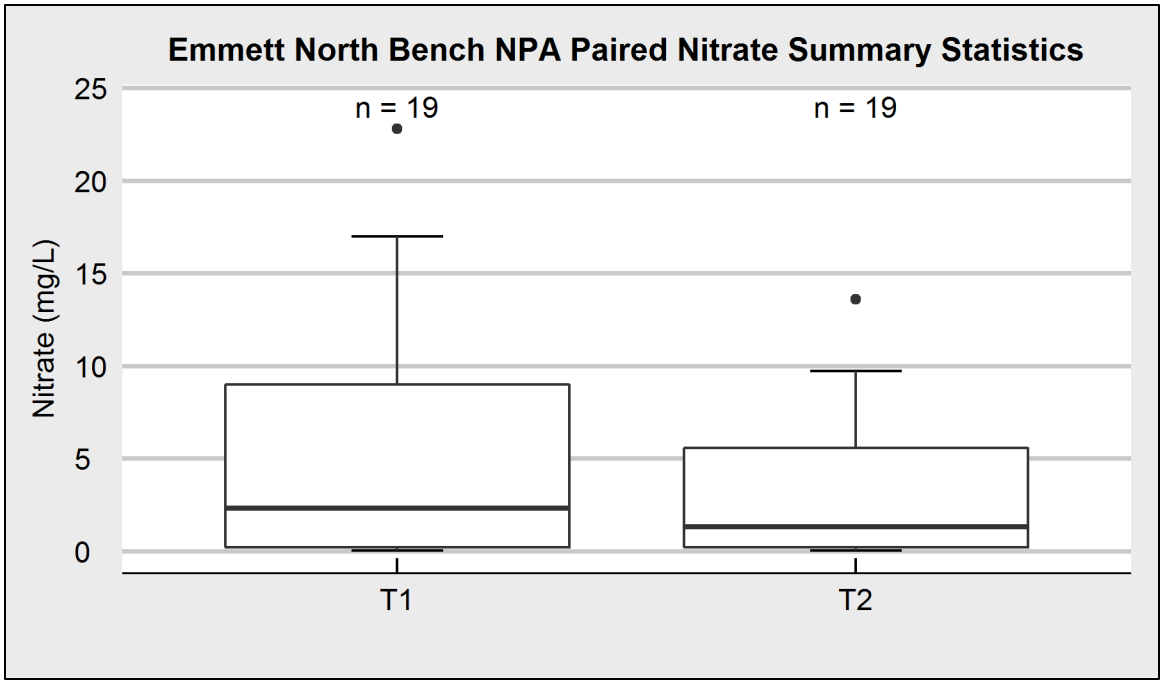


Figure A-11. Boxplots of Emmett North Bench Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

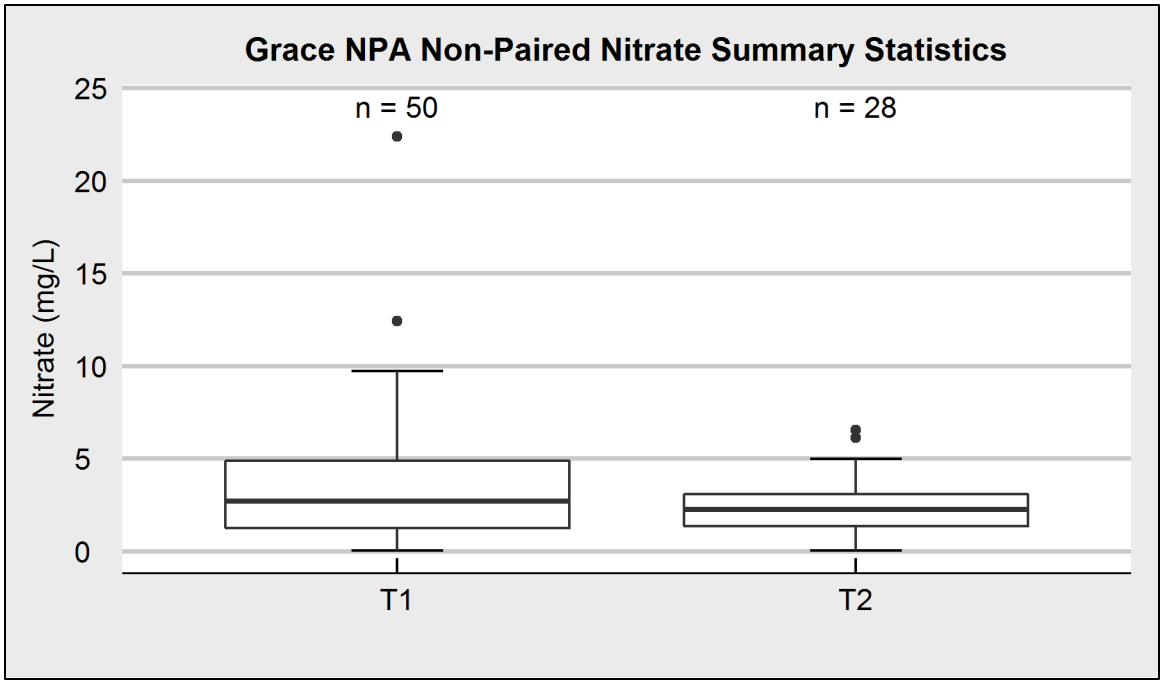


Figure A-12. Boxplots of Grace Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

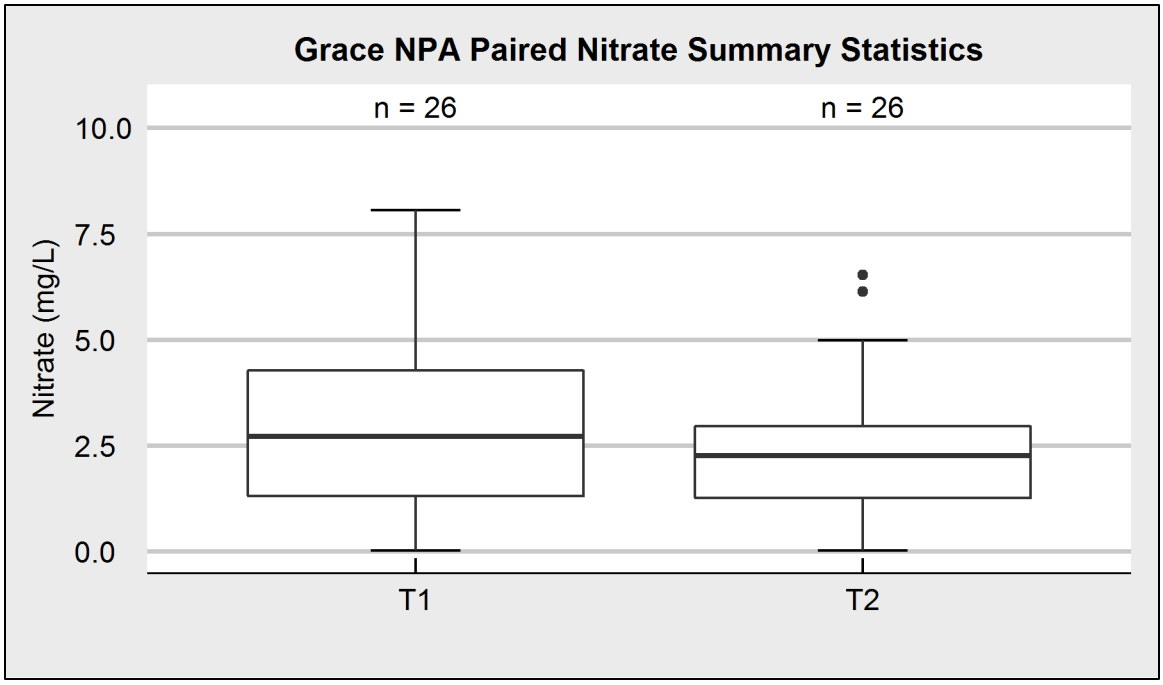


Figure A-13. Boxplots of Grace Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

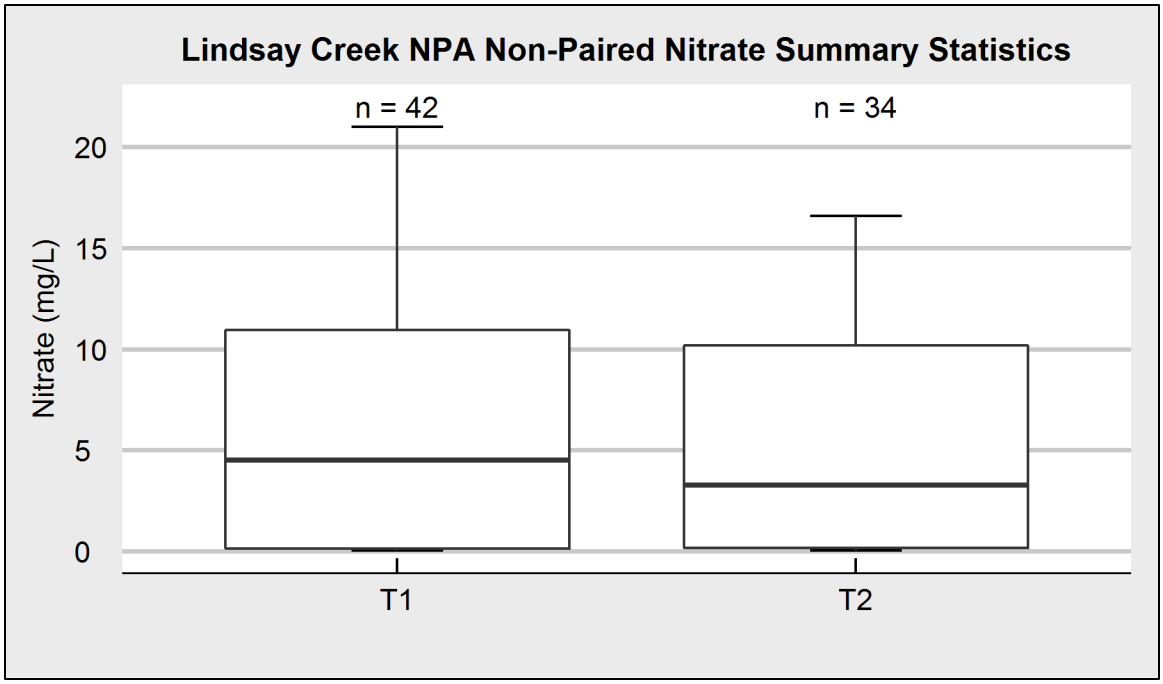


Figure A-14. Boxplots of Lindsay Creek Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

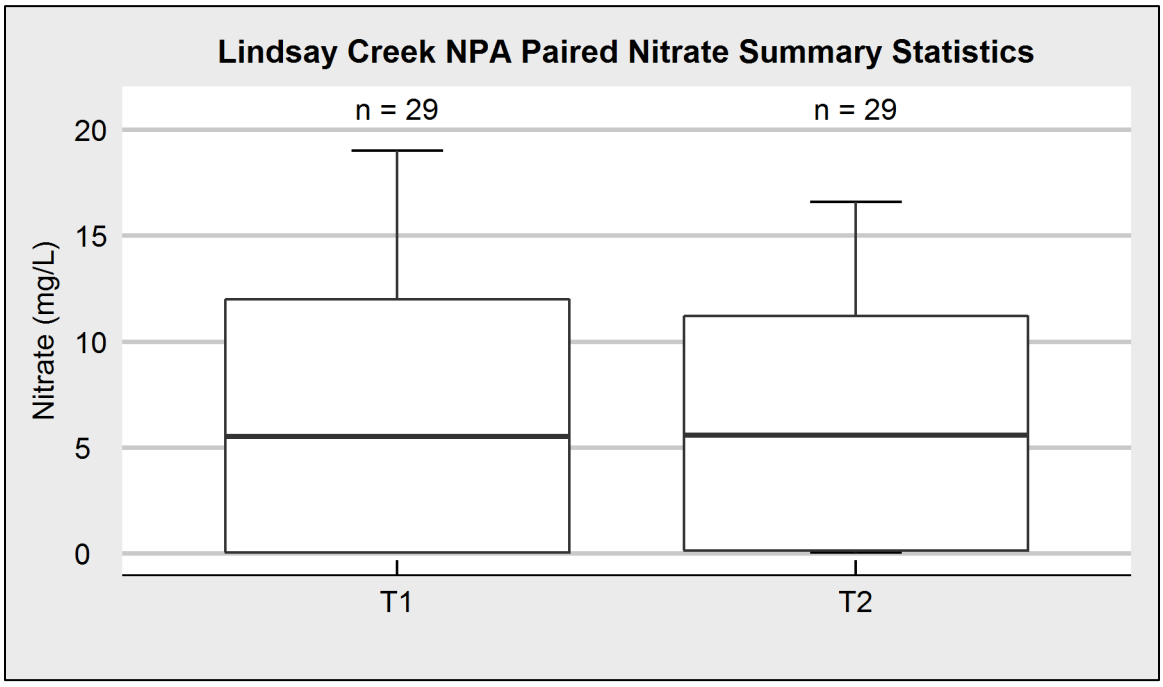


Figure A-15. Boxplots of Lindsay Creek Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

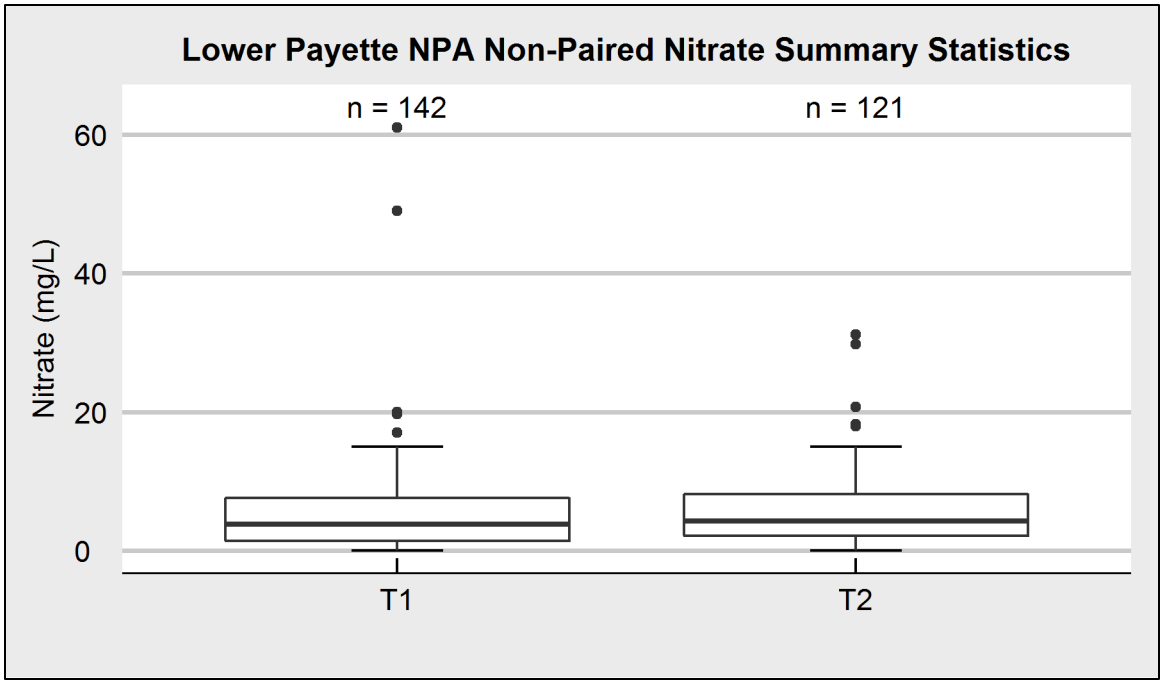


Figure A-16. Boxplots of Lower Payette Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

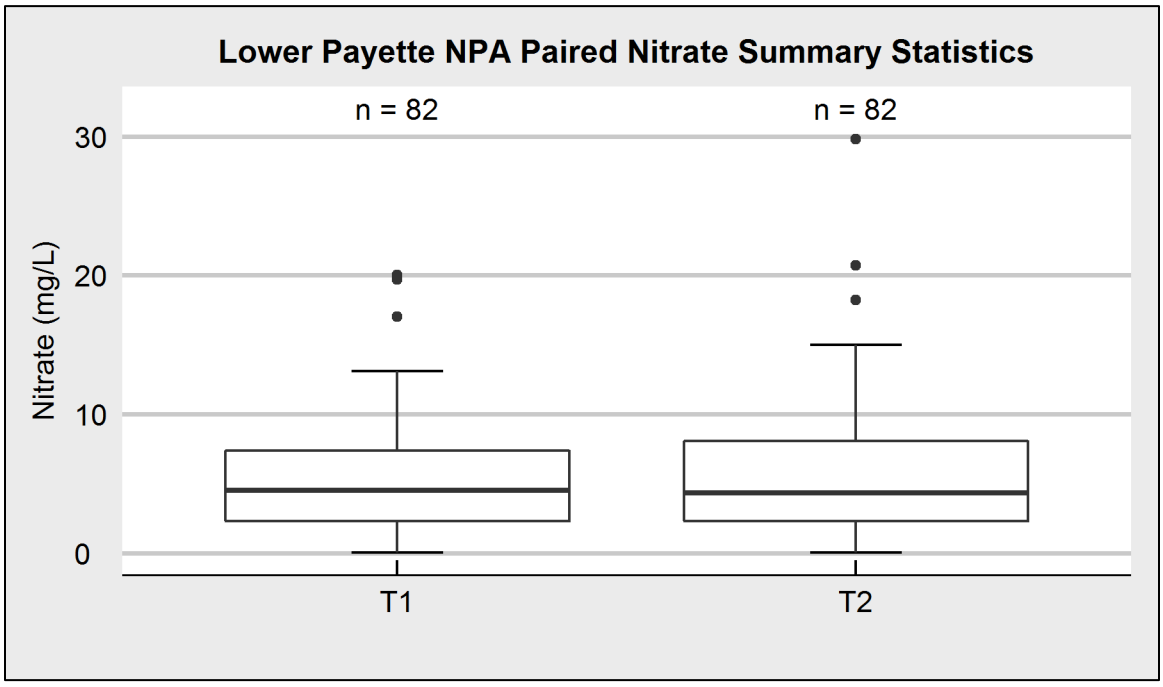


Figure A-17. Boxplots of Lower Payette Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

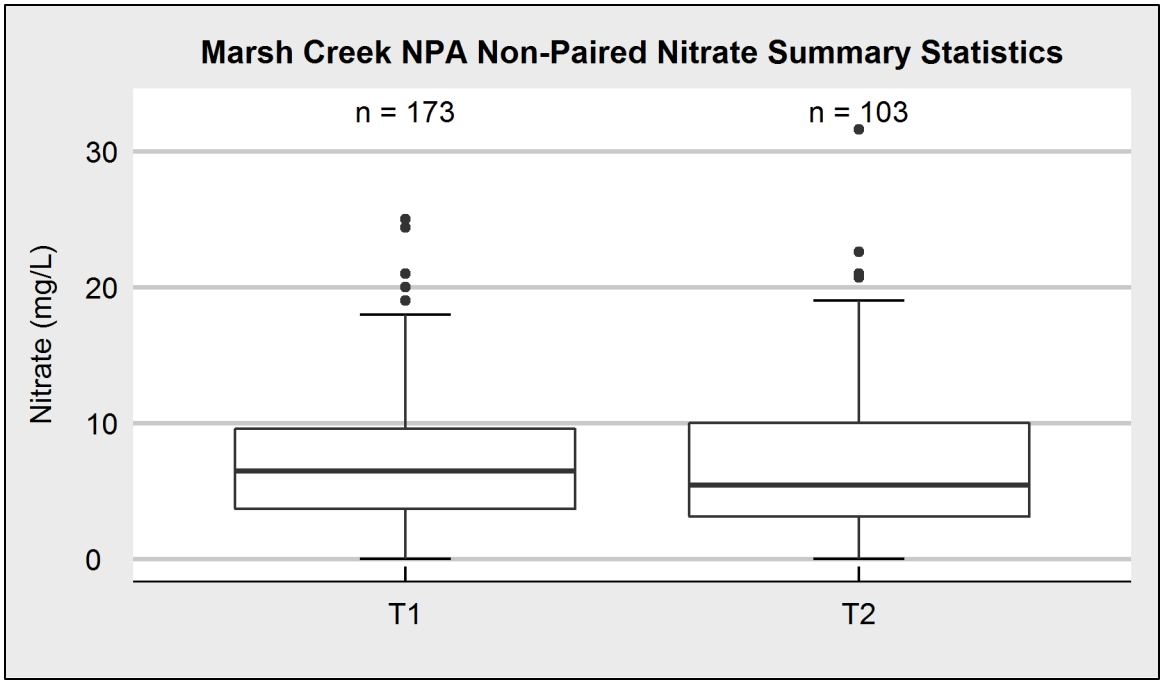


Figure A-18. Boxplots of Marsh Creek Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

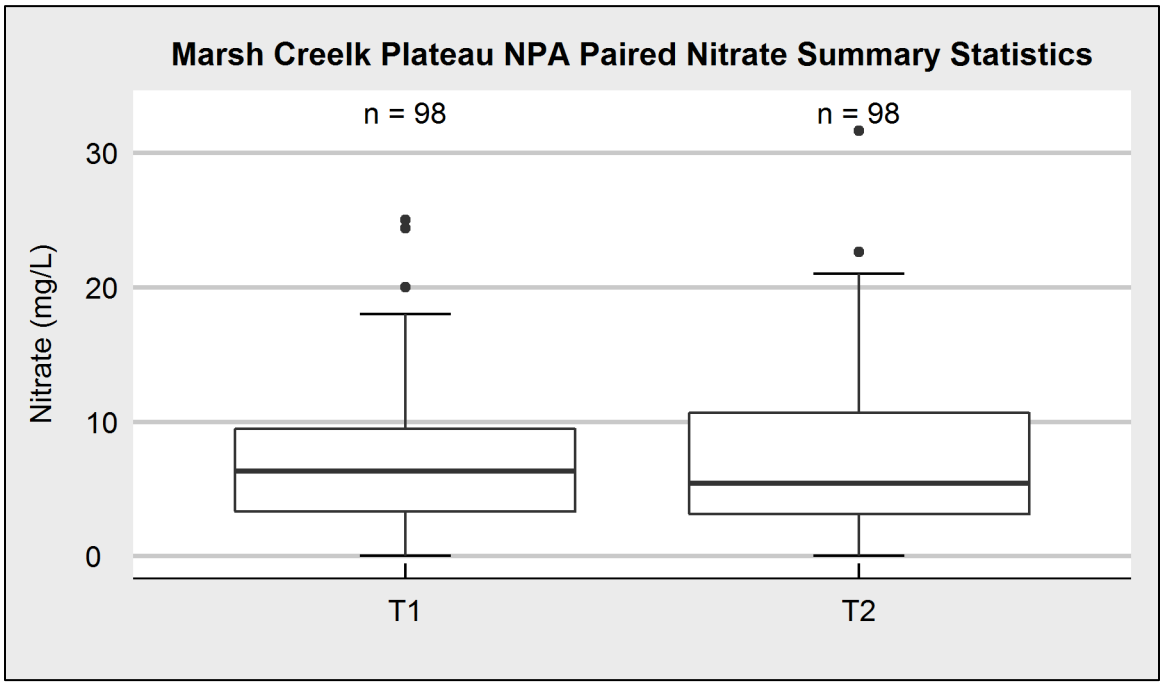


Figure A-19. Boxplots of Marsh Creek Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

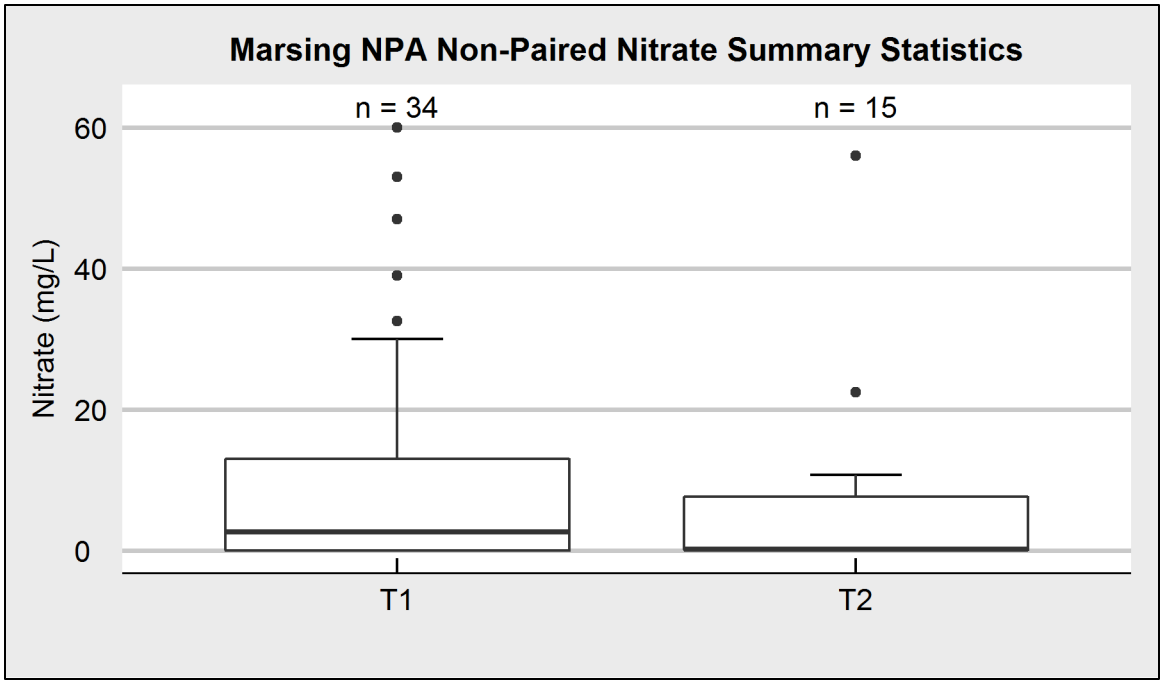


Figure A-20. Boxplots of Marsing Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

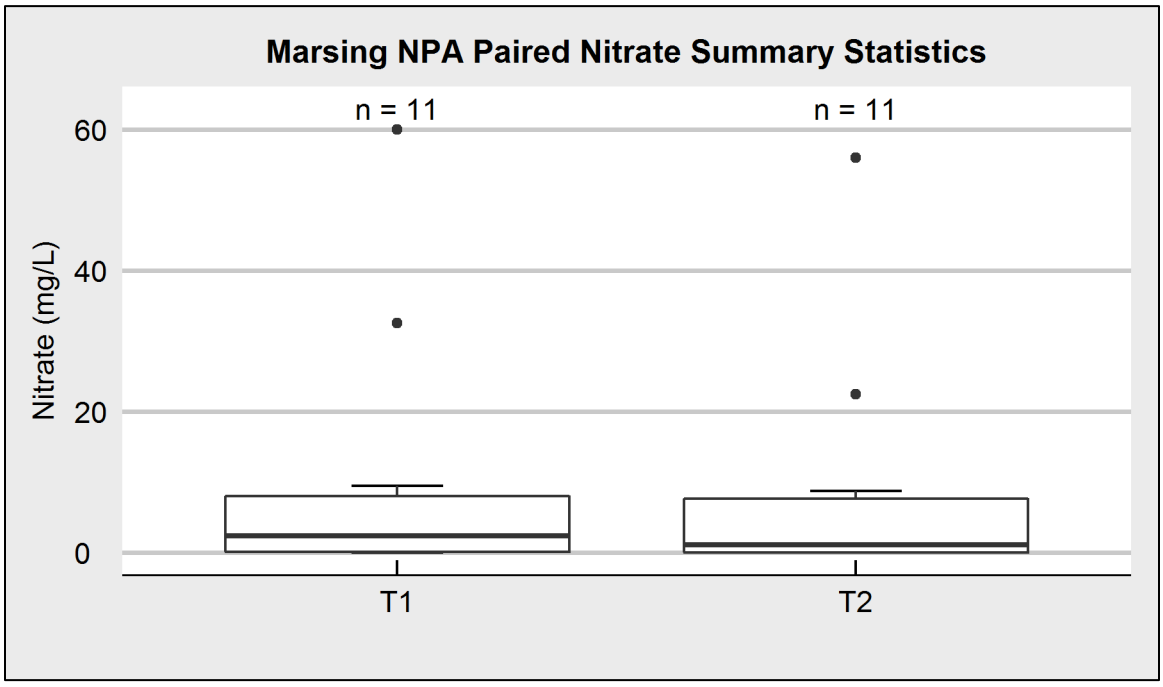


Figure A-21. Boxplots of Marsing Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

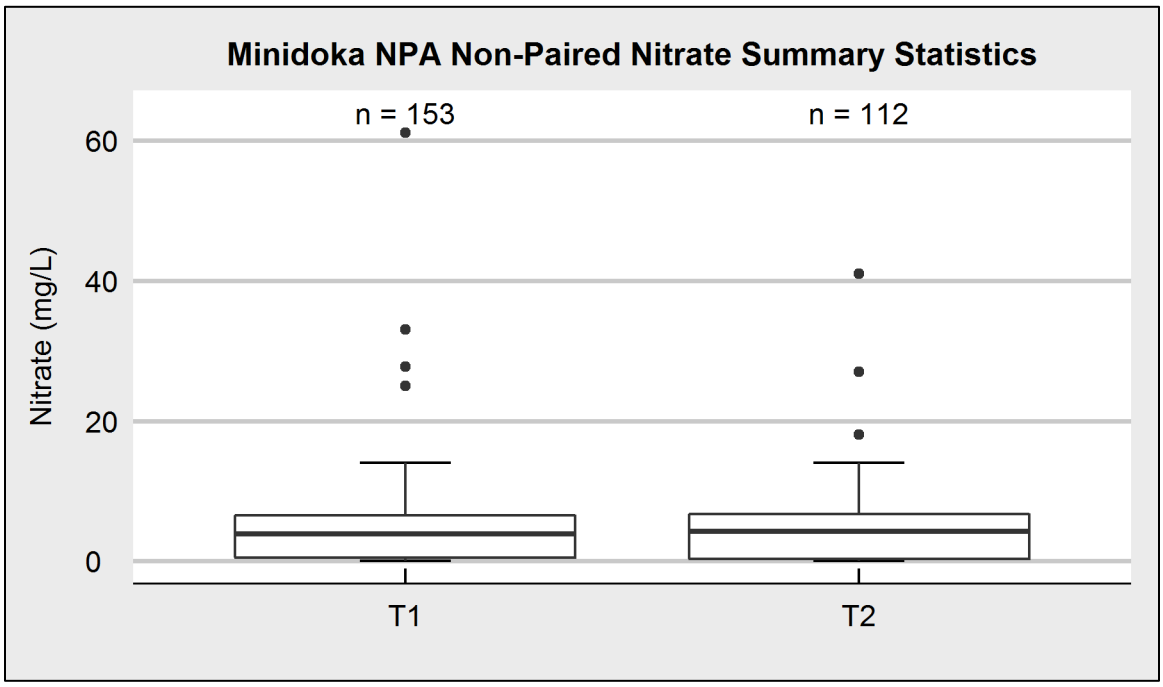


Figure A-22. Boxplots of Minidoka Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

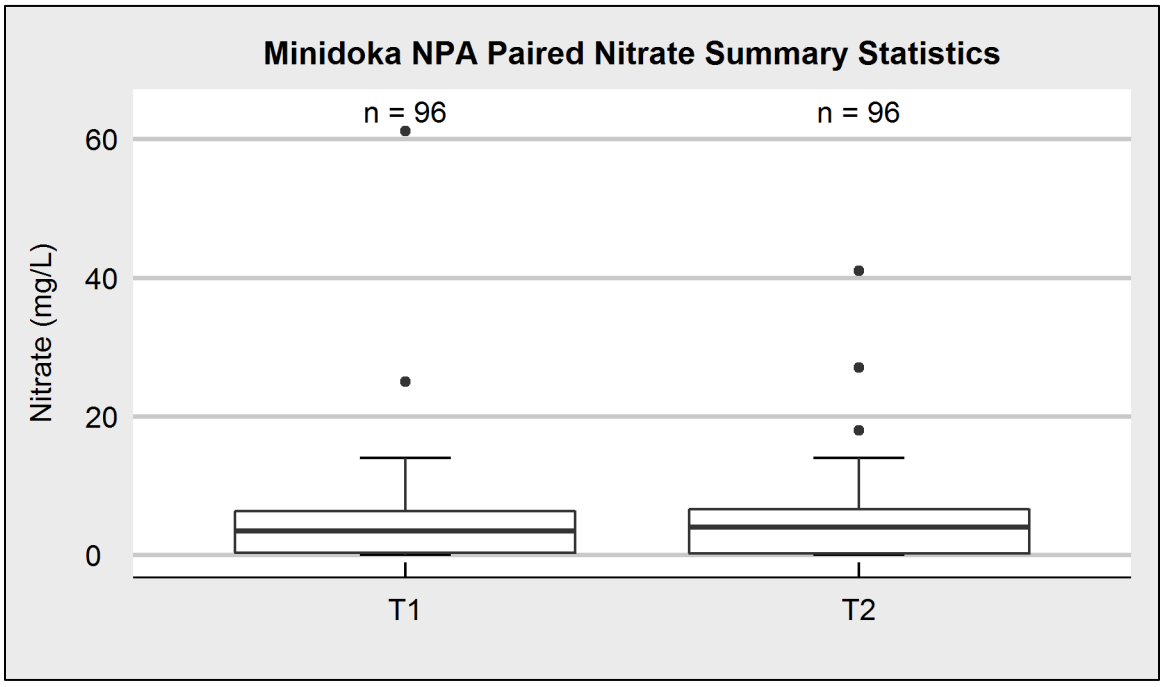


Figure A-23. Boxplots of Minidoka Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

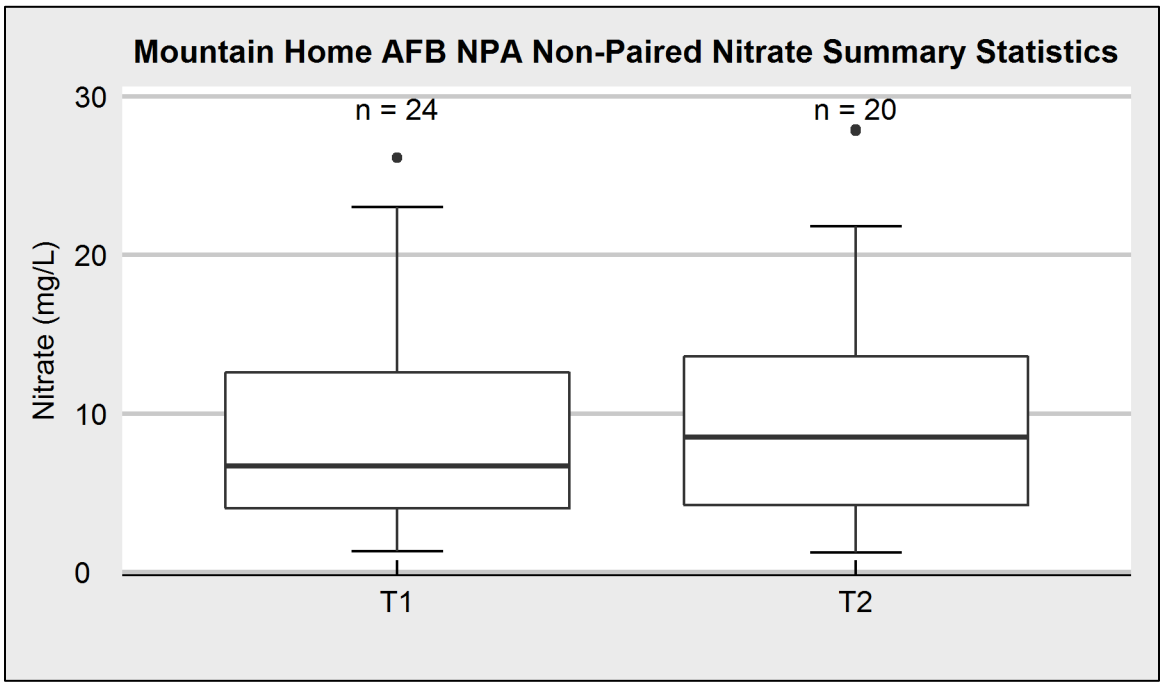


Figure A-24. Boxplots of Mountain Home AFB Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

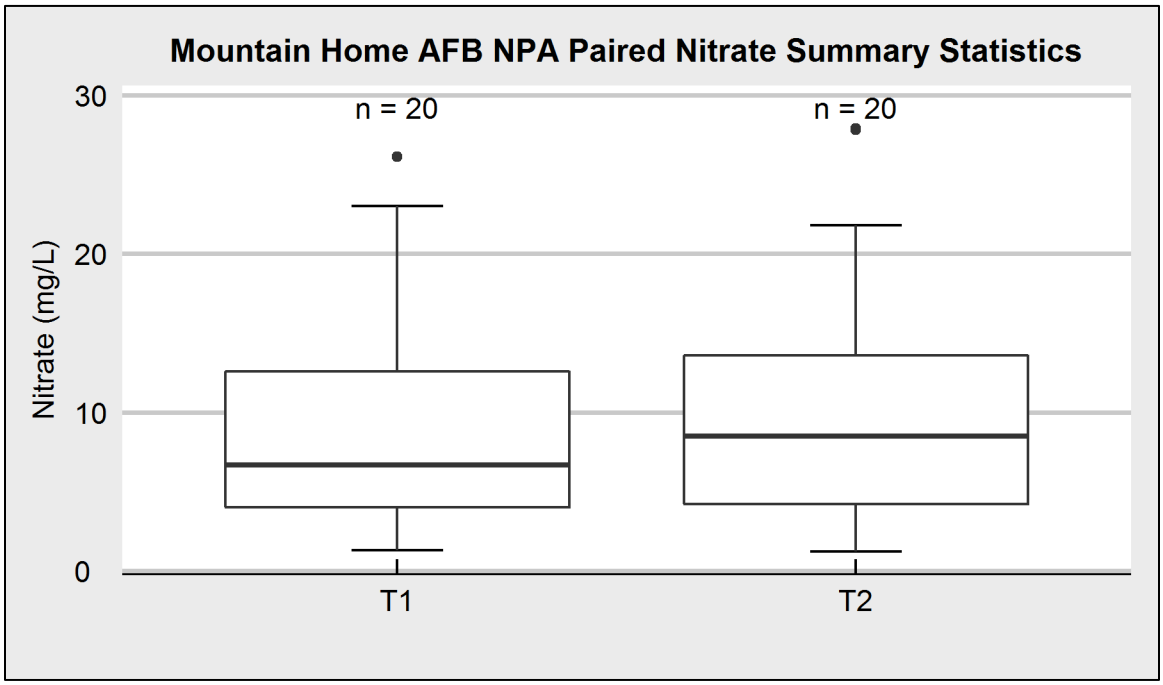


Figure A-25. Boxplots of Mountain Home AFB Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

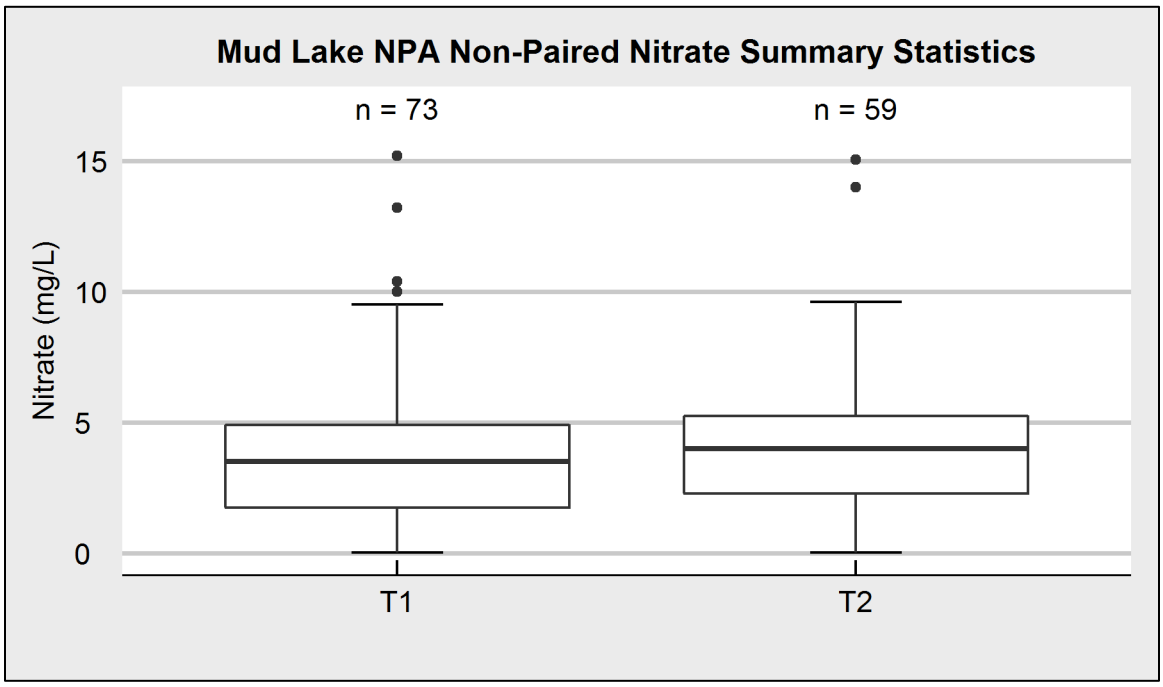


Figure A-26. Boxplots of Mud Lake Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

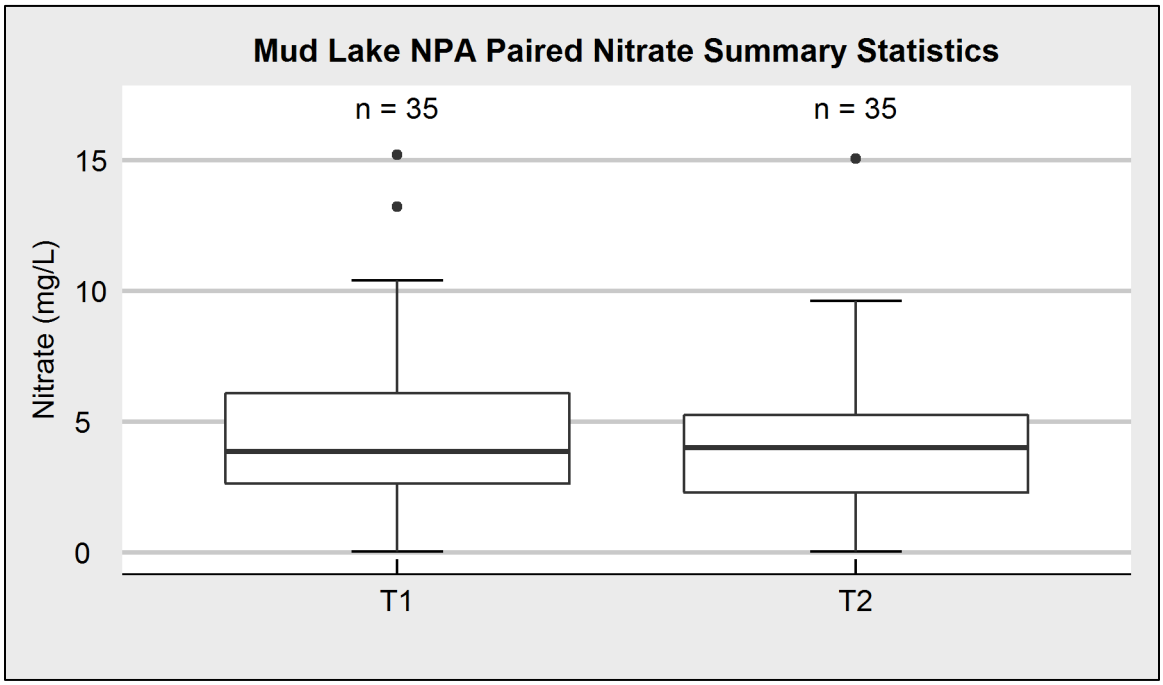


Figure A-27. Boxplots of Mud Lake Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

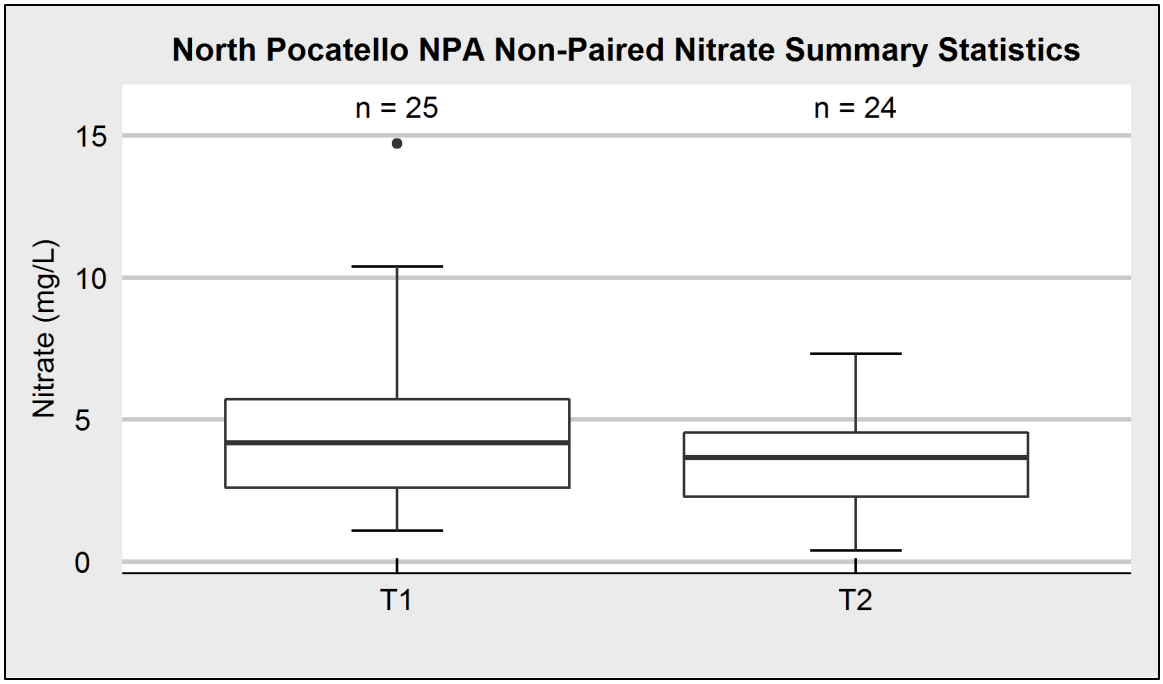


Figure A-28. Boxplots of North Pocatello Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

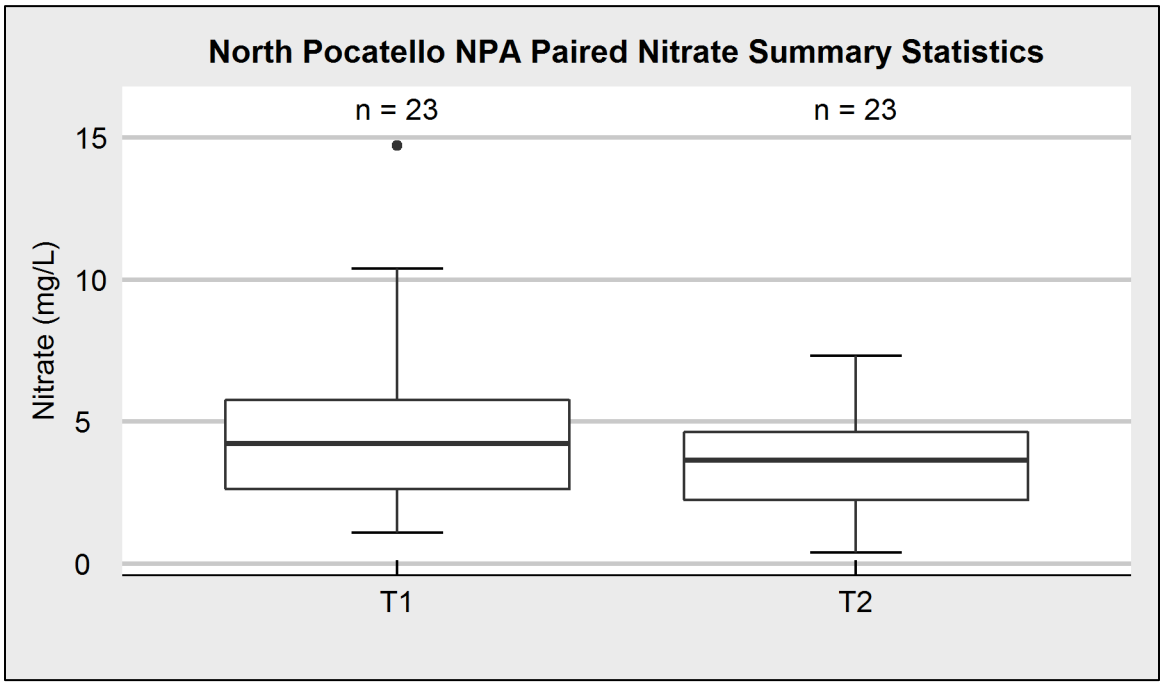


Figure A-29. Boxplots of North Pocatello Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

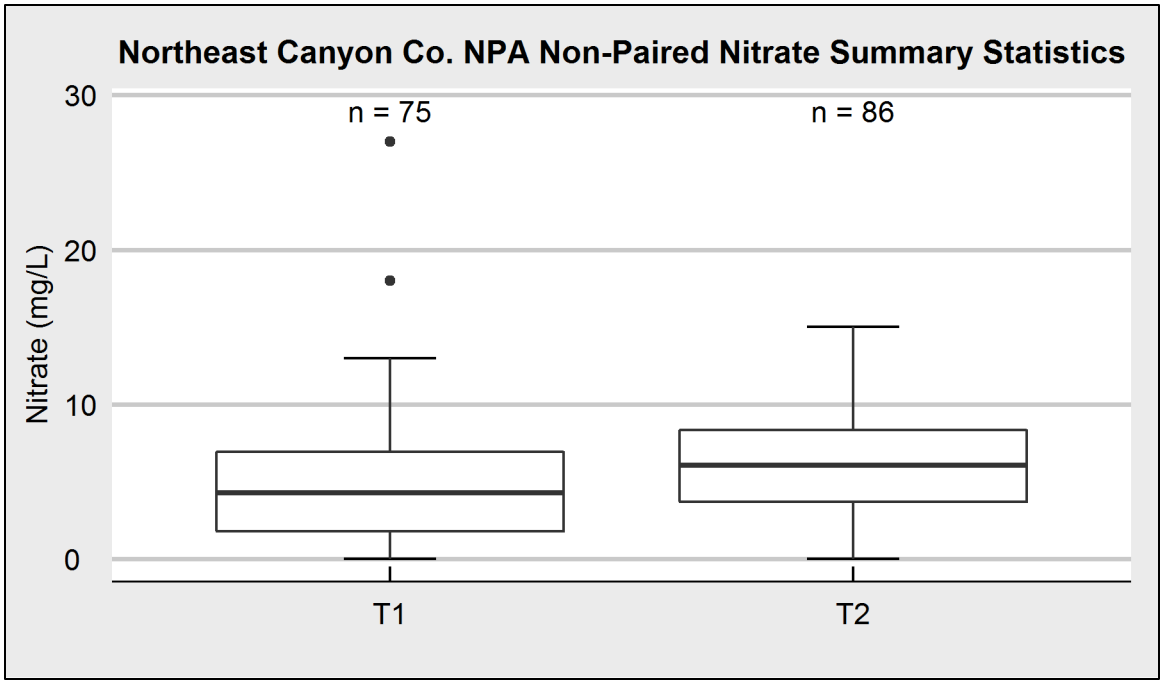


Figure A-30. Boxplots of Northeast Canyon Co. (Purple Sage) Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

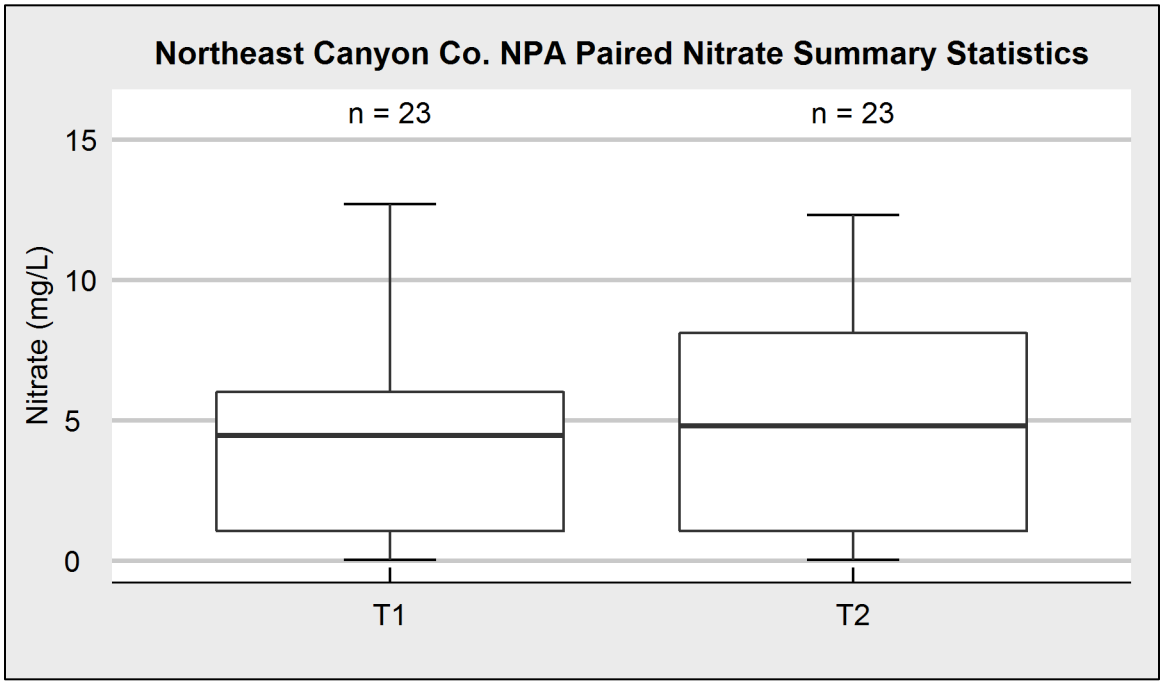


Figure A-31. Boxplots of Northeast Canyon Co. (Purple Sage) Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

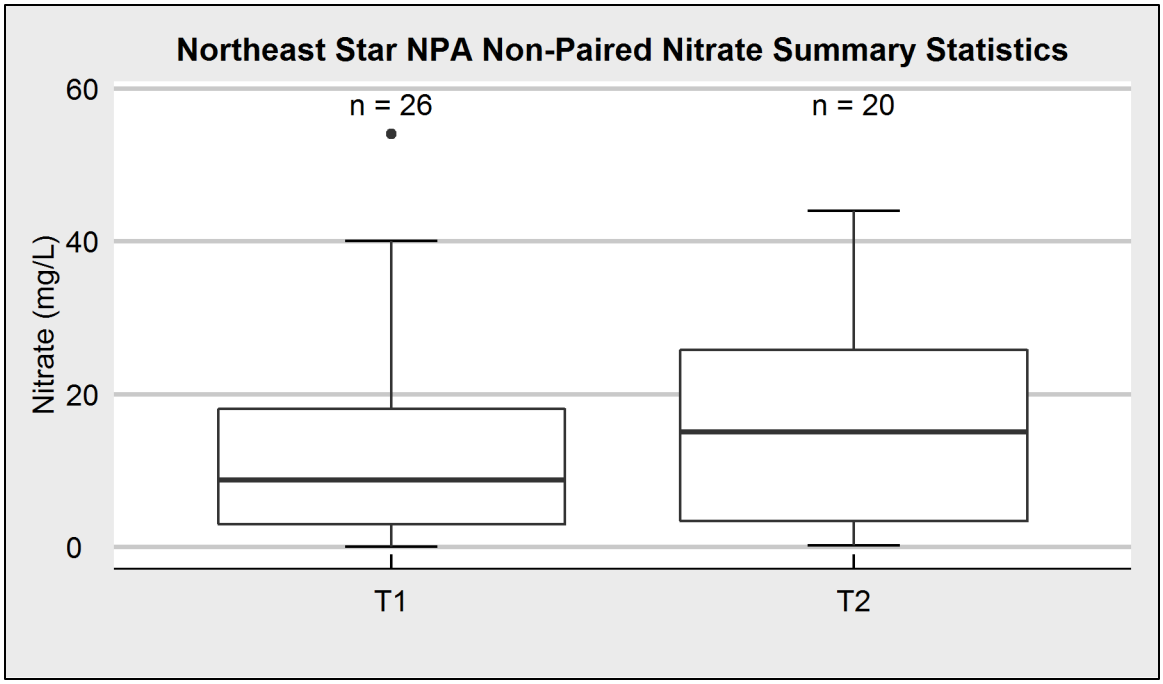


Figure A-32. Boxplots of Northeast Star Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

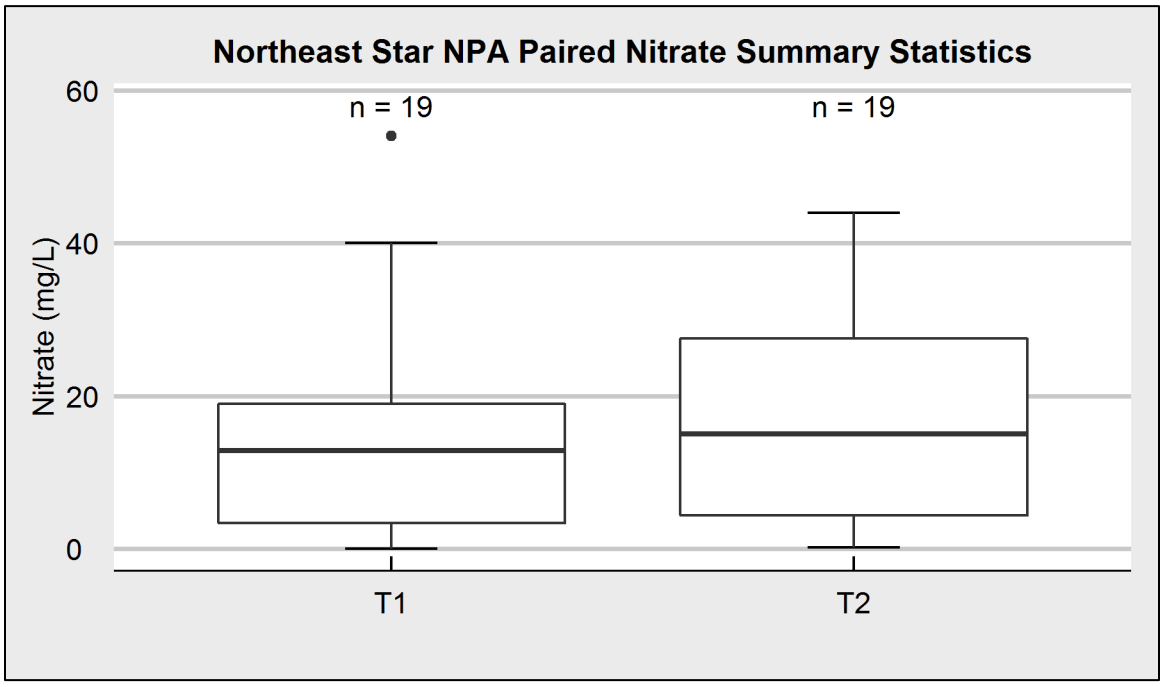


Figure A-33. Boxplots of Northeast Star Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

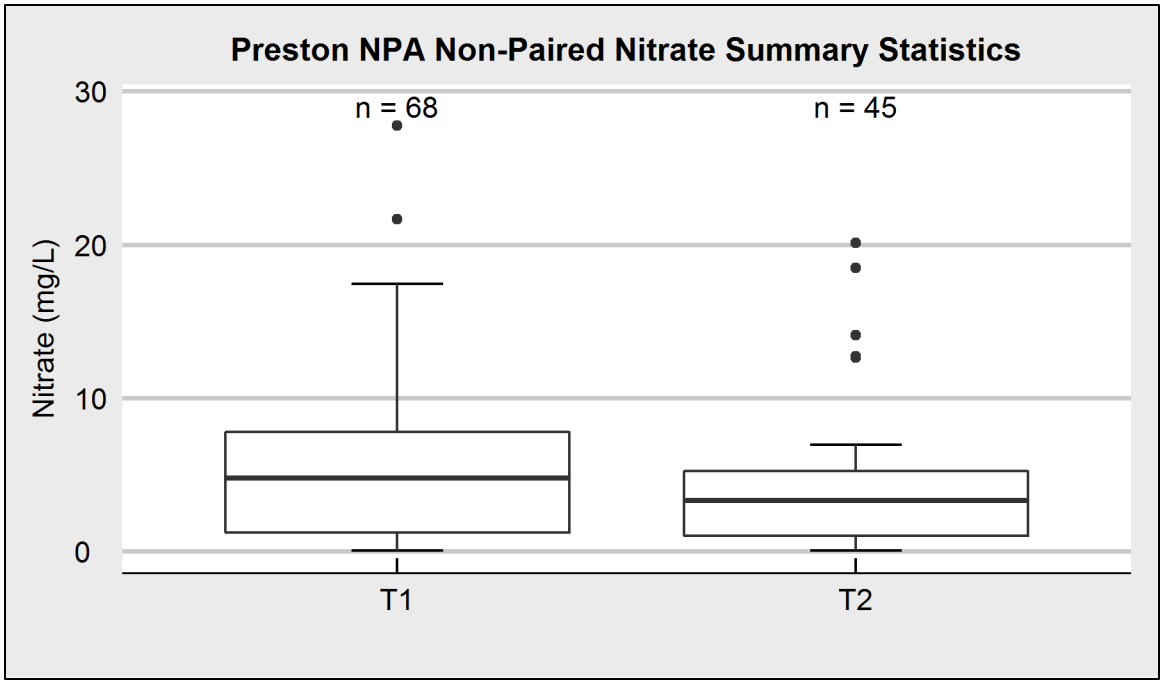


Figure A-34. Boxplots of Preston Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

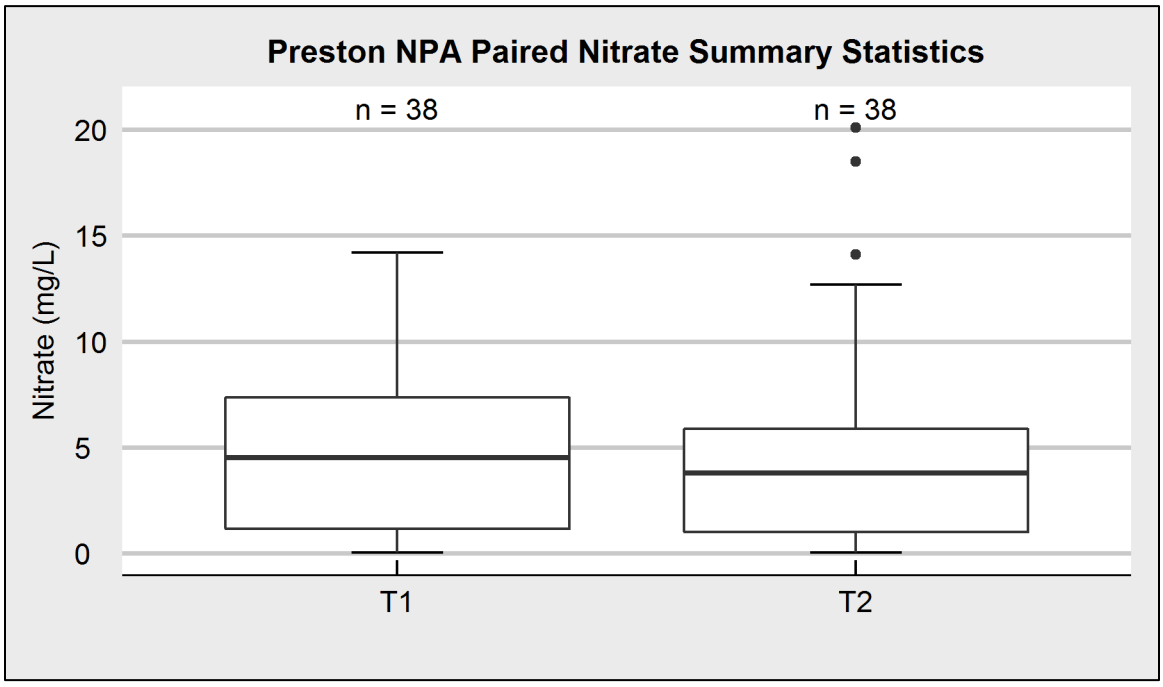


Figure A-35. Boxplots of Preston Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

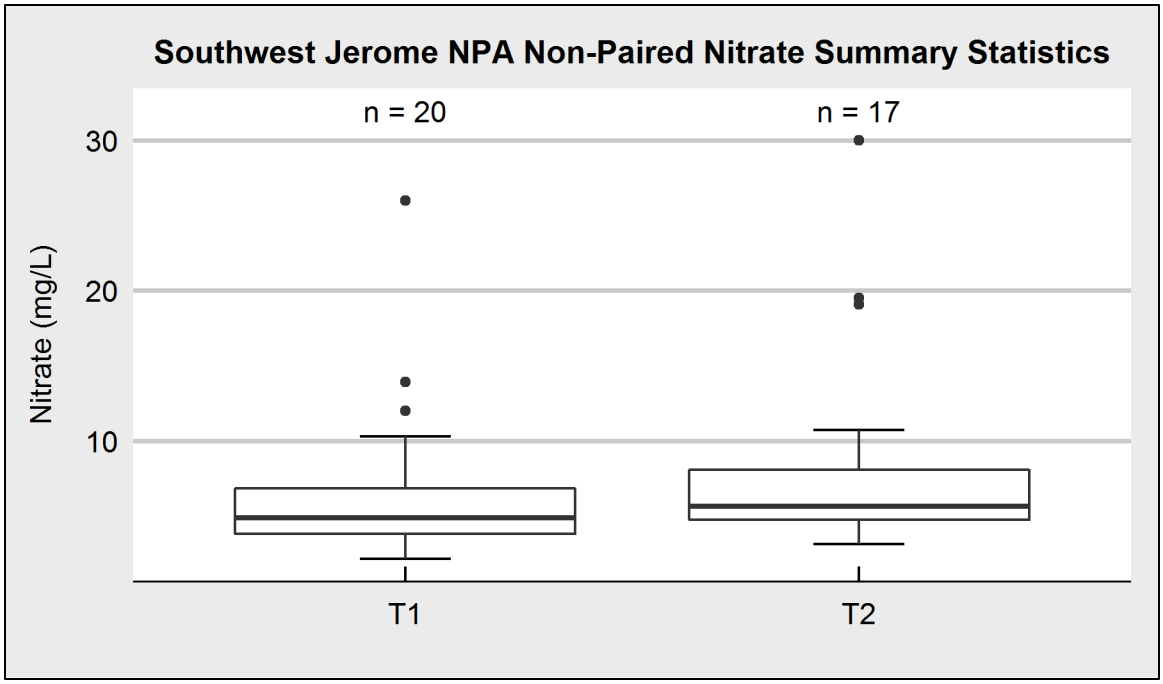


Figure A-36. Boxplots of Southwest Jerome Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

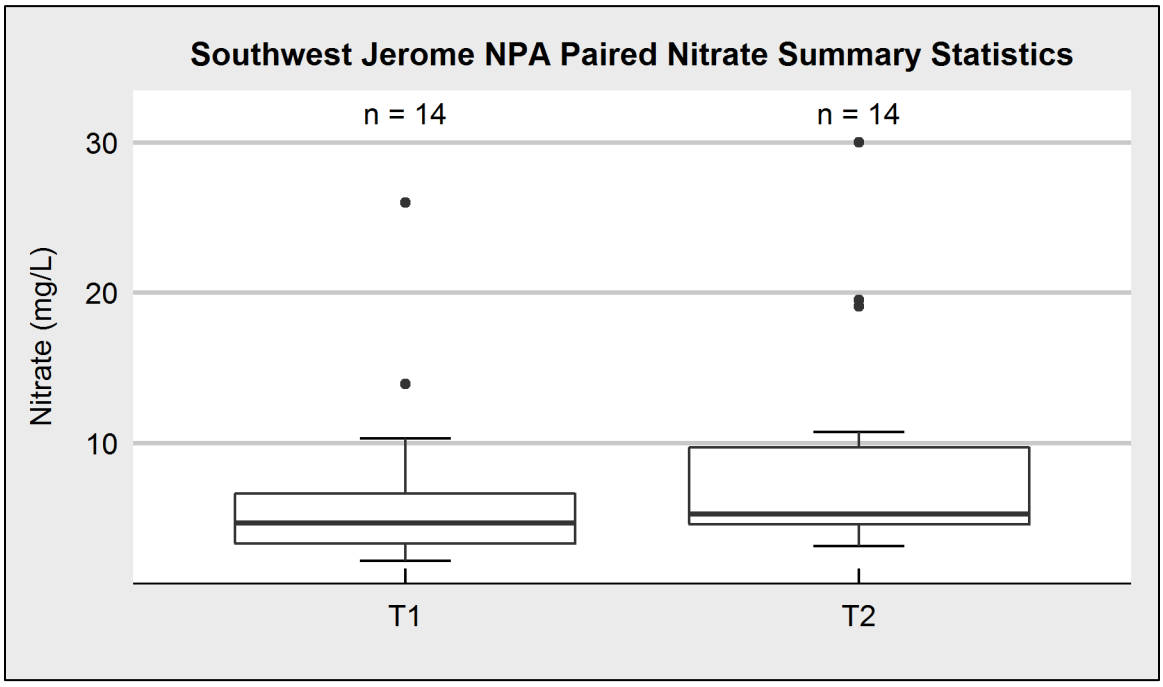


Figure A-37. Boxplots of Southwest Jerome Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

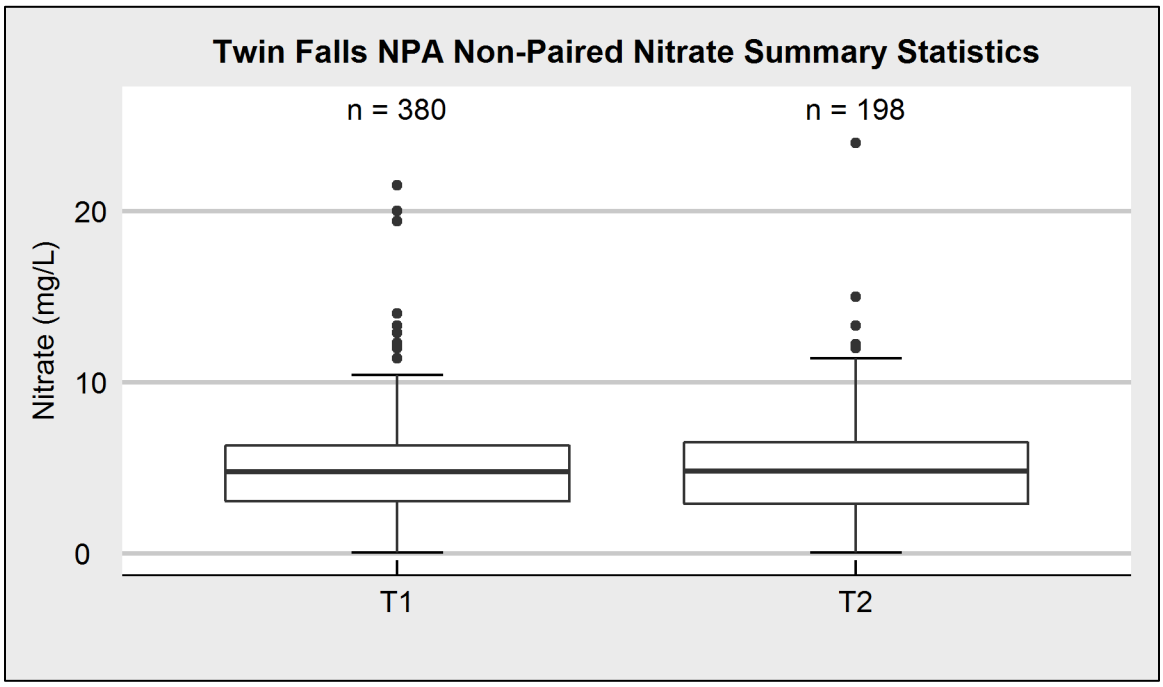


Figure A-38. Boxplots of Twin Falls Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

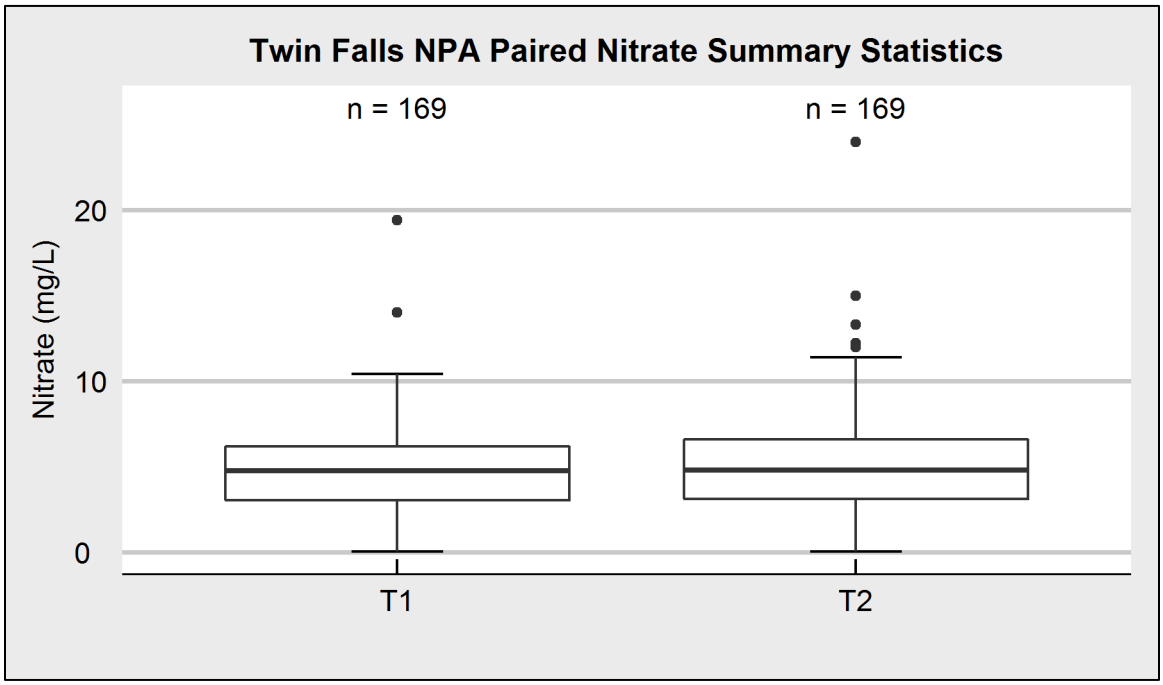


Figure A-39. Boxplots of Twin Falls Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

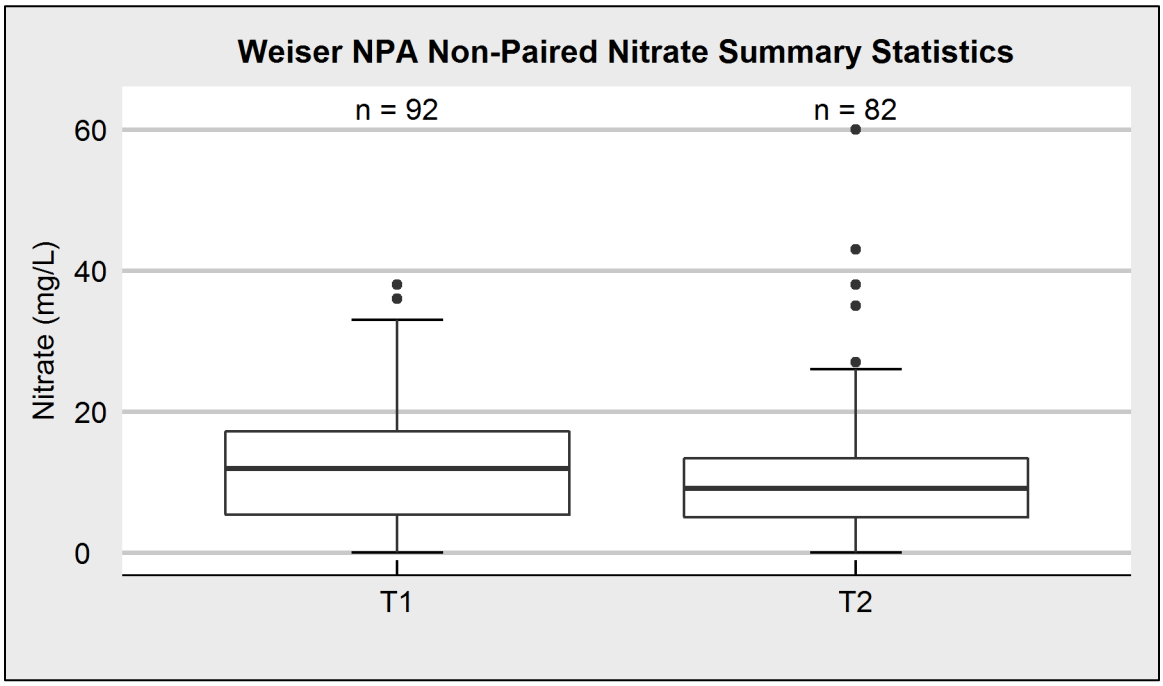


Figure A-40. Boxplots of Weiser Nitrate Priority Area nonpaired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).

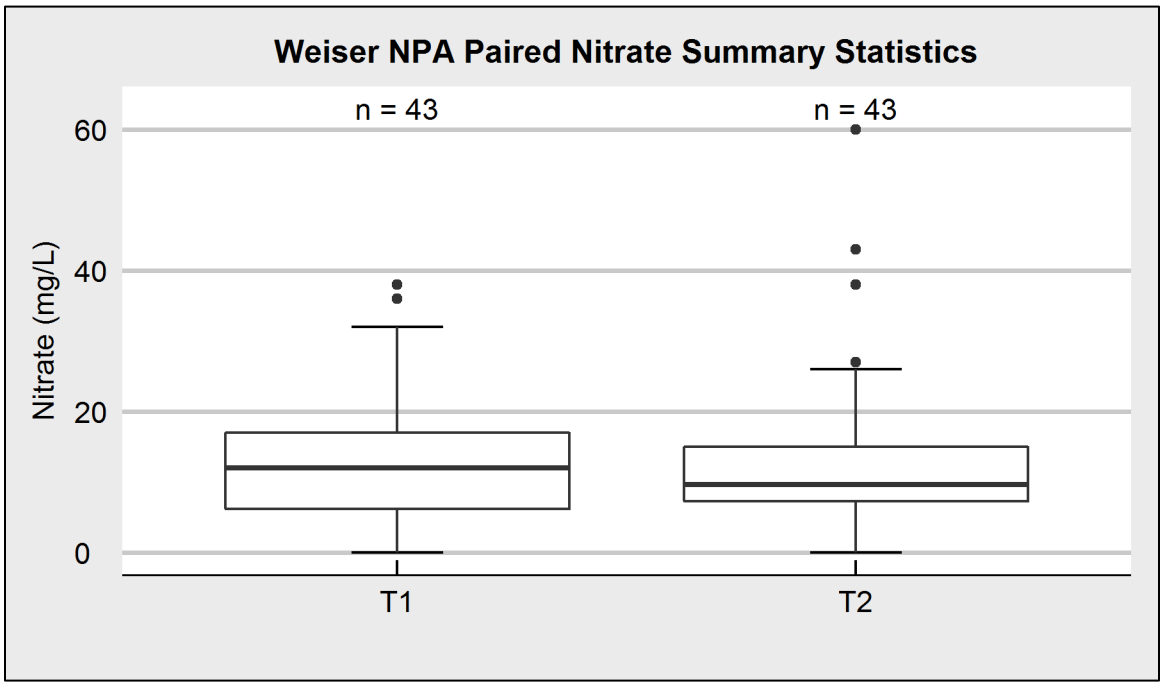


Figure A-41. Boxplots of Weiser Nitrate Priority Area paired nitrate data for 2007–2011 (T1) and 2012–2016 (T2).