TECHNICAL MEMORANDUM

Date: January 18, 2017
Project No.: 113-80037
To: Rita Lloyd-Mills, Lynn Lande
Company: Chino Mines Company
From: Lewis Munk and Doug Romig
cc:
Email: lmunk@golder.com

RE: **CHINO TEST PLOTS VEGETATION STATISTICS**

1.0 INTRODUCTION

Chino Mines Company (Chino) operates an open pit copper mine, milling, and solution extraction-electrowinning (SX/EW) facility near Silver City, New Mexico. Chino is evaluating reclamation options with respect to meeting applicable requirements of the New Mexico Water Quality Control Act (WQA), the Water Quality Control Commission (WQCC) regulations, and the New Mexico Mining Act (NMMA). Chino is permitted as an existing mine (No. GR009RE) with the New Mexico Mining and Minerals Division (MMD).

In the North Mine Area (NMA), the Kneeling Nun Rhyolite was approved by the MMD as suitable cover in Permit GR009RE. The New Mexico Environmental Department (NMED) indicated that the cover shall consist of volcanic rock (such as the Kneeling Nun Rhyolite Tuff or Sugarlump Tuff formations) under Discharge Permit 1340. In 2003 when the permits were issued, the primary cover material in the NMA was expected to be rhyolite contained in the Upper South Stockpile. However, subsequent investigations associated with Condition 81 (DP-1340) and Section 8.L.5 (GR009RE) indicated that the best available cover materials for closure were rhyolite, Santa Rita Stock, and Colorado Formation with minor amounts of late-stage intrusive dikes and sills or mixtures of these materials. For the purpose of this report, these materials are hereafter referred to as reclamation cover materials (RCM). The RCM were further evaluated at the Chino Stockpile Test Plots in accordance with Conditions 81 and 82 of DP-1340 and Section 8.L.1 of Permit GR009RE.

After completion of the Final Annual Test Plot report in August 2015 (Golder 2015a), the Agencies requested a demonstration of its suitability to support plant growth through a comparison of the vegetation on the test plots to Rustler Canyon reference area. Chino conducted additional vegetation studies and submitted an addendum to the 2015 test plot report in November 2015 (Golder 2015b). This information is intended to be used to demonstrate the suitability of Chino's RCM.

Golder Associates Inc.
5200 Pasadena Avenue N.E., Suite C
Albuquerque, NM 87113 USA
Tel: (505) 821-3043 Fax: (505) 821-5273 www.golder.com

1.1 MMD request for additional information

On April 25, 2016, FMI and MMD met to discuss the results of the test plot study and the vegetation addendum reports submitted in November 2015 (Golder 2015b). The intent of the meeting was to "*identify a means of demonstrating that the cover material from Upper South Stockpile at Chino can support adequate vegetation to meet the revegetation requirements of Permit GR009RE."* Following the meeting, the MMD provided a list of items that required clarification before the agency could reach a conclusion. Reproduced below is a summary of the meeting provided by MMD in an email from Holland Shepherd to Lynn Lande (May 3, 2016). Specific items to be address are provided below:

1. Provide an explanation as to why the survey method used in 2012 and 2014 was modified from that submitted in the September 2006 Revised Cover, Erosion, and Revegetation Test Plots Work Plan Chino Stockpiles, Condition 82 Supplemental Discharge Plan DP-1340, and Permit GR009RE.
2. Explain the rationale for using a single survey of the reference area (in 2015), rather than surveying the reference during each year quantitative surveys of the test plots were conducted.
3. Re-analyze the 2012 and 2014 data to include only transects on top-surfaces and 3:1 slope test plots.
4. Determine if there is interaction between quadrats in the 2012 and 2014 by comparing canopy cover means of the 2012 and 2014 data sets that include all four quadrats per transect and data sets, then eliminating one, two and/or three of the quadrats per transect to determine if there is interaction between quadrats.
5. Re-calculate sampling adequacy for 2012 and 2014 based on the re-defined data set.
6. Notify MMD of any potential problems with re-analyzing the 2012 and 2014 data and limitations in statistical comparisons of the 2012, 2014, and 2015 data sets.

If the initial re-analysis of 2012 and 2014 vegetation survey data indicates that the quadrats on each transect are independent, and that sampling adequacy for 90% confidence interval of sample mean has been achieved, FMI will propose appropriate statistical methods for comparison of reclaimed areas with the reference area. The response should address:

1. Is the data normally distributed? If not, what method of data transformation will be used?
2. How transects or quadrats from the 2012 and 2014 data sets will be eliminated based on the results of the test for interactions.
3. How transects or quadrats from the 2012 and 2014 data sets will be selected to ensure randomization during re-analysis.
4. The possibility of running a regression analysis, or providing some other graphical representation of the statistical trend, resulting from the reworked data.

MMD also requested that a detailed discussion of alternate lines of evidence to support the determination of cover material suitability be included.

The objective of this technical memorandum is to address the issues raised by the MMD regarding RCM at Chino and demonstrate its suitability to support plant growth and meet the revegetation requirements of Permit GR009RE.

2.0 RESPONSE TO ADDITIONAL ANALYSIS REQUEST

This section includes results of the additional analysis of the items discussed during the April 25, 2016 meeting. Below are MMD's comments or request for additional information (in bold) followed by Chino's response.

2.1 Difference in Survey Methods

Provide an explanation as to why the survey method used in 2012 and 2014 was modified from that submitted in the September 2006 Revised Cover, Erosion, and Revegetation Test Plots Work Plan Chino Stockpiles, Condition 82 Supplemental Discharge Plan DP-1340, and Permit GR009RE.

The vegetation on the test plots was measured using a random located transect with systematically placed quadrats with cover, frequency, density, and composition determined in quadrats. The vegetation sampling methods used in 2012 and 2014 on the test plots were essentially the same as the method described in the 2006 Work Plan, with two differences. The transect length and quadrat size were reduced to accommodate the relatively small areas being monitored on the test plots in 2012 and 2014. Because the cover thickness plots were combined for the 2015 monitoring, the larger transects and quadrats were used on the test plots and reference area. The 2015 monitoring approach was agreed to with the agencies following the test plot inspection on September 16, 2015.

The vegetation analysis layout in the 2003 work plan was adapted from the methods applied in the baseline studies for the mine area and the methods approved for the reclaimed areas. In both of these situations, relatively large areas are investigated with the mine area representing thousands of acres and the reclamation areas typically occupying hundreds of acres. For these larger areas, ≈30 meter dog-leg transects with a 15 m (50 ft) sides were specified. Four 1-m^2 quadrats are systematically placed on the transect about 5 meters apart. The transect origins are located using a 50-ft grid with about 16 locations possible in an acre.

The survey methods in 2012 and 2014 had to be modified from the 2003 work plan to accommodate the much smaller test plot area compared to actual reclaimed areas. The cover thickness plots at Chino are all less than 2 acres with the fertilizer treatment plots occupying about 0.23 acres. The size of the fertilizer plots was an important consideration controlling the size of the transects. Imposing a 50-foot grid on the test plots would have limited the number of available vegetation plots, particularly in the fertilizer treatment areas (Figure 1). Thus, the grid size for sampling the test plots was reduced to approximately 5 meters, which resulted in a dog-leg transect length of 10 m.

For the 2012 and 2014 surveys, the transect length was reduced to increase potential interspersion (i.e., separation of the vegetation monitoring plots within each cover thickness plot). The 5 m grid spacing would allow about 160 potential sampling locations per acre compared to 16 locations per acre with the 15 m grid spacing. The quadrat size was reduced accordingly for the smaller transect lengths to increase the physical separation between the quadrats to ensure statistical independence.

Quadrat size is determined based on the character of the vegetation being surveyed (Elzinga et al. 1998). Quadrat size for the 2012 and 2014 test plot monitoring was 0.5 m^2 to accommodate the shorter transect. In general, quadrats should be both larger than the average-sized plant and the average space between plants (Launchbaugh 2009). It is standard practice to size a quadrat such that each one captures the most abundant species, but not so large that each captures the two most abundant species in every plot. Quadrats which are larger than needed require more time and are less efficient, but are not inherently negative from a data quality perspective. For the 2012 and 2014 test plots surveys, essentially all 0.5 m^2 quadrats contained the most abundant plant (side-oats grama, *Bouteloua curtipendula*), but not the second most abundant plants (blue grama, *B. gracilis* and white prairie clover, *Dalea candida*) (Golder 2013 and 2015a). Thus, on this basis the 0.5 m^2 quadrats were appropriately sized.

Quadrat spacing is important for maintaining sample independence (Elzinga et al. 1998). To ensure independence, the quadrats must be spaced far enough apart that the plants in one quadrat do not physically affect the plant in other quadrat(s). Large stature vegetation would require the quadrats to be placed farther apart than low stature vegetation to eliminate concerns related to competitive interactions (e.g., shading and root). Factors used to determine quadrat spacing along the transect are the average size of gaps (i.e., bare soil interspaces) and the average size and density of individual plants (Elzinga et al. 1998). In general, root density mimics the patchy plant distribution and bare soil interspaces.

The closest quadrats were spaced about 1.8 m apart on the transects used in the 2012 (year 5) and 2014 (year 7) monitoring events. Because the vegetation during those years was characterized by relatively low stature grasses with widely scattered shrubs and forbs, we believe this spacing was adequate to avoid competitive interactions. In other words, it is unlikely that an individual sideoats grama or bricklebush would directly affect another individual 1.8 m away. There was no possibility of canopy overlap and the rooting studies conducted in 2015 indicated that roots of individual plants typically do not extend much beyond the plant's canopy.

2.2 Appropriateness of the 2015 Reference Area Comparison

Explain the rationale for using a single survey of the reference area (in 2015), rather than surveying the reference during each year quantitative surveys of the test plots were conducted.

One of the main objectives of the test plot program was to determine the relative performance of the various cover thickness treatments (i.e., 2-ft versus 3-ft or 4-ft thick covers). The 2012 and 2014 test plot monitoring was conducted to evaluate vegetation performance among these cover thicknesses and fertilizer treatments. Reference area monitoring was not critical to determining the relative performance among the cover thickness treatments. After reviewing the data from the 2014 surveys, MMD requested one additional year of monitoring and comparison to the reference area. Chino agreed to one additional monitoring event during the close-out meeting following the test plot inspection in September 2014.

The 2015 monitoring is essentially equivalent to a mid-term monitoring event, which is typically conducted in Year 6 on reclaimed areas to assess the progress of vegetation relative to the performance standards. The mid-term monitoring does not require meeting statistical adequacy or multiple years of data, which are reserved for bond release monitoring efforts in 2 of the last 4 years. Thus, we believe the single year of data from 2015 is consistent with standard practice and adequate to make a determination of the likely trajectory of the vegetation.

The additional data collected in 2012 and 2014 complement the 2015 data by providing information that would not normally be required under the permit requirements.

2.3 2012 and 2014 Data Analyses

Re-analyze the 2012 and 2014 data to include only transects on top-surfaces and 3:1 slope test plots.

Total canopy cover data from 2012 and 2014 were re-analyzed to determine the normality of data and whether sample adequacy was achieved. Additionally, interactions between quadrat locations along the transects were evaluated within each dataset.

Quadrat data were evaluated for individual locations (Q1, Q2, Q3 and Q4) and in various combinations (Q1&2, Q1&4, Q2&3 and Q3&4) to determine if there was any interaction among sample subsets. Data analyses included test of homogeneity of variance and evaluation of the differences in means. Univariate statistical tests were performed using Microsoft Excel and *Analyse-it* statistical analysis add-in (version 4.60.1) to evaluate the distribution and normality of the data. Summaries of total canopy cover data are provided in Attachment A.

2.4 Quadrat Interactions Based on Means

Determine if there is interaction between quadrats in the 2012 and 2014 by comparing canopy cover means of the 2012 and 2014 data sets that include all four quadrats per transect and data sets, then eliminating one, two and/or three of the quadrats per transect to determine if there is interaction between quadrats.

The interactions among the quadrats is assessed by determining the population means (and variances) with the sequential exclusion of quadrats. The mean, standard deviation, and 90% confidence intervals for single quadrat locations and combinations of quadrat locations are listed in Table 1. The means and 90% confidence intervals for the various combinations of data from the 2012 are displayed on Figure 2. Similarly, the data from the 2014 survey is shown on Figure 3. The means from the grouping of 2012 and 2014 data are not considered different based on the overlapping 90% confidence intervals. Because the means from individual quadrat locations and combinations of quadrat locations were not statistically different, we conclude that the population could have reasonably been described by data from any single quadrat location or combination of quadrat locations in either year. The minor differences in the mean values within years reflects the random variability that can be expected across the test plots.

Descriptive statistics, frequency histograms and tests for normality were generated for total cover for the three years monitoring events (Attachment A). Descriptive statistics for the 2012, 2014, and 2015 datasets are provided in Table 1.

Table 1. Descriptive statistics for total canopy cover at the Chino Test Plots and Reference Area

Quadrat(s)	Mean	Std. Dev	90% Confidence Limit			N[1]	Sample Adequacy[2]	
			90% CI	Upper	Lower		*m*	*n*
2012 Test Plots								
1	20.2	12.7	3.1	23	17	48	112	27
2	16.2	11.1	2.7	19	14	48	131	23
3	18.0	13.9	3.4	21	15	48	166	25
4	22.4	18.6	4.5	27	18	48	195	29
1&4	21.3	15.9	2.7	24	19	96	154	28
1&2	18.2	12.0	2.0	20	16	96	121	25
3&4	20.2	16.5	2.8	23	17	96	183	27
2&3	17.1	12.5	2.1	19	15	96	147	24
All	19.2	14.4	1.7	21	17	192	154	26
2014 Test Plots								
1	28.2	18.4	4.5	33	24	47	120	34
2	30.6	17.7	4.3	35	26	47	94	36
3	28.7	16.0	3.9	33	25	47	87	35
4	32.4	20.7	5.1	37	27	47	115	37
1&4	30.3	19.6	3.4	34	27	94	115	35
1&2	29.4	18.0	3.1	33	26	94	103	35
3&4	30.5	18.5	3.2	34	27	94	101	35
2&3	29.7	16.8	2.9	33	27	94	89	35
All	30.0	18.2	2.2	32	28	188	101	35
2015 Reference Area								
All	53.5	10.6	2.8	56	51	40	11	NA
2015 Test Plots								
All	37.6	13.2	3.5	41	34	40	35	NA

Notes: [1] N = sample number; [2] sample adequacy for normally distributed data (*m*) and non-normal data distributions (*n*)

2.5 Sample Adequacy

Re-calculate sampling adequacy for 2012 and 2014 based on the re-defined data set.

Sample adequacy was evaluated for the various combinations of data from the 2012 and 2014 test plots surveys. Prior to determining sample adequacy, the data were assessed for normality so the proper statistical tests (i.e., parametric or non-parametric) could be selected. Vegetation cover data from semi-arid plant communities is often characterized as non-normal distribution, long-tailed or skewed to the right, and contain infrequent outliers (Huenneke et al. 2001, CMRP 1999).

Normality for each dataset was assessed using the Shapiro-Wilk test at an alpha of 0.10. Attachment A provides the *Analyse-it* output for Shapiro-Wilk normality testing and frequency histograms. The Shapiro-Wilk test found the distribution of total canopy cover from the 2012 and 2014 surveys was not normal. Individual quadrat data from 2012 and 2014 also exhibited non-normality. Conversely, data from the test plots and reference area in 2015 were normally distributed, though the histograms illustrate that these distributions slightly deviate from the normal probability curve (Attachment A).

Sample adequacy was calculated depending on the distribution of the data (normal versus non-normal). For normally distributed data, sample adequacy was determined using Snedecor and Cochran (1967).

$$m = \frac{t^2 s^2}{(\bar{x}D)^2} \qquad \text{(Eq. 1)}$$

Where m equals minimum number of samples required, t is the two-tailed t-distribution value based on a 90% level of confidence with n-1 degrees of freedom, s is the standard deviation of the sample data, $\bar{x}$ is the mean, and D is the desired level of accuracy which is 10 percent of the mean.

For non-normal data, sample adequacy was calculated using Hofmann and Ries (1990).

$$n = \frac{t^2 pq}{d^2} \qquad \text{(Eq. 2)}$$

Where n equals minimum number of samples required, t is the one-tailed t-distribution value based on a 90% level of confidence with $n-1$ degrees of freedom, p is the cover percentage, q = 100 – p and d is the absolute error (10 percent).

Data from the 2012 and 2014 surveys were not normally distributed, thus sample adequacy was calculated using Equation 2. Sample adequacy was met in all instances (individual, combinations, and all) for the various quadrat sample sets (Table 1).

Equation 1 was used to determine sample adequacy for the 2015 total cover data that were normally distributed. For the reference area, sample adequacy was generally met with less than 20 samples. Given the higher variance associated with total cover for the test plots, sample adequacy was achieved at 35 samples (Table 1).

Meeting sample adequacy is further confirmed using a stabilization of the mean approach (Clark 2001) where running means are calculated for incremental additions of data. Figures 4 and 5 illustrate the running mean with the 90% confidence interval for total canopy cover data collected in 2015 on the reference area and test plots, respectively. While the mean stabilizes, we see little change in the 90% confidence interval with increasing sample size above about 20 samples. The consistent variability with increasing sample size suggests that there is an inherent variability in the system that cannot be overcome with increased sampling.

2.6 Randomization

How transects or quadrats from the 2012 and 2014 data sets will be selected to ensure randomization during re-analysis.

The MMD requested to randomly select quadrats for the re-analysis. We did not perceive the need to further randomize the data after grouping as no interactions were found between quadrats in either year (Section 2.4). Furthermore, randomization was implemented during the field investigations by selecting random points for the systematic samples. Prior to the mid-term field surveys in 2012 and 2014, a 5-m vegetation plot grid was imposed over the test plots. The grid's origin was located using randomly generated coordinates. Randomly generated x-y coordinates were then used to select specific 5-m vegetation plots for the quantitative field work on the test plots. In 2015, similar randomization techniques were used to establish the 50-foot grid from which individual vegetation plots for quantitative sampling were selected for the reference area, the test plot's top surface, and 3:1 outslopes. No further randomization of the data was done in conjunction with the additional statistical analyses.

2.7 2015 Test Plot and Reference Area Hypothesis Testing

If the initial re-analysis of 2012 and 2014 vegetation survey data indicates that the quadrats on each transect are independent, and that sampling adequacy for 90% confidence interval of sample mean has been achieved, FMI will propose appropriate statistical methods for comparison of reclaimed areas with the reference area.

The 2012 and 2014 test plot monitoring did not include reference area monitoring for reasons discussed in Section 2.2. Because vegetation cover may vary substantially in response to year to year fluctuations in precipitation, comparing 2012 and 2014 data to the 2015 reference area data was deemed inappropriate.

For data collected in 2015, total canopy cover of the test plots was compared to the reference area-based performance standard using MMD guidance (CMRP 1999, MARP 1996). Hypothesis testing was performed to compare reclaimed test plot vegetation to the reference area standard using a two-sample t-test. Welch's test was used for this analysis. The Welch t-test is a modification of the Student's t-test used to test the differences in means under the assumption the data are distributed normally. The Welch's t-test also accounts for unequal population variances by using a Satterthwaite correction to determine degrees of freedom and select an appropriate t-value. Levene's test was used to determine whether the variances of the test plots and reference area total canopy data were equal. The result of Levene's test indicates that the variances were unequal at the 10 percent significance level (Attachment A).

A one-sided hypothesis test was constructed to determine if the difference between the means of the populations is greater than zero. The null hypothesis is described as the total canopy cover of the reclaimed vegetation is greater than or equal to 70 percent of the reference area (with the alternate hypothesis that the reclaimed vegetation cover is less than 70 percent of the reference area). The test was performed with a 90% level of confidence. A two-sample unpaired Welch's t-test produces a t-value of -0.06 at a p-value of 0.476 which indicates that we cannot reject the null hypothesis that the difference in population means is greater than zero at the 90% level of confidence. Statistical outputs for these tests are provided in Attachment A.

The diamond-plots in Figure 6 illustrate the mean, upper, and lower 90% confidence intervals for total canopy cover for the test plots and reference area standard. Overlap of the 90% confidence intervals about the means for the two populations further confirms the hypotheses testing results that the means are not significantly different. This further supports the demonstration of vegetation success on the test plots for total canopy cover.

2.8 Additional Lines of Evidence of Vegetation Progression

Additional lines of evidence that the vegetation is progressing towards a self-sustaining ecosystem are found in the increased number of species found on the test plots over time (Golder 2015a) and photographic documentation. Native species are volunteering and reoccupying the site. The progression of vegetation is clearly illustrated through sequential photographs (Attachment B).

2.9 Trajectory of Test Plot Vegetation

The possibility of running a regression analysis, or providing some other graphical representation of the statistical trend, resulting from the reworked data.

The intent of the 2015 work was to compare the data from test plots to the reference area to determine if it was on a "trajectory" to eventually meeting the vegetation success criteria. We understand the value in having information about the progression of the vegetation over time to support the trajectory concept. Figure 7 graphs vegetation cover over time based on field estimates made in the past years and measurements from the quantitative surveys, illustrating the progression and increased canopy cover as the reclaimed plant community matures.

3.0 CONCLUSION

The sampling methods used for 2012 and 2014 test plot monitoring were essentially the same as the methods used in the 1999 and 2015 reference area monitoring. Differences in transect length and quadrat size were required to accommodate the size of the areas being monitored. The smaller quadrat size used in the 2012 and 2014 were appropriate considering the structure of the vegetation. The quadrat spacing is considered adequate based on the structure of the vegetation to ensure independence. Re-analysis of the vegetation data indicated that they are statistically equivalent regardless of number of quadrats used in the analysis. Thus, the differences in survey methods are relatively minor and would allow for inter-year comparisons of the data.

Vegetation cover has progressively increased over time with the year to year changes, which is partially a function of the climatic conditions. For instance, the above normal precipitation in 2010 resulted in a substantial increase in vegetation cover from 5 percent in 2009 (year 2) to 15 percent in the fall of 2010 (year 3).

The data from the test plots and reference area from 2015 were found to be normally distributed and sample adequacy was achieved for both areas. Results from the one-sided hypothesis test (Welch's t-test) indicate that the difference in population means is greater than zero at the 90% confidence level. This supports the conclusion that vegetation on the test plot meets Chino's reference area-based performance standard for total canopy cover and demonstrates the suitability of the RCM to support adequate vegetation.

4.0 REFERENCES

Clark, D. 2001. Stabilization of the mean as a demonstration of sample adequacy. Paper presented at the 2001 Am. Soc. for Surface Mining and Reclamation. Albuquerque, NM. June 3-7 2001.

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Launchbaugh, K. 2009. Principles of Vegetation Measurement & Assessment and Ecological Monitoring & Analysis. Available at: http://www.webpages.uidaho.edu/veg_measure/index.htm.

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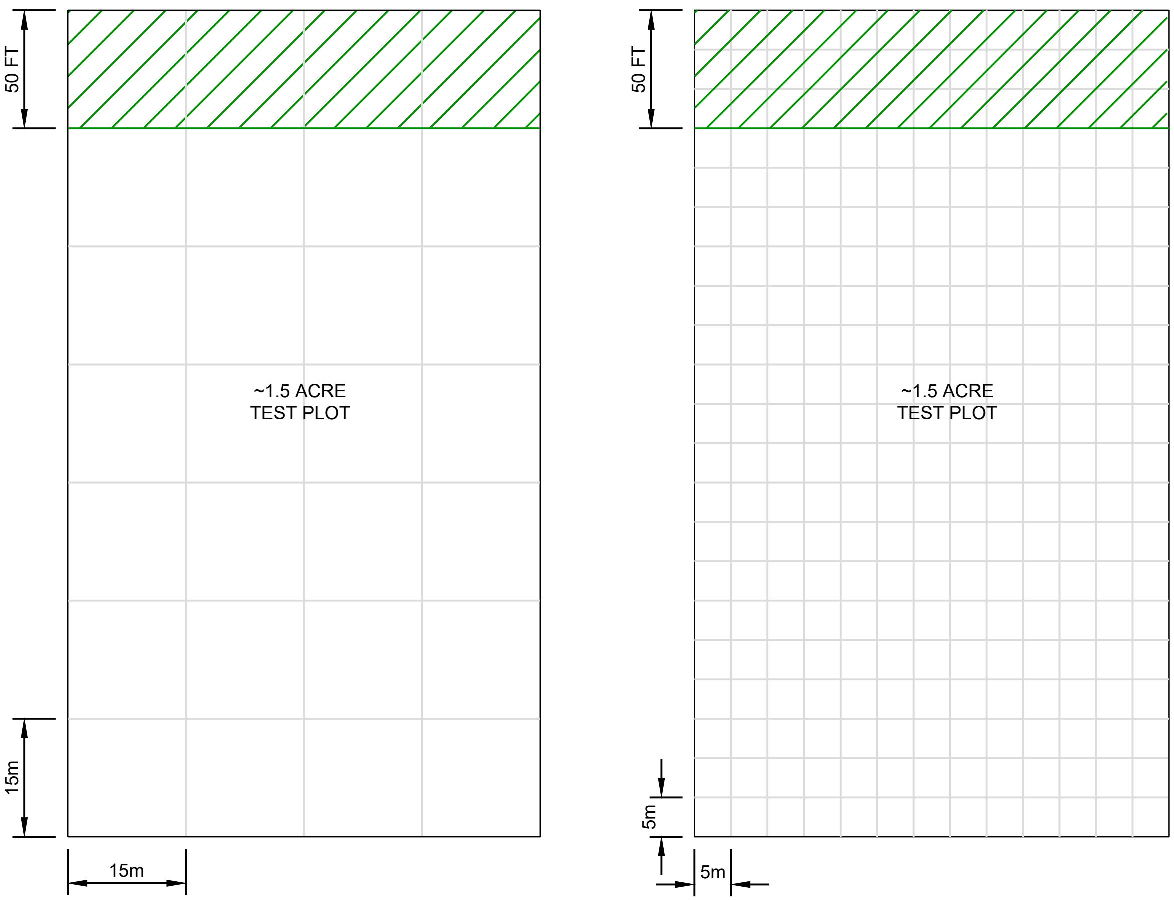
Attachments: Figures
A. Total Canopy Data Summaries
B. Photo Documentation of Vegetation Progression on the Chino Test Plots

FIGURES

Path: \\albuquerque\Cad\2011 Projects\11380037\Production\2015\ | File Name: Chino TP Grid.dwg



NOT TO SCALE

LEGEND

FERTILIZER PLOT

CLIENT
FREEPORT McMoRan CHINO MINES COMPANY
GRANT COUNTY, NEW MEXICO

PROJECT
TEST PLOT CHINO STOCKPILE

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-05-10
DESIGNED	LM
PREPARED	CM
REVIEWED	LM
APPROVED	LM

TITLE
VEGETATION SURVEY 5 METER AND 15 METER GRIDS

PROJECT NO.	PHASE	REV.	FIGURE
11380037	--	--	1

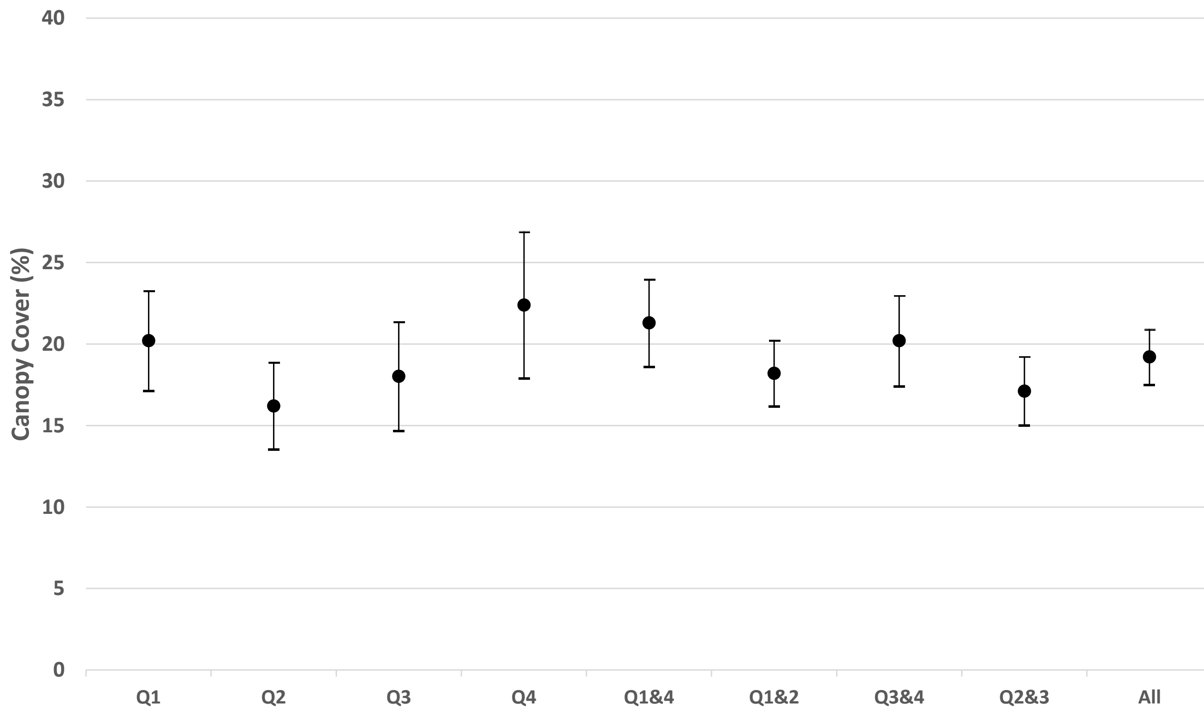


Figure 2. Mean ± 90% CI for total canopy cover for 2012 quadrat sample sets

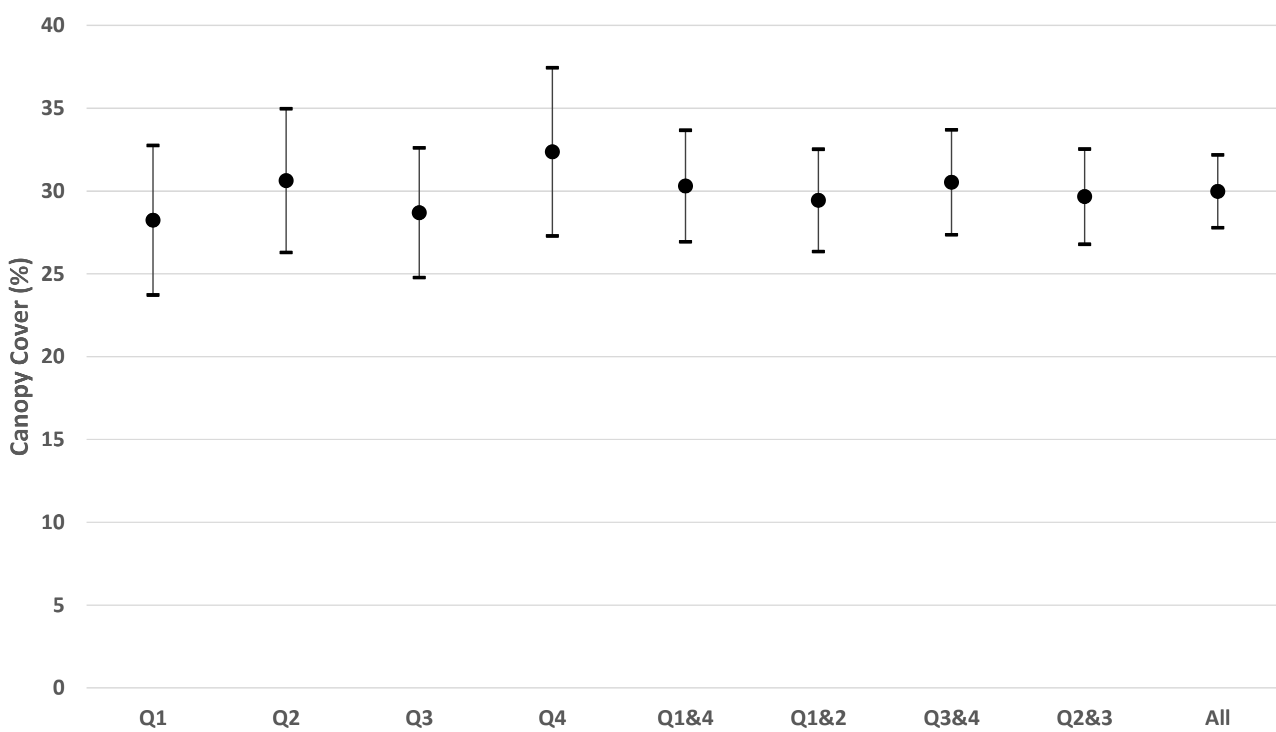


Figure 3. Mean ± 90% CI for total canopy cover for 2014 quadrat sample sets

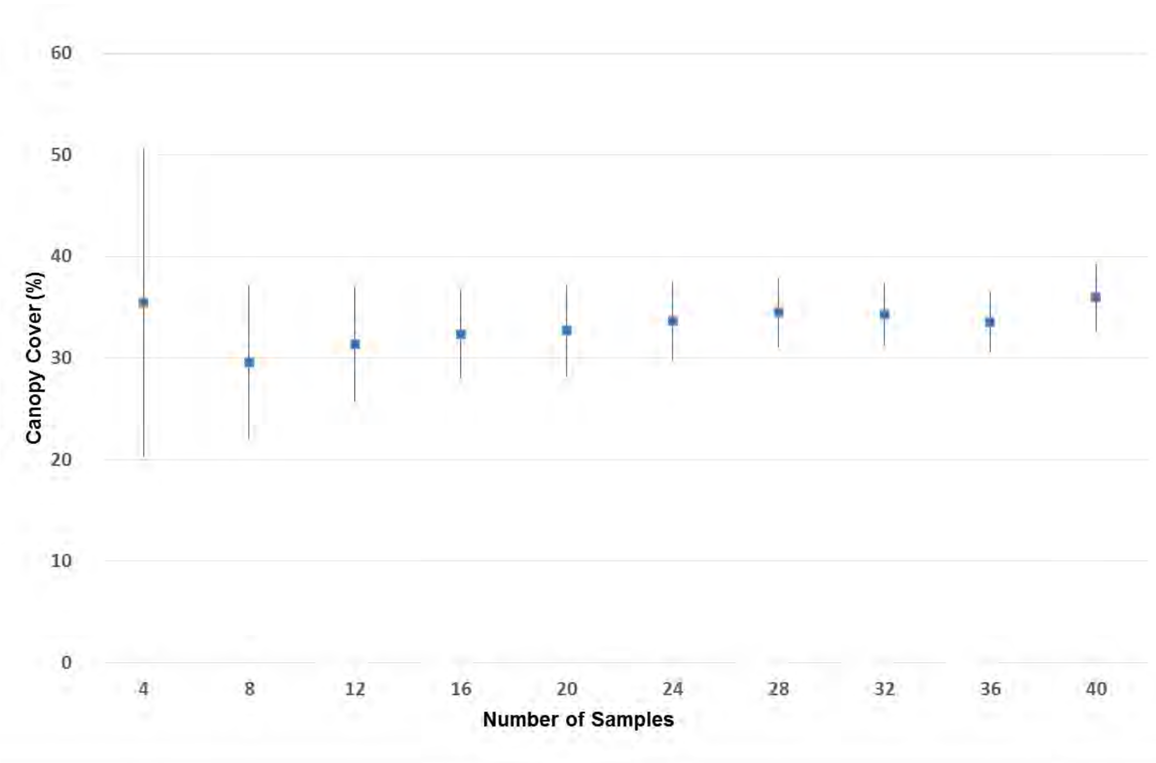


Figure 4. Stabilization of the mean ± 90% CI for 2015 total canopy cover at the Chino test plots, top surface and outslope

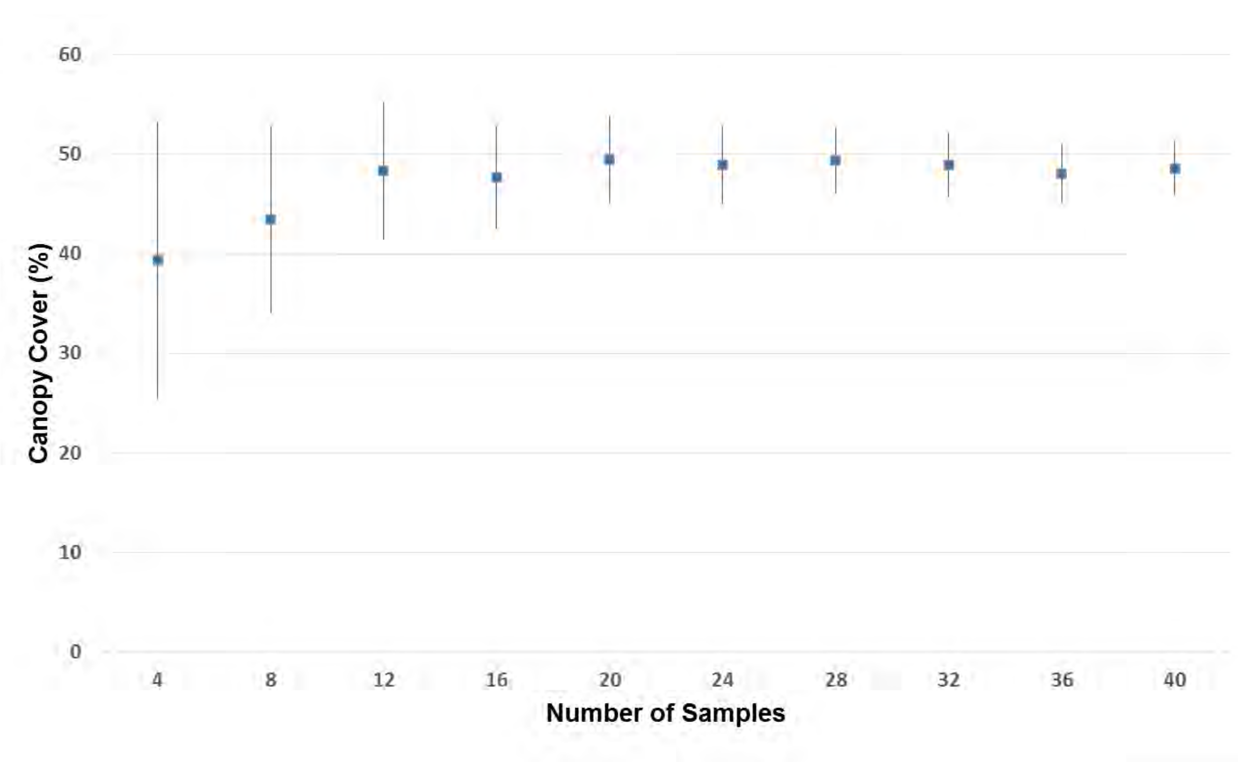
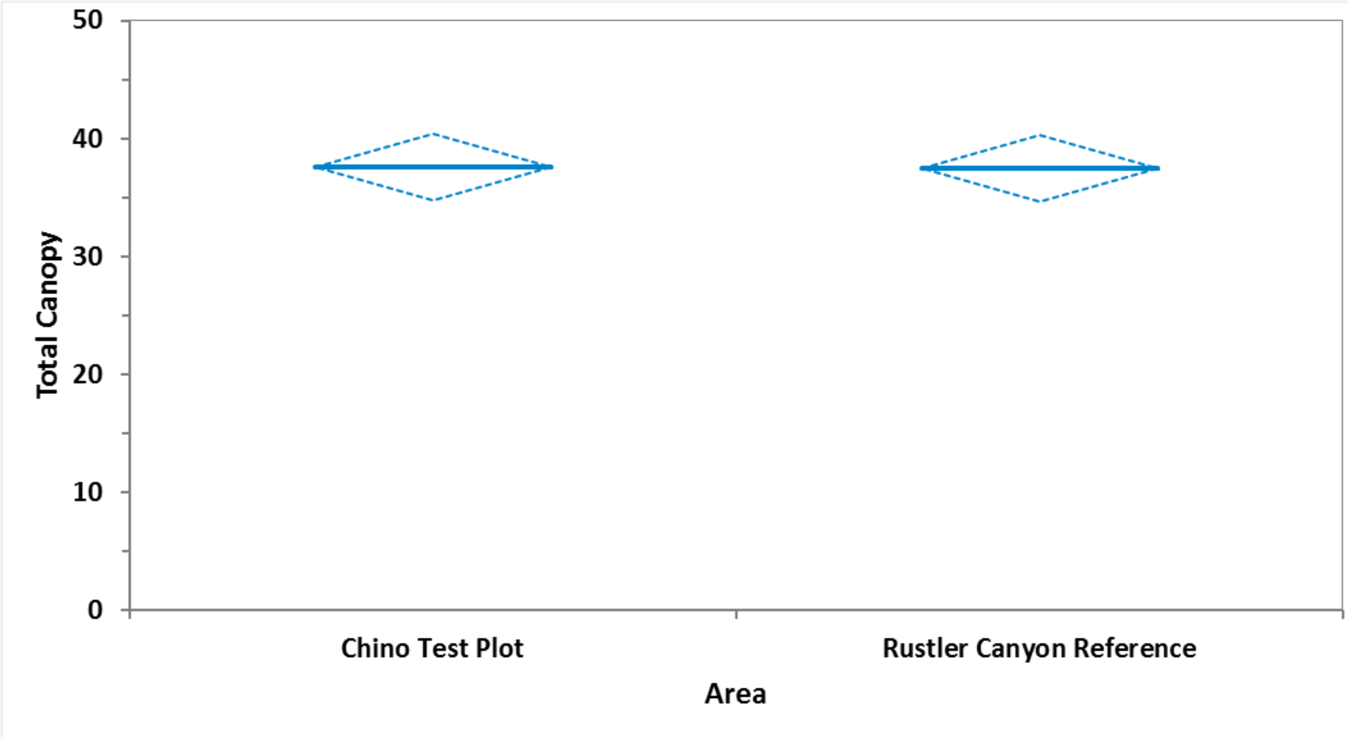


Figure 5. Stabilization of the mean ± 90% CI for 2015 total canopy cover at the Chino reference area



Note: blue diamonds represent 90% CI for the mean

Figure 6. Total canopy cover mean ± 90% CI for 2015 Chino Test Plots and the Reference Area Standard

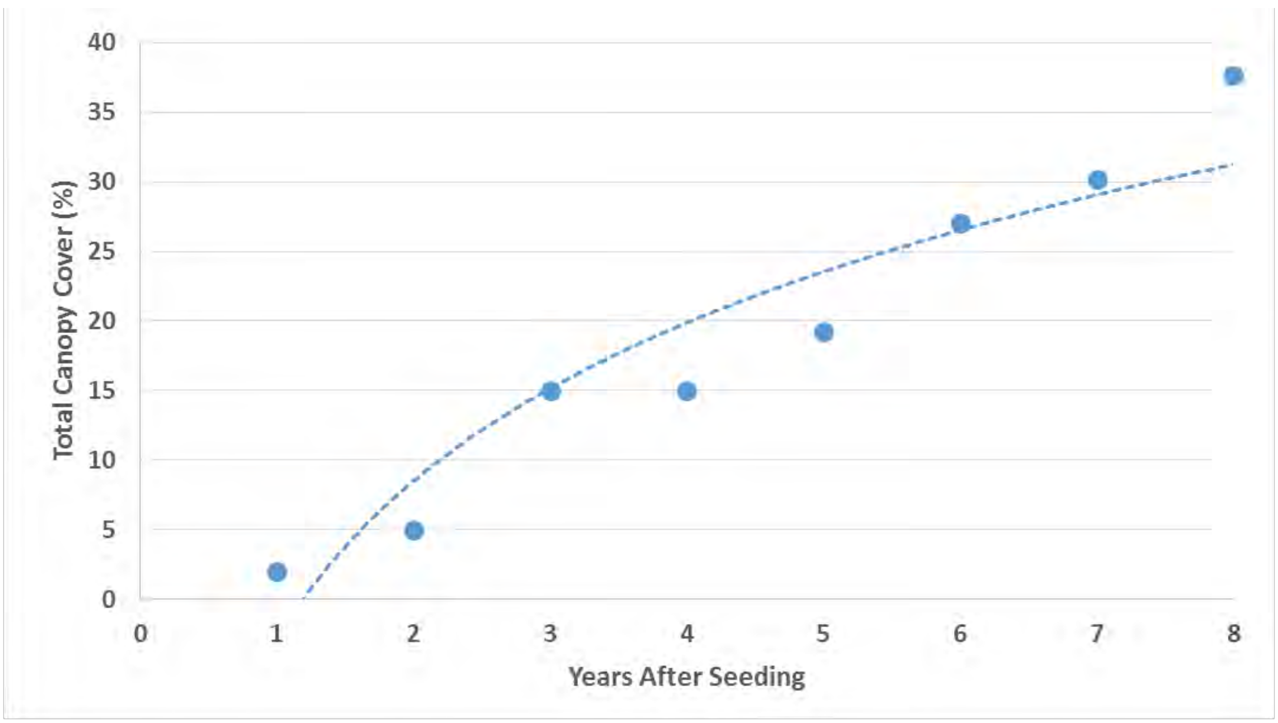


Figure 7. Trajectory of total canopy cover on the Chino Test Plots since seeding

ATTACHMENT A
TOTAL CANOPY DATA SUMMARIES

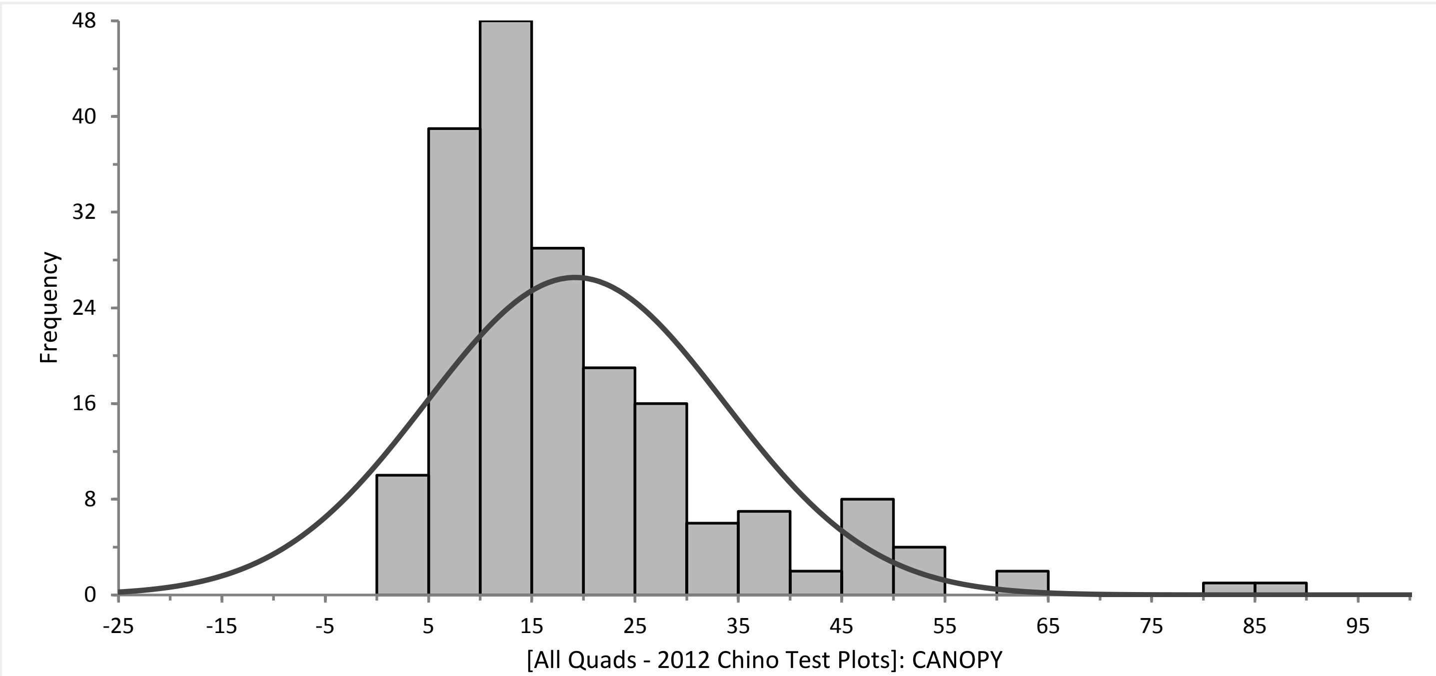
Distribution: [All Quads - 2012 Chino Test Plots]: CANOPY

Analyse-it v4.60.1

All Data A1:G194

Last updated 31 October 2016 at 10:12 by Romig, Doug

Descriptives



N	192

	Mean	Mean SE	SD	Variance	Skewness	Kurtosis
[All Quads - 2012 Chino Test Plots]: CANOPY	19.208	1.0412	14.427	208.151	1.9	4.50

	Minimum	1st quartile	Median	3rd quartile	Maximum	IQR
[All Quads - 2012 Chino Test Plots]: CANOPY	0.05	9.583	14.550	24.633	88.00	15.050

Normality

Shapiro-Wilk test

W statistic	0.83
p-value	<0.0001 [1]

H0: F(Y) = N(μ, σ)

The distribution of the population is normal with unspecified mean and standard deviation.

H1: F(Y) ≠ N(μ, σ)

The distribution of the population is not normal.

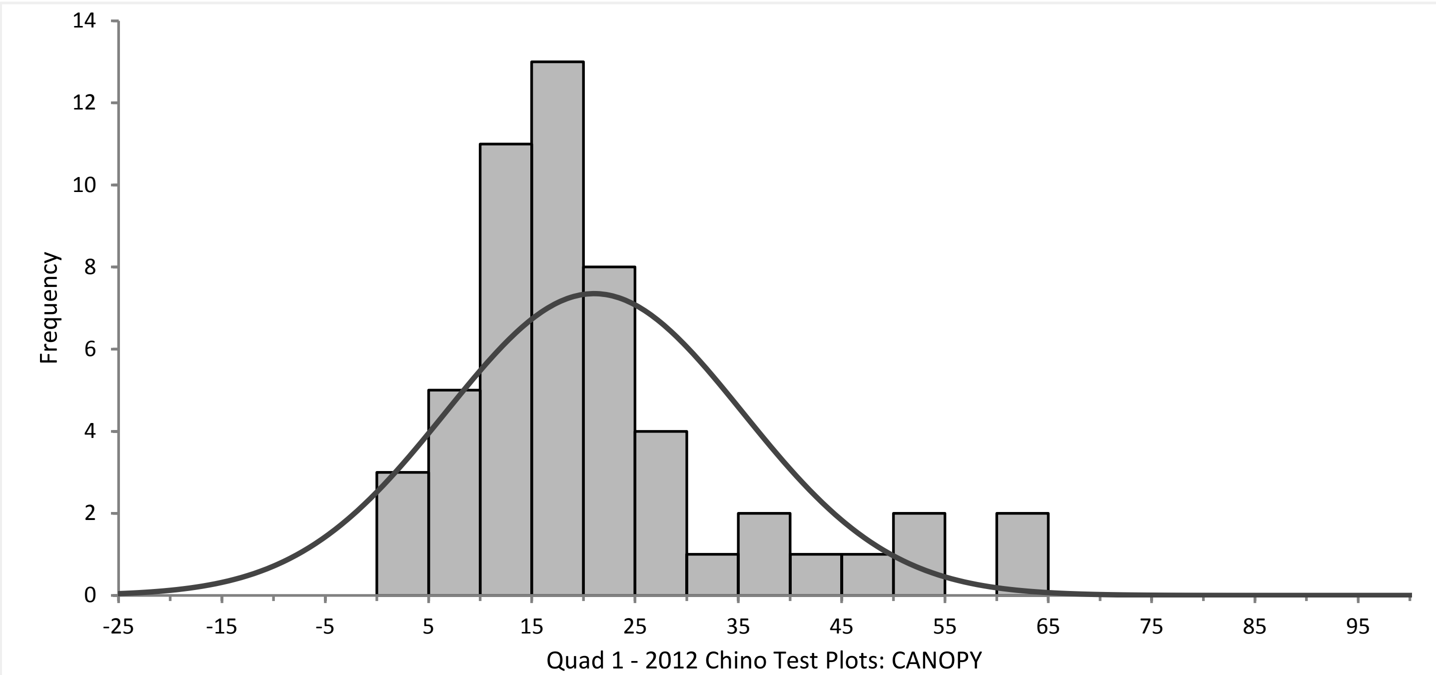
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

Distribution: Quad 1 - 2012 Chino Test Plots: CANOPY

Q1 12 A1:G55

Last updated 31 October 2016 at 9:41 by Romig, Doug

Descriptives



N	53

	Mean	Mean SE	SD	Variance	Skewness	Kurtosis
Quad 1 - 2012 Chino Test Plots: CANOPY	21.04	1.97	14.38	206.69	1.5	2.03

	Minimum	1st quartile	Median	3rd quartile	Maximum	IQR
Quad 1 - 2012 Chino Test Plots: CANOPY	0.01	11.47	18.70	25.27	64.00	13.80

Normality

Shapiro-Wilk test

W statistic	0.86
p-value	<0.0001[1]

H0: $F(Y) = N(\mu, \sigma)$
The distribution of the population is normal with unspecified mean and standard deviation.
H1: $F(Y) \neq N(\mu, \sigma)$
The distribution of the population is not normal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

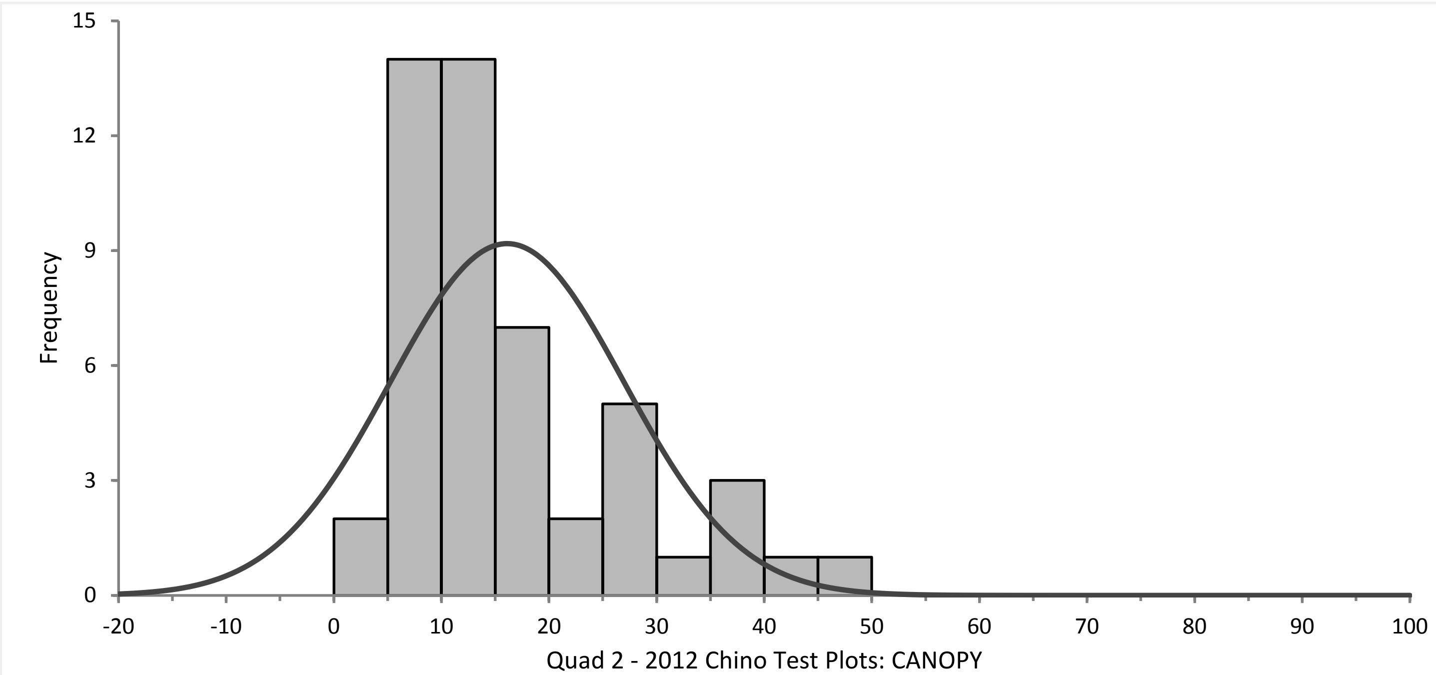
Distribution: Quad 2 - 2012 Chino Test Plots: CANOPY

Analyse-it v4.60.1

Q2 12 A1:H52

Last updated 31 October 2016 at 9:41 by Romig, Doug

Descriptives



N	50

	Mean	Mean SE	SD	Variance	Skewness	Kurtosis
Quad 2 - 2012 Chino Test Plots: CANOPY	16.11	1.54	10.86	117.93	1.3	1.01

	Minimum	1st quartile	Median	3rd quartile	Maximum	IQR
Quad 2 - 2012 Chino Test Plots: CANOPY	0.20	8.60	12.00	20.08	48.10	11.48

Normality

Shapiro-Wilk test

W statistic	0.88
p-value	<0.0001[1]

H0: F(Y) = N(μ, σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ, σ)
The distribution of the population is not normal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

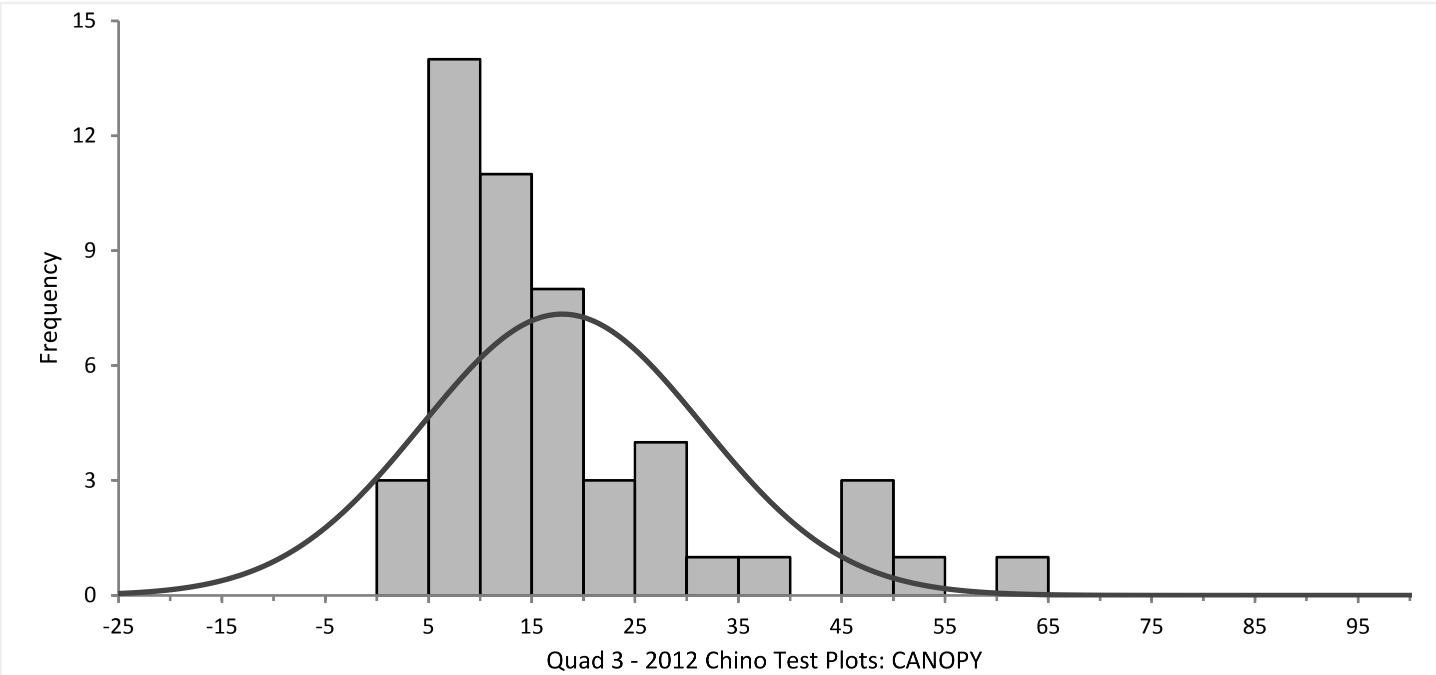
Distribution: Quad 3 - 2012 Chino Test Plots: CANOPY

Analyse-it v4.60.1

Q3 12 A1:G52

Last updated 31 October 2016 at 9:41 by Romig, Doug

Descriptives



N	50

	Mean	Mean SE	SD	Variance	Skewness	Kurtosis
Quad 3 - 2012 Chino Test Plots: CANOPY	17.94	1.92	13.58	184.44	1.5	1.91

	Minimum	1st quartile	Median	3rd quartile	Maximum	IQR
Quad 3 - 2012 Chino Test Plots: CANOPY	1.00	9.19	14.15	20.87	60.40	11.68

Normality

Shapiro-Wilk test

W statistic	0.84
p-value	<0.0001[1]

H0: F(Y) = N(μ, σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ, σ)
The distribution of the population is not normal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

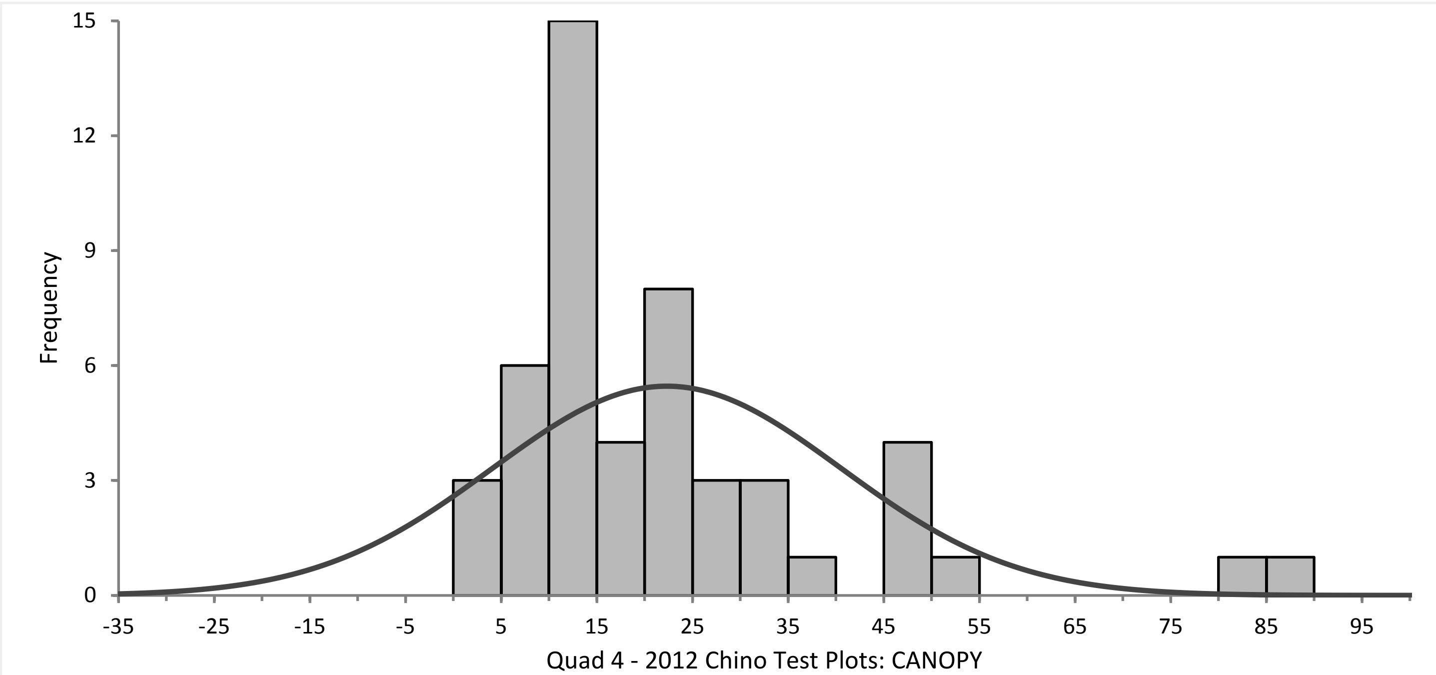
Distribution: Quad 4 - 2012 Chino Test Plots: CANOPY

Analyse-it v4.60.1

Q4 12 A1:G52

Last updated 31 October 2016 at 9:41 by Romig, Doug

Descriptives



N	50

	Mean	Mean SE	SD	Variance	Skewness	Kurtosis
Quad 4 - 2012 Chino Test Plots: CANOPY	22.31	2.58	18.26	333.35	2.0	4.43

	Minimum	1st quartile	Median	3rd quartile	Maximum	IQR
Quad 4 - 2012 Chino Test Plots: CANOPY	0.05	10.93	15.95	26.54	88.00	15.61

Normality

Shapiro-Wilk test

W statistic	0.80
p-value	<0.0001[1]

H0: F(Y) = N(μ, σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ, σ)
The distribution of the population is not normal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

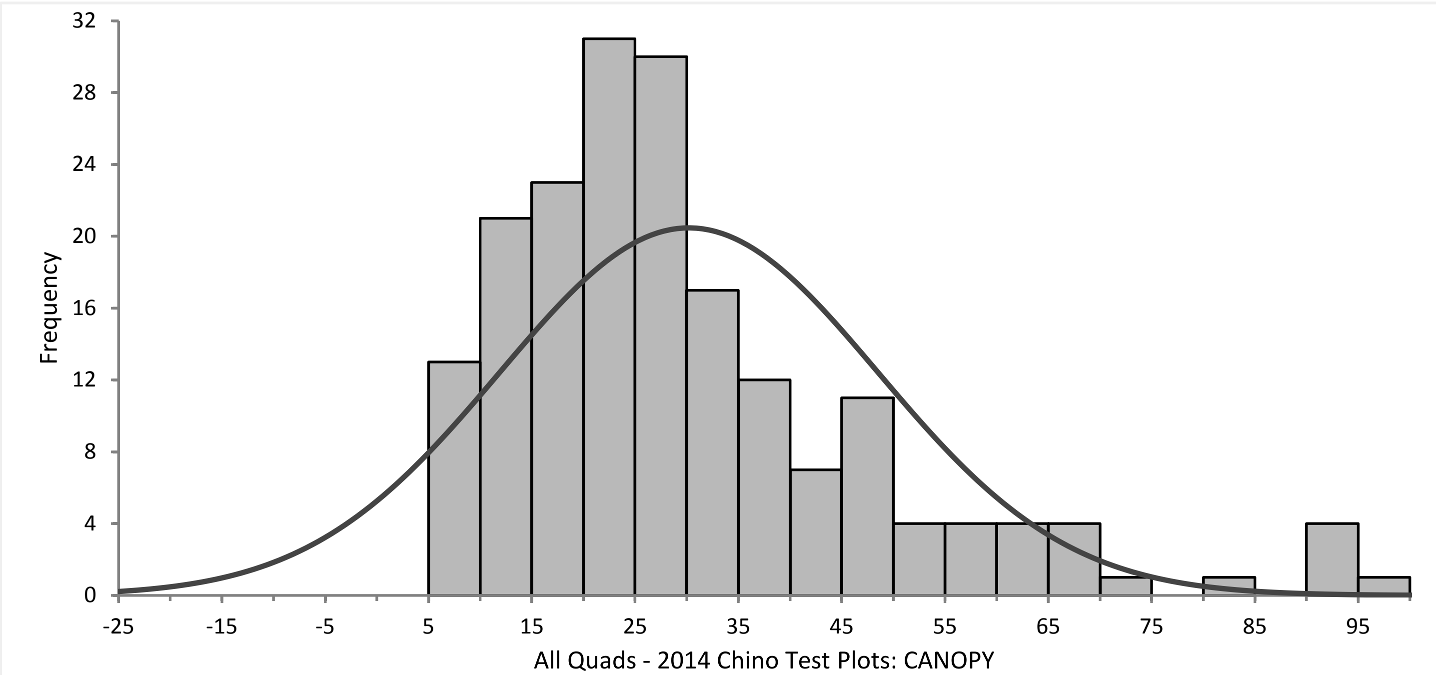
Distribution: All Quads - 2014 Chino Test Plots: CANOPY

Analyse-it v4.60.1

All Data A1:G190

Last updated 31 October 2016 at 10:26 by Romig, Doug

Descriptives



N	188

	Mean	Mean SE	SD	Variance	Skewness	Kurtosis
All Quads - 2014 Chino Test Plots: CANOPY	30.20	1.336	18.32	335.65	1.5	2.51

	Minimum	1st quartile	Median	3rd quartile	Maximum	IQR
All Quads - 2014 Chino Test Plots: CANOPY	6.2	18.04	25.70	37.19	97.0	19.15

Normality

Shapiro-Wilk test

W statistic	0.87
p-value	<0.0001 [1]

H0: $F(Y) = N(\mu, \sigma)$

The distribution of the population is normal with unspecified mean and standard deviation.

H1: $F(Y) \neq N(\mu, \sigma)$

The distribution of the population is not normal.

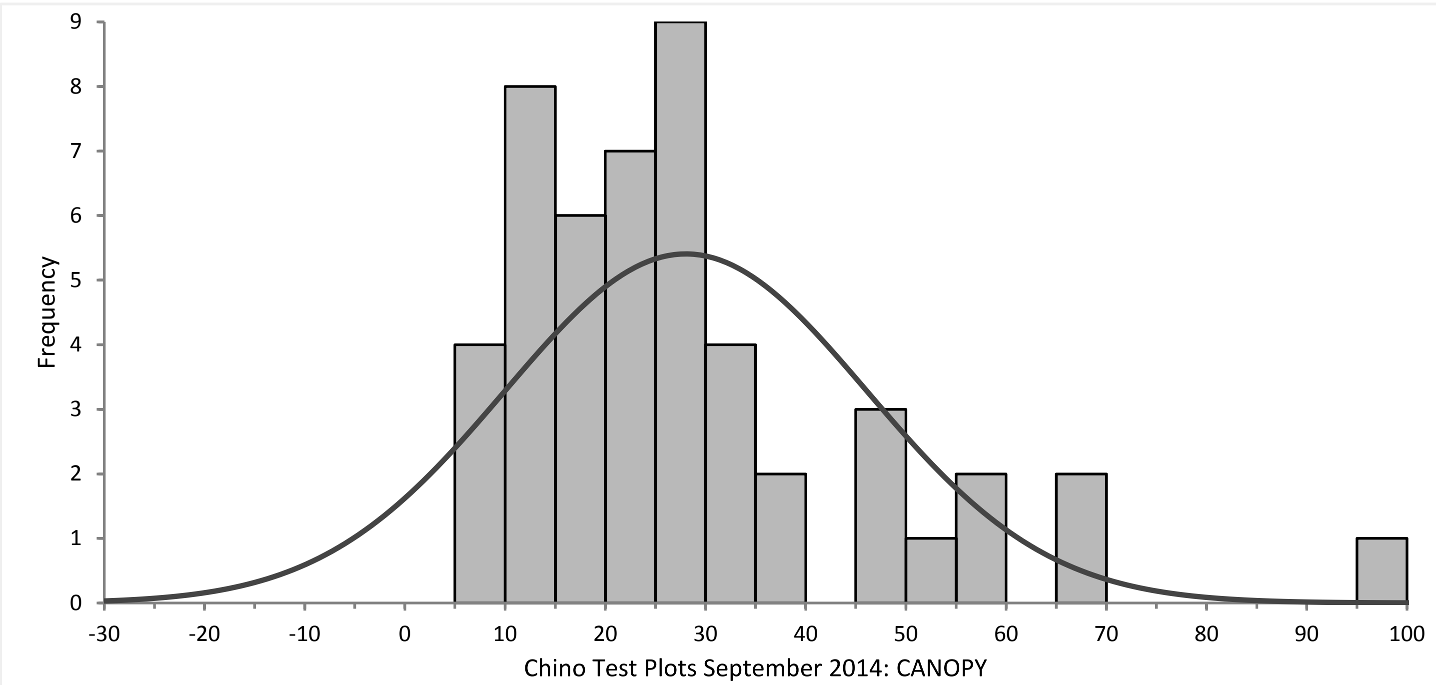
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

Distribution: Chino Test Plots September 2014: CANOPY

Q1 14 A1:G51

Last updated 8 June 2016 at 14:22 by Romig, Doug

Descriptives



N	49

	Mean	Mean SE	SD	Variance	Skewness	Kurtosis
Chino Test Plots September 2014: CANOPY	28.0	2.6	18.1	326.9	1.7	3.49

	Minimum	1st quartile	Median	3rd quartile	Maximum	IQR
Chino Test Plots September 2014: CANOPY	6.5	15.6	23.2	33.8	97.0	18.3

Normality

Shapiro-Wilk test

W statistic	0.85
p-value	<0.0001[1]

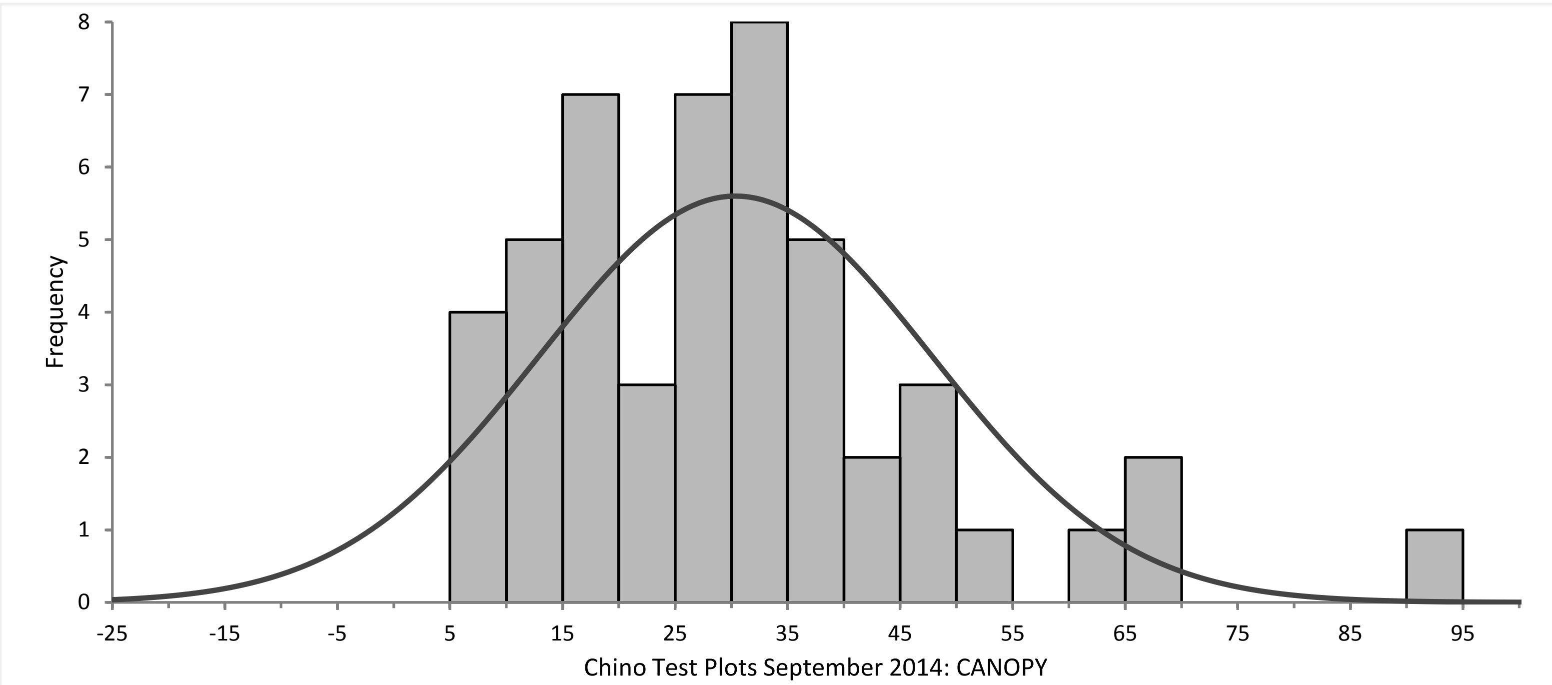
H0: F(Y) = N(μ, σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ, σ)
The distribution of the population is not normal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

Distribution: Chino Test Plots September 2014: CANOPY

Q2 14 A1:G51

Last updated 8 June 2016 at 14:23 by Romig, Doug

Descriptives



N	49

	Mean	Mean SE	SD	Variance	Skewness	Kurtosis
Chino Test Plots September 2014: CANOPY	30.4	2.5	17.5	304.5	1.3	2.49

	Minimum	1st quartile	Median	3rd quartile	Maximum	IQR
Chino Test Plots September 2014: CANOPY	7.7	17.2	29.1	39.2	93.4	22.0

Normality

Shapiro-Wilk test

W statistic	0.90
p-value	0.0008[1]

H0: F(Y) = N(μ, σ)

The distribution of the population is normal with unspecified mean and standard deviation.

H1: F(Y) ≠ N(μ, σ)

The distribution of the population is not normal.

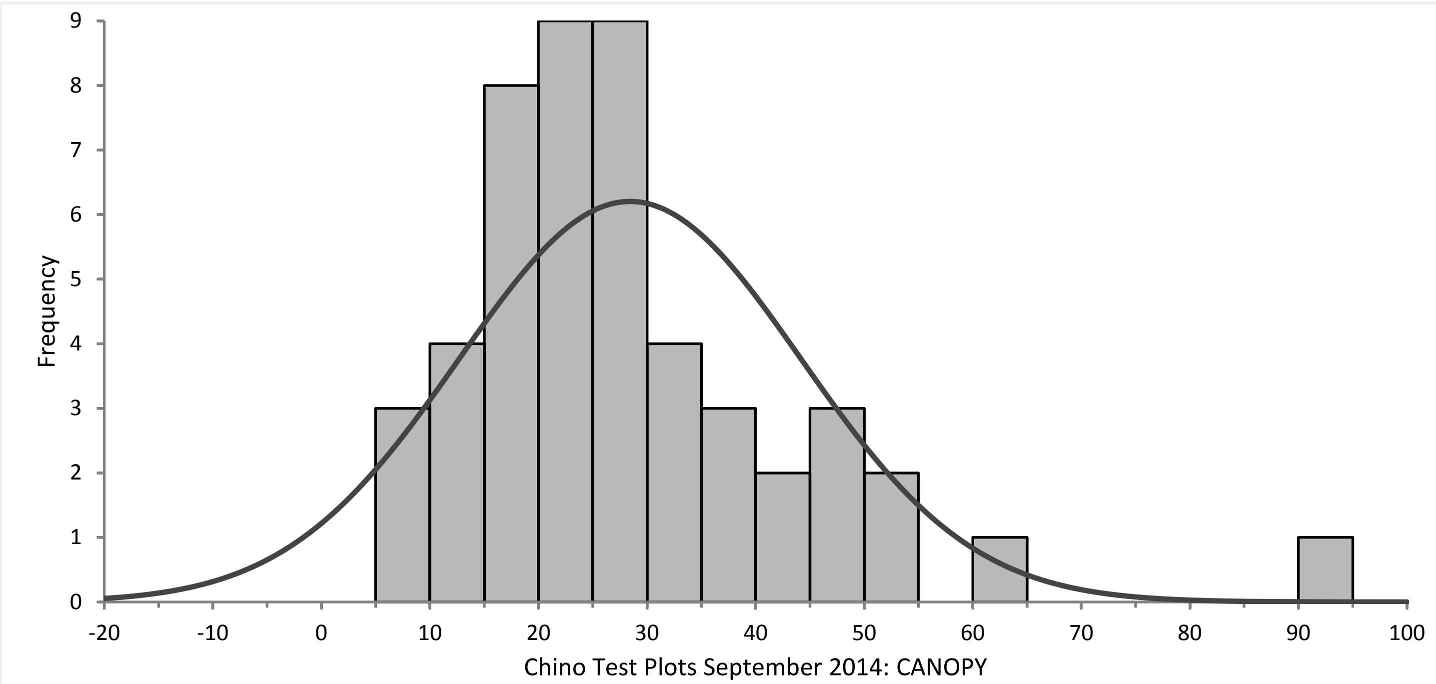
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

Distribution: Chino Test Plots September 2014: CANOPY

Q3 14 A1:G51

Last updated 8 June 2016 at 14:23 by Romig, Doug

Descriptives



N	49

	Mean	Mean SE	SD	Variance	Skewness	Kurtosis
Chino Test Plots September 2014: CANOPY	28.4	2.3	15.8	248.2	1.7	5.12

	Minimum	1st quartile	Median	3rd quartile	Maximum	IQR
Chino Test Plots September 2014: CANOPY	6.2	18.7	25.5	34.9	94.0	16.3

Normality

Shapiro-Wilk test

W statistic	0.88
p-value	0.0001[1]

H0: F(Y) = N(μ, σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ, σ)
The distribution of the population is not normal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

Distribution: Chino Test Plots September 2014: CANOPY

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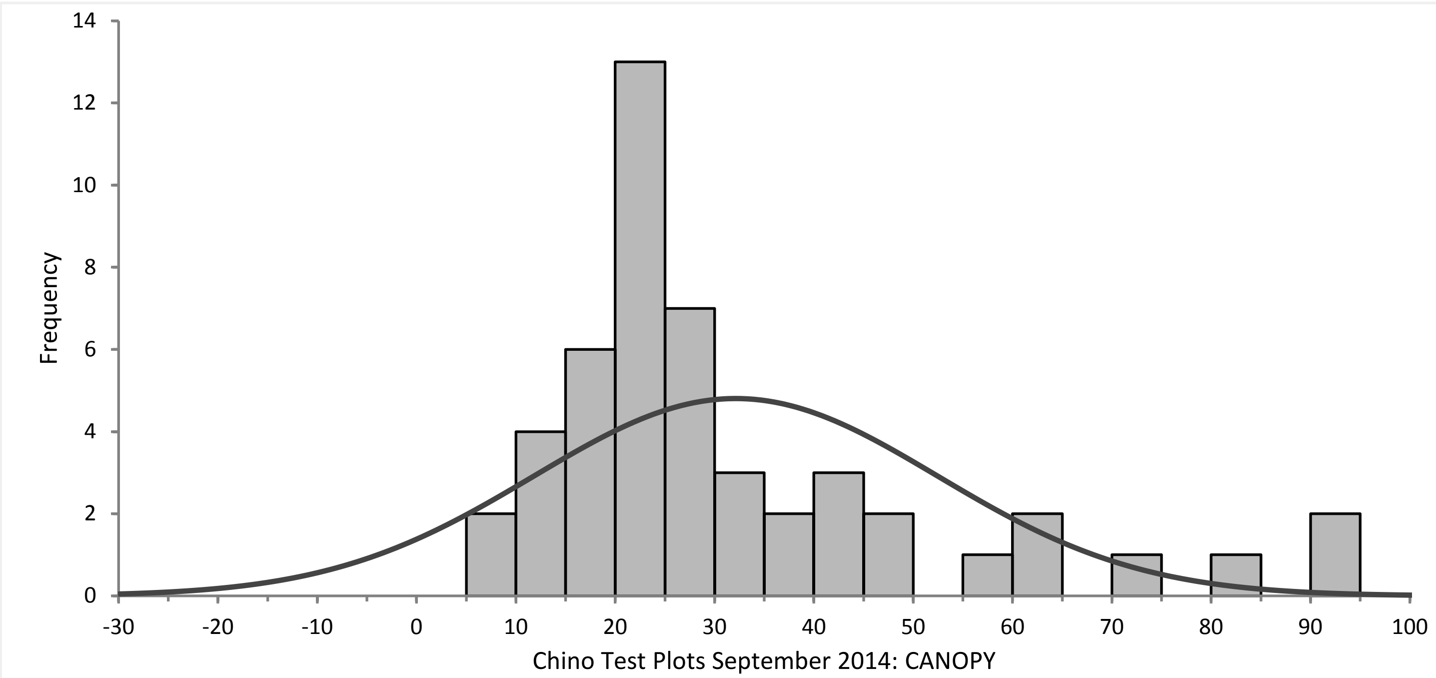
Q4 14 A1:G53

Last updated 8 June 2016 at 14:24 by Romig, Doug

Descriptives



N	49

	Mean	Mean SE	SD	Variance	Skewness	Kurtosis
Chino Test Plots September 2014: CANOPY	32.1	2.9	20.3	413.8	1.6	2.12

	Minimum	1st quartile	Median	3rd quartile	Maximum	IQR
Chino Test Plots September 2014: CANOPY	8.8	20.4	24.8	39.9	94.0	19.6

Normality

Shapiro-Wilk test

W statistic	0.83
p-value	<0.0001 [1]

H0: F(Y) = N(μ, σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ, σ)
The distribution of the population is not normal.

[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

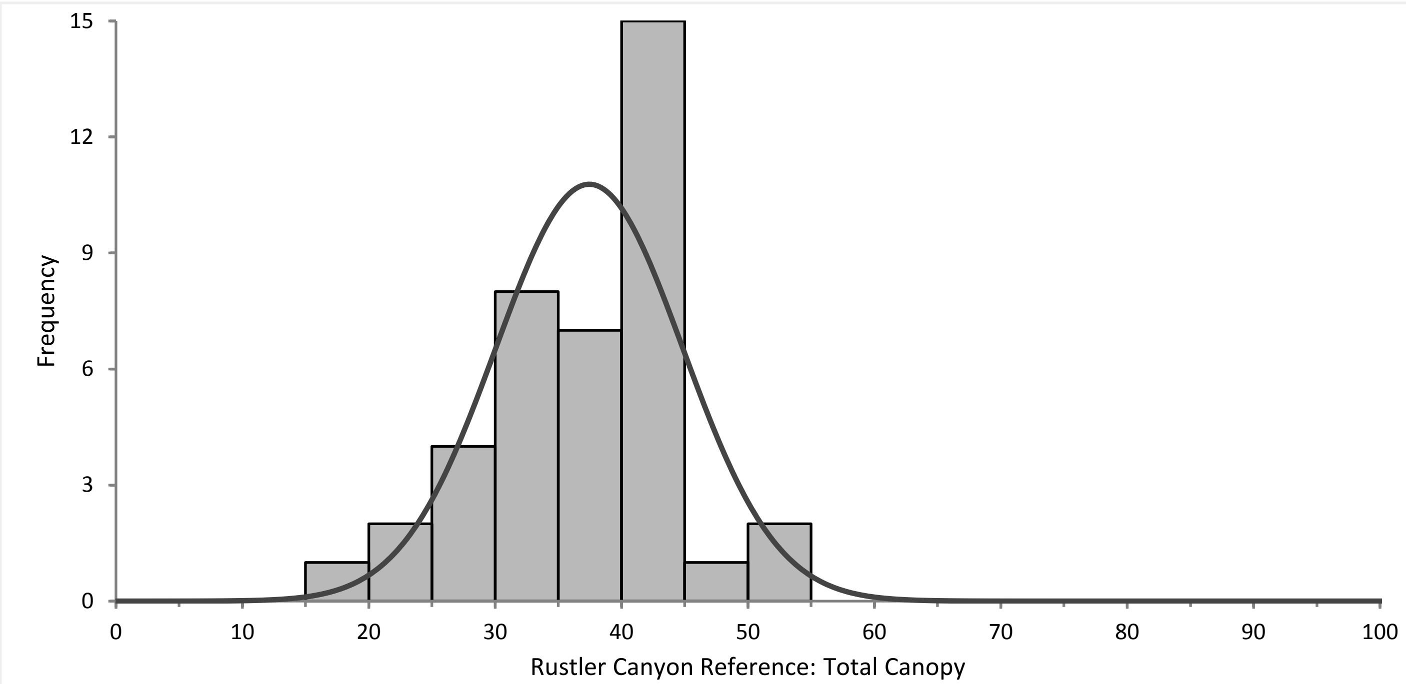
Distribution: Rustler Canyon Reference: Total Canopy

Analyse-it v4.60.1

All Data P1:Q42

Last updated 31 October 2016 at 10:22 by Romig, Doug

Descriptives



N	40

	Mean	Mean SE	SD	Variance	Skewness	Kurtosis
Rustler Canyon Reference: Total Canopy	37.44	1.170	7.40	54.80	-0.3	0.21

	Minimum	1st quartile	Median	3rd quartile	Maximum	IQR
Rustler Canyon Reference: Total Canopy	19.3	32.15	38.91	42.84	54.7	10.69

Normality

Shapiro-Wilk test

W statistic	0.98
p-value	0.5918[1]

H0: F(Y) = N(μ, σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ, σ)
The distribution of the population is not normal.
[1] Do not reject the null hypothesis at the 10% significance level.

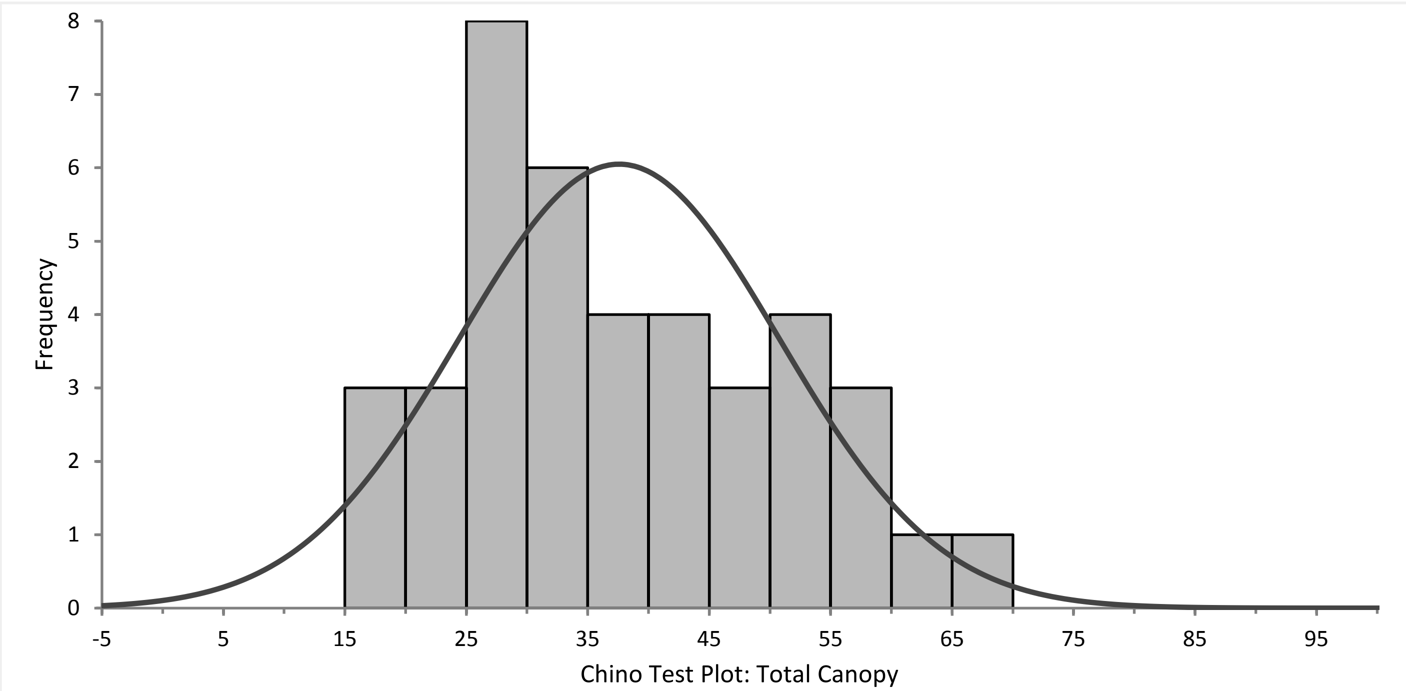
Distribution: Chino Test Plot: Total Canopy

Analyse-it v4.60.1

All Data S1:T42

Last updated 31 October 2016 at 10:22 by Romig, Doug

Descriptives



N	40

	Mean	Mean SE	SD	Variance	Skewness	Kurtosis
Chino Test Plot: Total Canopy	37.59	2.09	13.19	173.95	0.4	-0.79

	Minimum	1st quartile	Median	3rd quartile	Maximum	IQR
Chino Test Plot: Total Canopy	16.54	26.76	34.94	46.44	66.14	19.68

Normality

Shapiro-Wilk test

W statistic	0.96
p-value	0.1614[1]

H0: F(Y) = N(μ, σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ, σ)
The distribution of the population is not normal.
[1] Do not reject the null hypothesis at the 10% significance level.

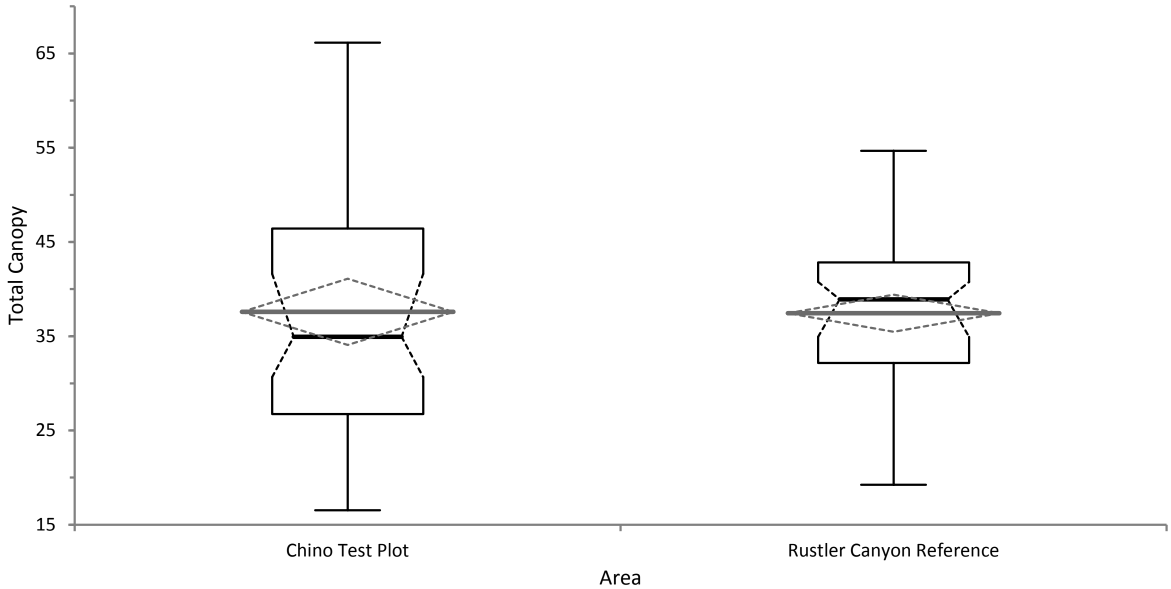
Compare Groups: Total Canopy by Area

Analyse-it v4.60.1

All Data P1:Q81

Last updated 30 October 2016 at 14:14 by Romig, Doug

Descriptives



N	80

Total Canopy by Area	N	Mean	90% CI	Mean SE	Variance	SD
Chino Test Plot	40	37.59	34.07 to 41.10	2.085	173.95	13.19
Rustler Canyon Reference	40	37.44	35.47 to 39.42	1.170	54.80	7.40

Total Canopy by Area	Minimum	1st Quartile	Median	90% CI	3rd Quartile	Maximum	Inter-quartile range
Chino Test Plot	16.5	26.76	34.94	30.67 to 41.61	46.44	66.1	19.68
Rustler Canyon Reference	19.3	32.15	38.91	34.93 to 40.76	42.84	54.7	10.69

Compare Groups: Total Canopy by Area

Analyse-it v4.60.1

All Data P1:Q81

Last updated 30 October 2016 at 14:14 by Romig, Doug

Dispersion

Levene test

F statistic	15.40
Numerator DF	1
Denominator DF	78
p-value	0.0002[1]

H0: $\sigma^2_1 = \sigma^2_2 = \sigma^2 \ldots$

The variance of the populations are all equal.

H1: $\sigma^2_i \neq \sigma^2_j$ for at least one i,j

The variance of the populations are not all equal.

[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

Location

Mean difference	-0.14
90% upper CI	$-\infty$ to 2.95
SE	2.391

$\mu_\Delta = \mu_{\text{Rustler Canyon Reference}} - \mu_{\text{Chino Test Plot}}$

Welch t test

Hypothesized difference	0

t statistic	-0.06
DF	61.4
p-value	0.4760[1]

H0: $\mu_\Delta \geq 0$

The difference between the means of the populations is greater than or equal to 0.

H1: $\mu_\Delta < 0$

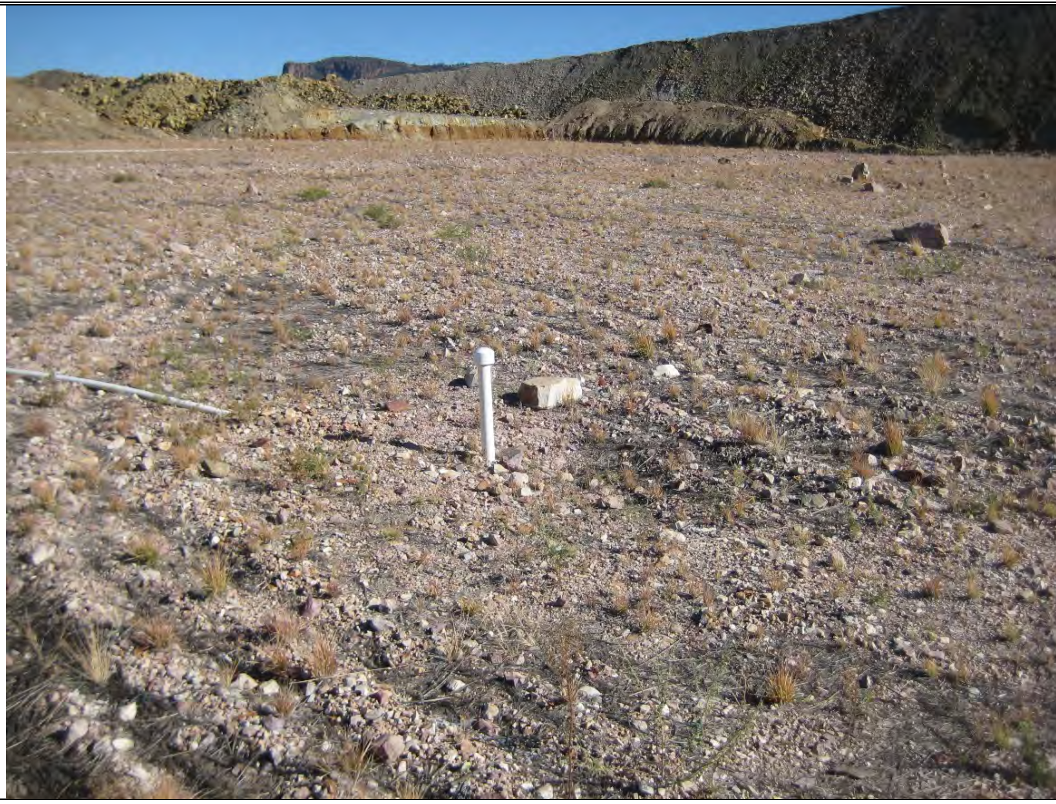
The difference between the means of the populations is less than 0.

[1] Do not reject the null hypothesis at the 10% significance level.

ATTACHMENT B
PHOTO DOCUMENTATION OF VEGETATION PROGRESSION
ON THE CHINO TEST PLOTS

2007

2008



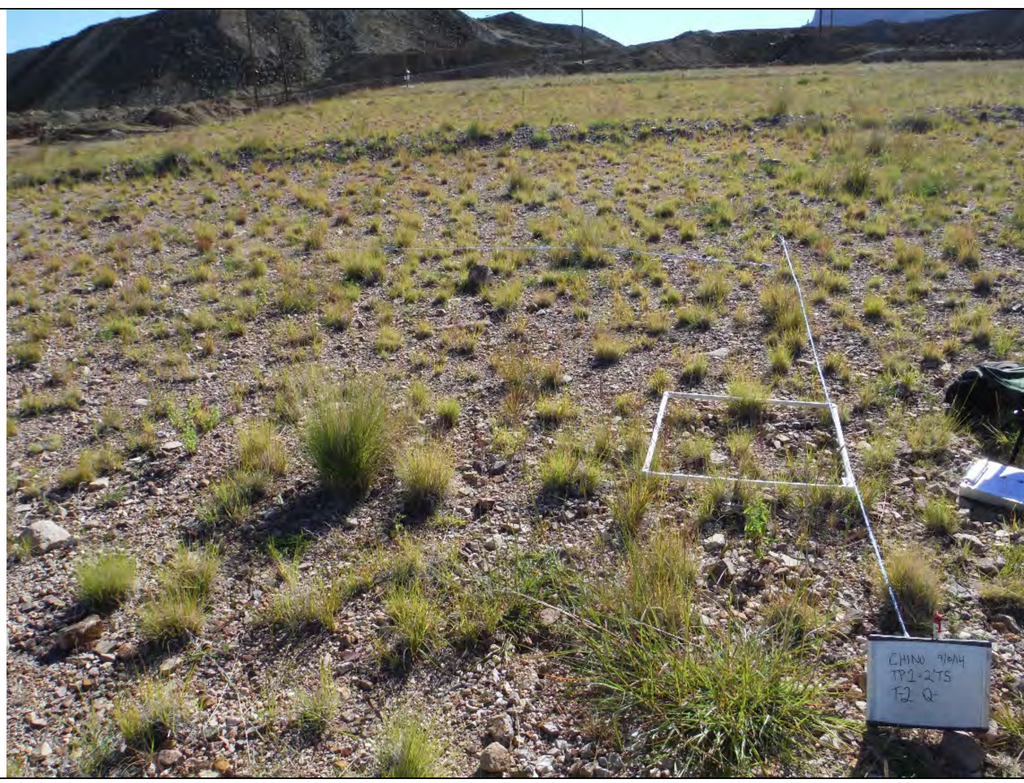
2009

2010

2011

2012

2013



2014

2015