Addendum to Revisions of Survey Protocol for HMP Annual Plants: Implementation of Macroplot Sampling at Former Fort Ord

Prepared for

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SECTION 1

Introduction

In 2013, Tetra Tech and Ecosystems West (2013) proposed a method for assessing changes in the distribution of HMP annual plants using macroplots. By assessing changes in the frequency of occurrence within macroplots under repeated sampling, it can be determined whether the population is expanding into newly opened areas (either by seed dispersal or germinating from a dormant seed bank), or remaining static in its distribution.

SECTION 2

Design and Selection

Macroplots will consist of 9 standard 100-foot by 100-foot sampling grids, arranged in a 3 by 3 square, centered on a grid that is being sampled for HMP density. Once established, the macroplots will be sampled in subsequent years to assess long-term changes in frequency. The presence or absence of each of the three HMP annual plants will be determined in each of the grids.

Macroplots will be selected and placed based on the following set of rules.

1. Macroplot center points will be randomly selected from the grids selected for quantitative density sampling for HMPs.
2. Initial frequencies for all possible macroplots within a Unit will be estimated based on the results of the meandering transects. This will provide the baseline (Year 0) estimate of frequency.
3. Macroplots will be selected from those potential locations which have a baseline frequency of 5 or less. As discussed in more detail in the following paragraphs, the working hypothesis is that the distribution of the HMP annual plants will increase after treatment. Frequencies within a macroplot can range between 0 and 9. Therefore, potential macroplots with a frequency of occurrence of greater than 5 occupied grids will be less sensitive to an increase in frequency.
4. Macroplots may not overlap.
5. For macroplots that are established along boundaries (either Unit or treatment), the position/shape of the macroplot may be adjusted to ensure that it remains within the subject area. In some cases, a two grid by 4 grid + 1 grid array may be used.
6. Macroplot size will be maintained at 9 grids, to the extent possible. If necessary, an occasional macroplot of 8 or 10 grids may be established. However, efforts will be made to minimize this occurrence.

7. There will be no stratification by treatment type (i.e., mastication or burning) within a Unit when selecting macroplots. However, once selected, macroplots will be assigned a treatment type based on the dominant treatment within the macroplot. Efforts will be made to maintain a macroplot within a single treatment type to the extent possible.
8. Treatment type effects on the magnitude of change between years will be evaluated using all data from Units of the same treatment age during a given year.
9. There will be no stratification by HMP annual species. Any effort to constrain selection of macroplots to ensure that specific locations are sampled will remove the random nature of the selection.

SECTION 3

Analytical Approach

The objective of the statistical analysis is to detect changes in the frequency of occurrence of HMP annual plants as a result of treatment. The same macroplot locations will be visited during each sampling event (Baseline, Year 1, Year 3, and Year 5). Since these macroplots will be permanent, this design results in a repeated-measures analysis, the simplest of which is the paired t-test. This analysis examines the difference between the frequency at time 1 relative to time 0. Using permanent plots with repeated sampling controls for differences between individual plots in terms of their starting conditions, and allows changes in frequency to be detected more readily as compared to macroplots that are randomly allocated each sampling event.

Separate analyses will be conducted for each of the three HMP annual species.

SECTION 4

Estimation of Sample Size

A key question to be addressed is to determine the number of macroplots per Unit that need to be sampled in order to detect a specified difference in frequency between sampling events. To accomplish this task it is necessary to have an estimate of the average frequency and variance within macroplots, as well as estimates of the likely magnitude of change in frequency.

To assess the behavior of the sampling effort on estimates of frequency the data from Units 10 and 28 were analyzed in detail. These Units have large numbers of occupied grids, and therefore large numbers of quantitatively sampled grids. Unit 9, which had few occupied grids was also included in the analysis to provide a counter-point in the assessment.

4.1. Mean Frequency

Maps of these Units that showed both the quantitatively sampled grids and the location of "occupied" grids based on the meandering transects were prepared. A 3 by 3 macroplot was then constructed around each of the quantitatively sampled grids within each Unit and the frequency of occurrence of HMP annual plants estimated based on the results of the meandering transects. The results of this analysis are summarized in Table 1. The distribution of the frequencies in Units 10 and 28 are shown in Figure 1 and Figure 2. The primary observation from these figures is that the frequency distributions of the macroplots include all possible frequency values from 1 to 9, and that the distributions are somewhat unimodal. In contrast, the histogram for Unit 9 only contains frequencies of 1 to 3 (Figure 3). This difference is likely due to the limited number of occupied grids in Unit 9.

Table 1
Summary of Macroplot Frequencies in Selected Units

Unit	# Occupied Grids	# Sampled Grids	Average Frequency per macroplot	Coefficient of Variation
9	10	10	2.4	29%
10	275	55	4.95	43%
28	141	37	6.03	29%

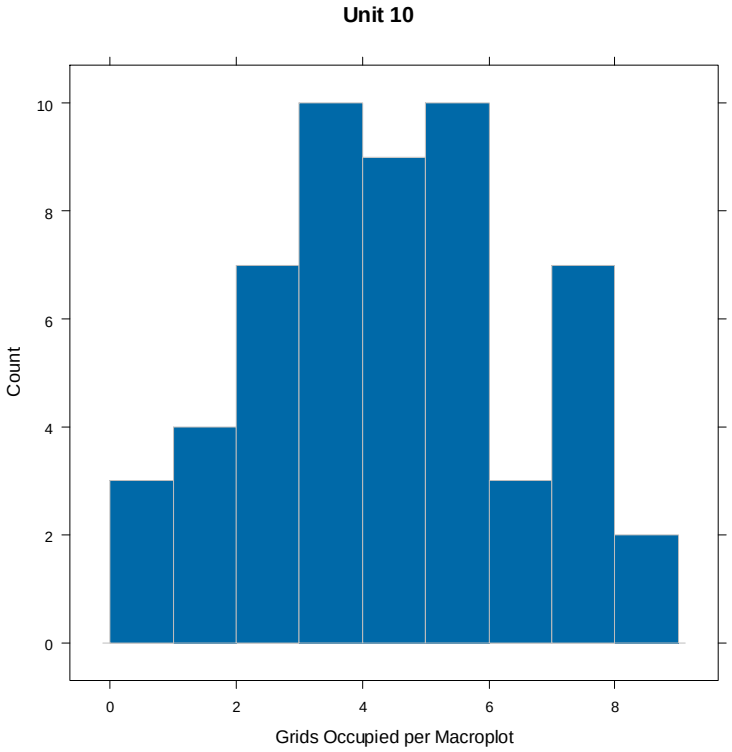

Figure 1 **Distribution of macroplot frequencies in Unit 10.**

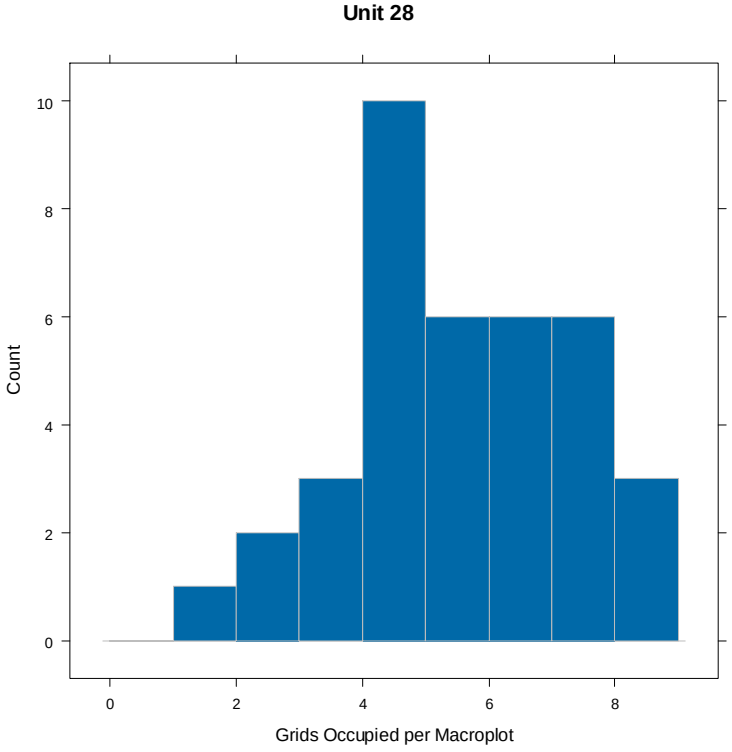

Figure 2 **Distribution of macroplot frequencies in Unit 28.**

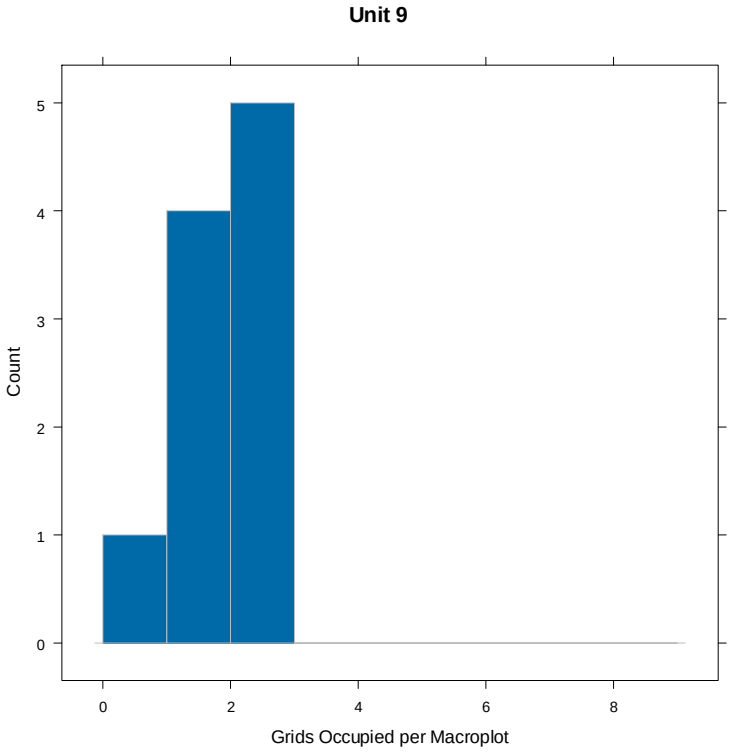

Figure 3 Distribution of macroplot frequencies in Unit 9.

To estimate the number of macroplots required to accurately estimate the mean frequency within each Unit, a boot strap analysis was performed using multiple sample sizes (e.g., 3, 5, 7, 9, and 11). For each sample size, the macroplot frequency data from each Unit was sampled repeatedly, and the mean, variance, and confidence interval for each sample was estimated. The results of the estimate of the mean are shown in Figure 4 and Figure 5 for Units 10 and 28, respectively. From these plots, it can be seen that the mean frequency is generally correctly estimated even with relatively small sample sizes, but that the variability in the estimated mean is greater with smaller sample sizes. It was noted that the confidence intervals generally decreased in size with increasing sample size, as expected. These results indicate that the number of macroplots selected should be as large as possible given the number of available locations within each Unit.

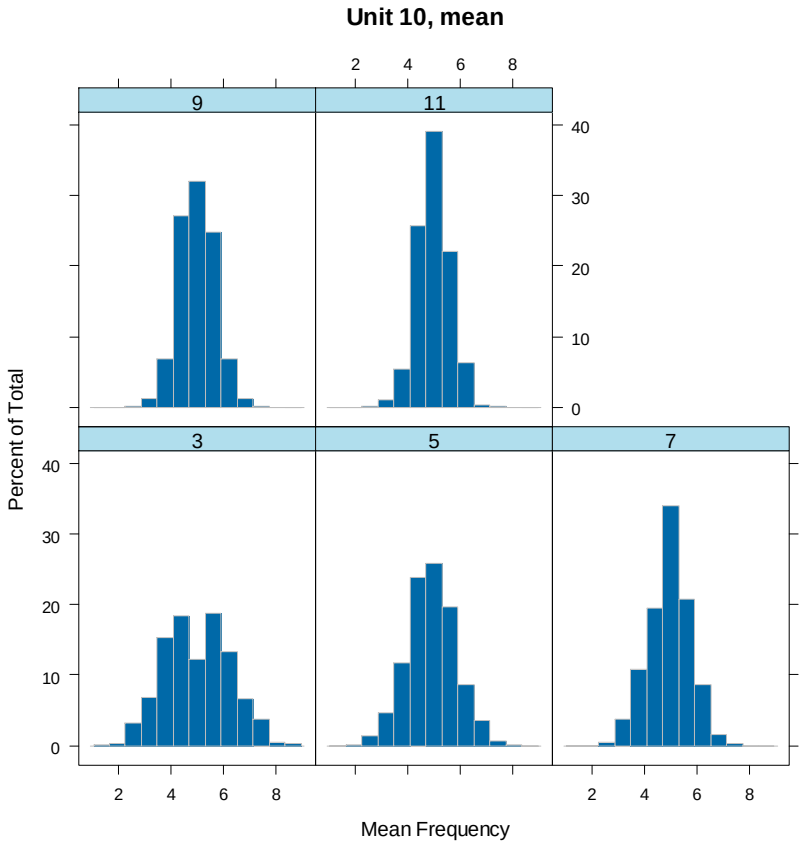

Figure 4 **Effect of sample size on the estimated mean frequency of occurrence in Unit 10.**

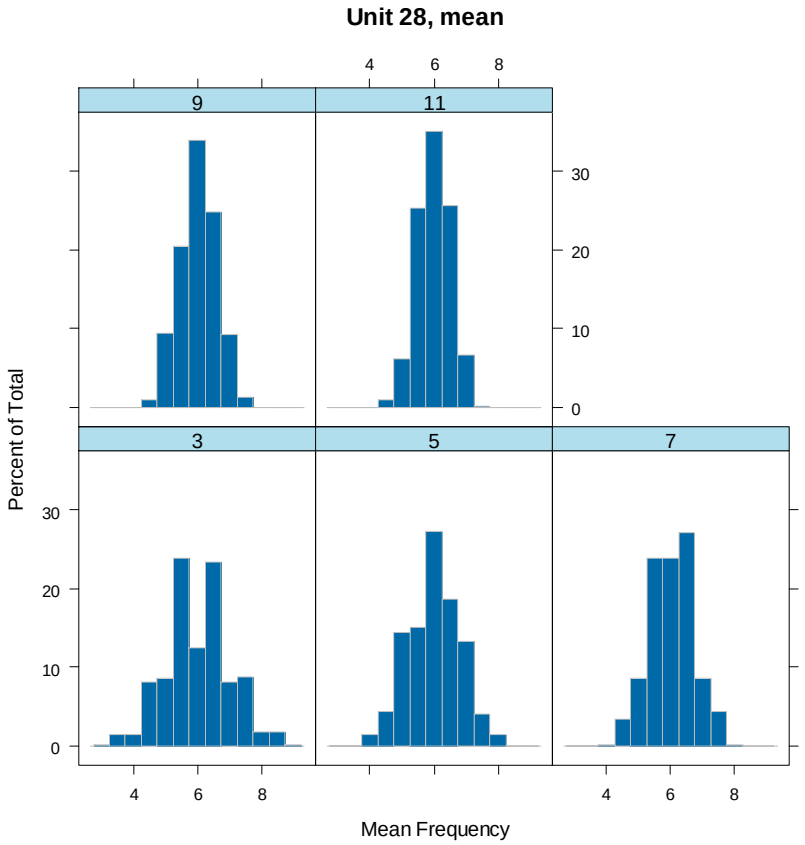

Figure 5 **Effect of sample size on the estimated mean frequency of occurrence in Unit 28.**

4.2. Evaluation of Change in Frequency

The objective of the macroplot study is to detect changes in frequency between sampling events. Therefore, estimation of the population mean frequency is not as important, rather it is the average change in frequency in a macroplot that is of primary importance. Currently, there are no data available on the change in frequency of occurrence in a macroplot after treatment. Therefore, two artificial distributions of the change in frequency were created and those distributions were used to estimate the power to detect change based on different sample sizes. An average change in frequency of 1 grid was assumed and the individual changes were allowed to vary between -1 (i.e., a decrease in frequency of 1 grid) to +3 (an increase in frequency of 3 grids). A uniform and a triangular distribution were selected as base cases (Table 2). For each distribution, 1000 samples, with replacement, consisting of between 3 and 11 macroplots per sample were obtained. Power was estimated as the number of times out of the 1000 samples that the null hypothesis of no change in frequency was correctly rejected at $\alpha = 0.1$ (i.e., the 90% confidence interval did not overlap 0).

Table 2
Frequency Distributions for Magnitude of Change Simulated in Power Analysis

Distribution type	Mean change	Change				
		-1	0	+1	+2	+3
Uniform	+1	1	1	1	1	1
Triangular	+1	1	2	3	2	1

The results of these simulations are presented in Figure 6 (uniform distribution) and Figure 7 (triangular distribution). The power to detect a difference is greater for the triangular distribution than for the uniform distribution. For example, at a sample size of 7, the power of the uniform distribution is approximately 0.45, whereas for the triangular distribution the power is approximately 0.6. Clearly, the stronger the central tendency of the distribution of change, the greater the power, and the smaller the sample size that can be used.

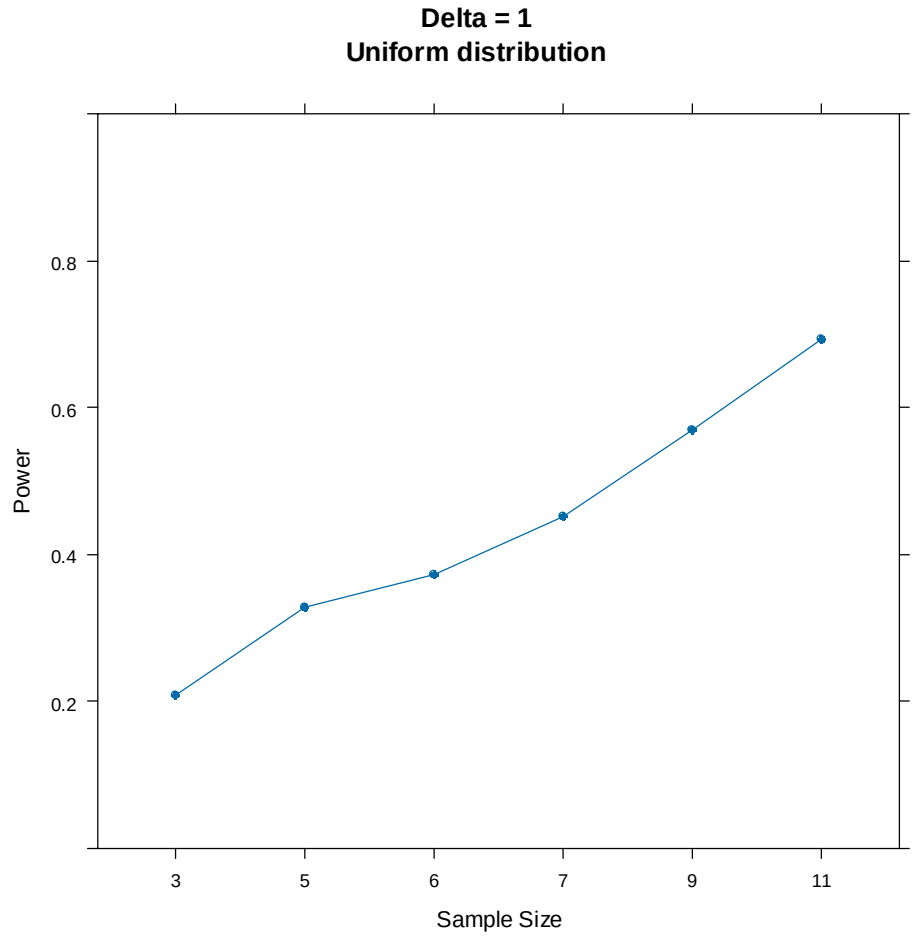

Figure 6 **Power for samples sizes between 3 and 11 based on the uniform distribution with a true mean change of +1.**

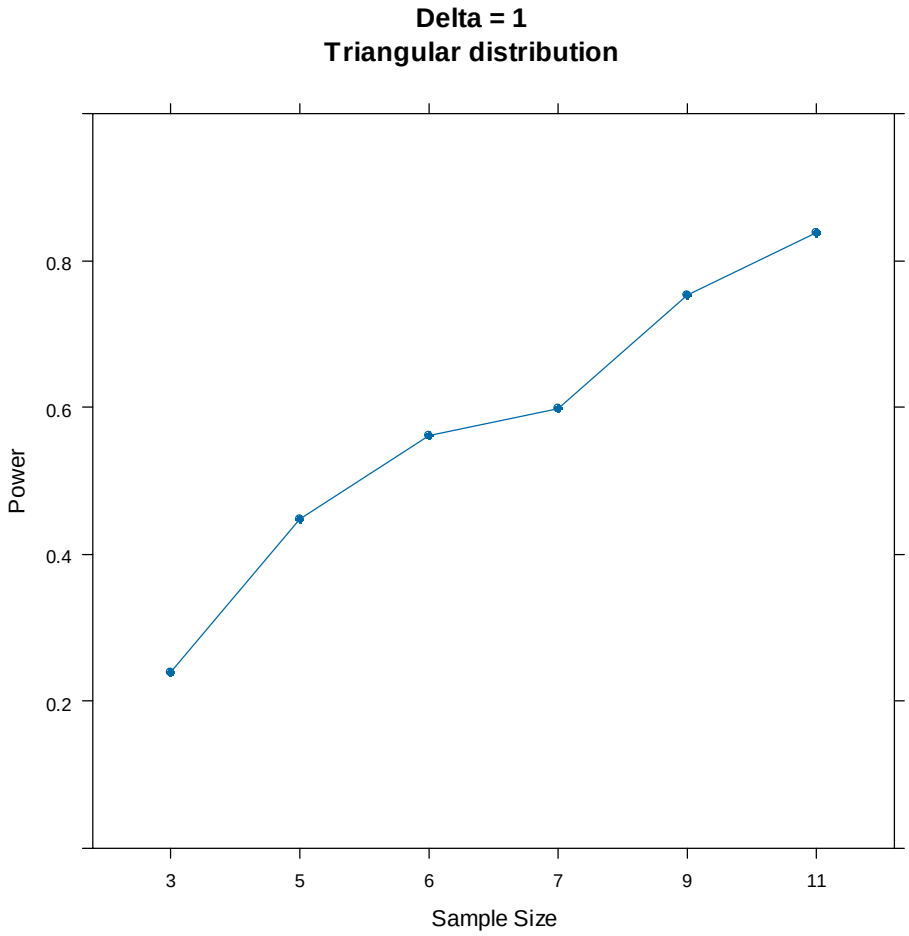

Figure 7 **Power for samples sizes between 3 and 11 based on the triangular distribution with a true mean change of +1.**

SECTION 5

Selected Macroplots

The total number of macroplots that are to be sampled is based on the statistical considerations described above, and the number of occupied grids within each Unit. The macroplot sampling in 2016 was based on the initial assumption that 10% of the quantitatively sampled density grids in each Unit would be sampled as macroplots. Macroplots were randomly allocated to each Unit to be sampled in 2016 using the rules defined in SECTION 2.

A total of 34 macroplot locations were selected for sampling in 2016 (Table 3). This number was based on a minimum sample size of 10% of the quantitative HMP grids, plus three additional macroplots in

Units with larger numbers of grids. The randomly selected macroplots were mapped, and then reviewed for suitability. Four alternate macroplot locations were also identified in Units 28 and WGBA. Placement of randomly selected macroplot locations using the rules listed above, suggests that there is a limit to the number of macroplots that can be sampled in a Unit. Considerations such as the maximum allowed frequency in a baseline macroplot, as well as topographic features and Unit shape may require selection of alternative locations.

Table 3 identifies the Units to be sampled in 2016 and the recommended number of macroplots. Alternative and additional grids are also identified. Maps showing proposed macroplot locations for each Unit are provided in Appendix A. Some of the selected grids may need to be altered based on field conditions.

Table 3
Selected Macroplot Grids

Unit	Number of Macroplots	Selected Macroplot Centers
Unit 28	5	B3I9D1, B3D5D7, B3H8I6, B3I9G9, B3E6H6 (alt), B3E6I8 (alt), B3F6E0 (alt)
Unit 10	7 (+1)	B2B2G6, B2B7F2, B2B5H1, B2B7J7, B2B2C6, B2B2D1, B2B6J0, B2B3A4 (additional grid)
Unit 9	2	A3H6B1, A3G6D5
Unit 4	1	A2F8A4
Unit 7	4 (+2)	A2J3E0, A2I4I3, A2I4C1, A2I6B6, A2J4B3 (additional grid), A2I7B1 (additional grid)
Unit 11	1	B3C2B5
Unit 12	5	B2A8F4, B2A8J0, B2C9C0, B2C0C4, B3C1A1
Unit 23N	1	B3A1C2
MOUT	0	Unit is not amenable to macroplot sampling; only 1 grid wide.
WGBA	5	B1C9I7, B2I3G9, B2J4B4, B2I4J9, B2J3C7, B2J3B0 (alt)
Unit 1 East	0	No HMP annuals present
Unit 6	0	No HMP annuals present

The results of the macroplot sampling in 2016 will be used to refine the estimates of the number of macroplots to be selected in each Unit to be surveyed in the future. The data from the 2016 sampling will

be used to estimate the sampling distribution of the differences between the baseline and post-treatment macroplots. Once the sampling distribution of the differences is characterized it will be possible to provide better estimates of the required number of macroplots.

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APPENDIX A

Proposed Macroplot Locations

Fort Ord
Unit 07
Macroplot Locations
2016

Legend

- Additional Macroplots
- Macroplots
- Unit Boundary
- Road

Aerial image date 2012

N

0 200 400 600 800

Feet

Fort Ord
Unit 09
Macroplot Locations
2016

Legend

- Macroplots
- Unit Boundary
- Road

Aerial image date 2012

N

0 100 200 300 400 500

Feet

Fort Ord
Unit 10
Macroplot Locations
2016

Legend

- Macroplots
- Unit Boundary
- Road

Aerial image date 2012

B2B2G6
B2B2D1
B2B2C6
B2B3A4
B2B5H1
B2B6J0
B2B7J7
B2B7F2

WATKINS GATE RD
EVOLUTION RD
AUSTIN RD
NGE 23 RD
WARTHOG RD
AUSTIN RD
NOWHERE RD
TORPEDO RD
JOLLY RANCHER RD

N

0 200 400 600 800

Feet

Fort Ord
Unit 11
Macroplot Locations
2016

Legend

- Macroplots
- Unit Boundary
- Road

Aerial image date 2012

N

0 200 400 600 800

Feet

Fort Ord
Unit 12
Macroplot Locations
2016

Legend

- Macroplots
- Unit Boundary
- Road

Aerial image date 2012

WATKINS GATE RD
EVOLUTION RD
HAWKEYE RD
ORION RD
NOWHERE RD
EVOLUTION RD
NOWHERE RD

B2C9C0
B2C0C4
B3C1A1
B2A8J0
B2A8F4

N

0 200 400 600 800
Feet

Fort Ord
Unit 23N
Macroplot Locations
2016

Legend

- Macroplots
- Unit Boundary
- Road

Aerial image date 2012

ORION RD

NOWHERE RD

NOWHERE RD

B3A1C2

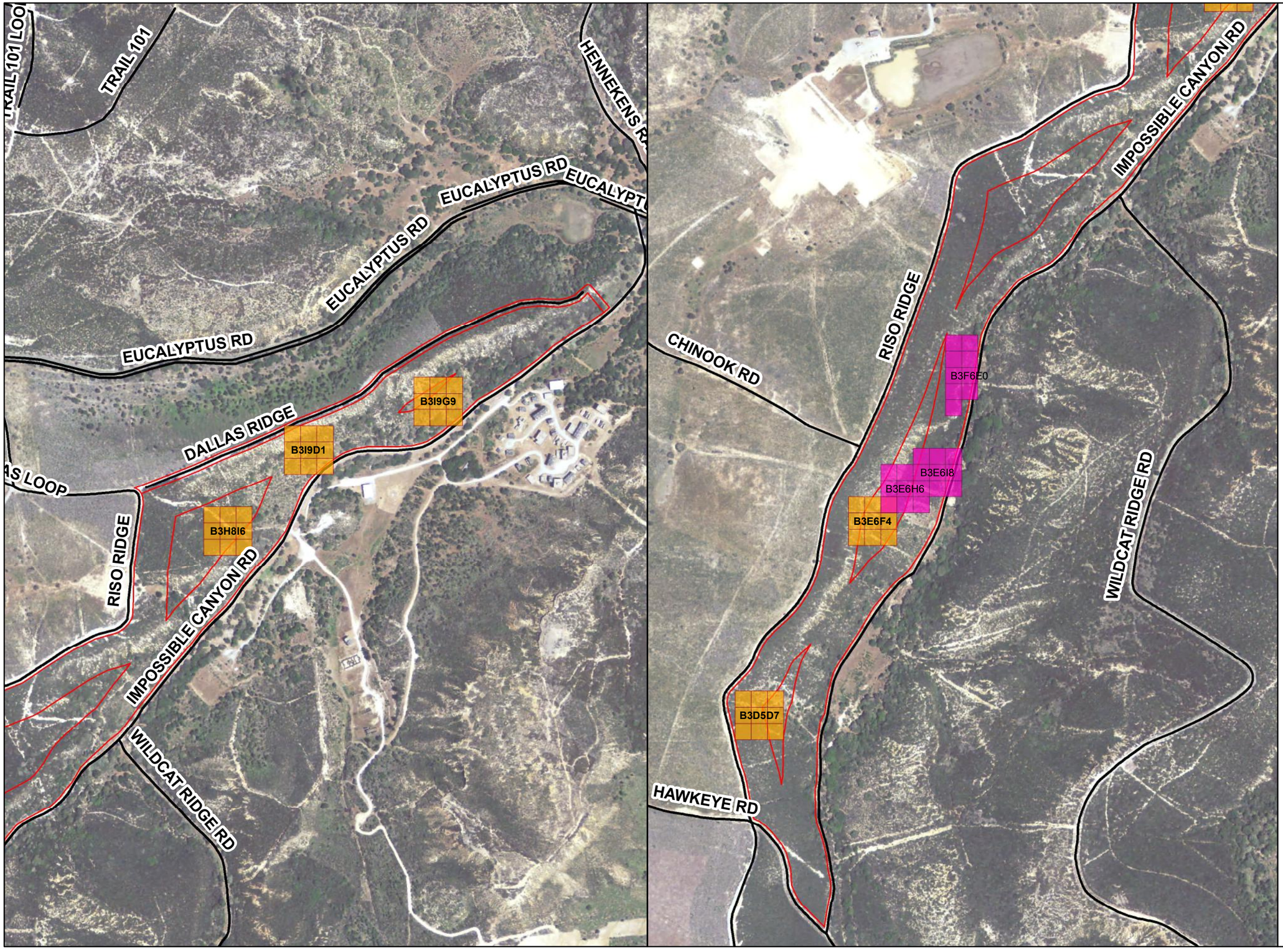
N

0 100 200 300 400

Feet

NORTHERN PORTION

SOUTHERN PORTION



Fort Ord
Unit 28
Macroplot Locations
2016

Legend

- Alt Macroplots
- Macroplots
- Unit Boundary

~~Aerial image~~ Page date 2012

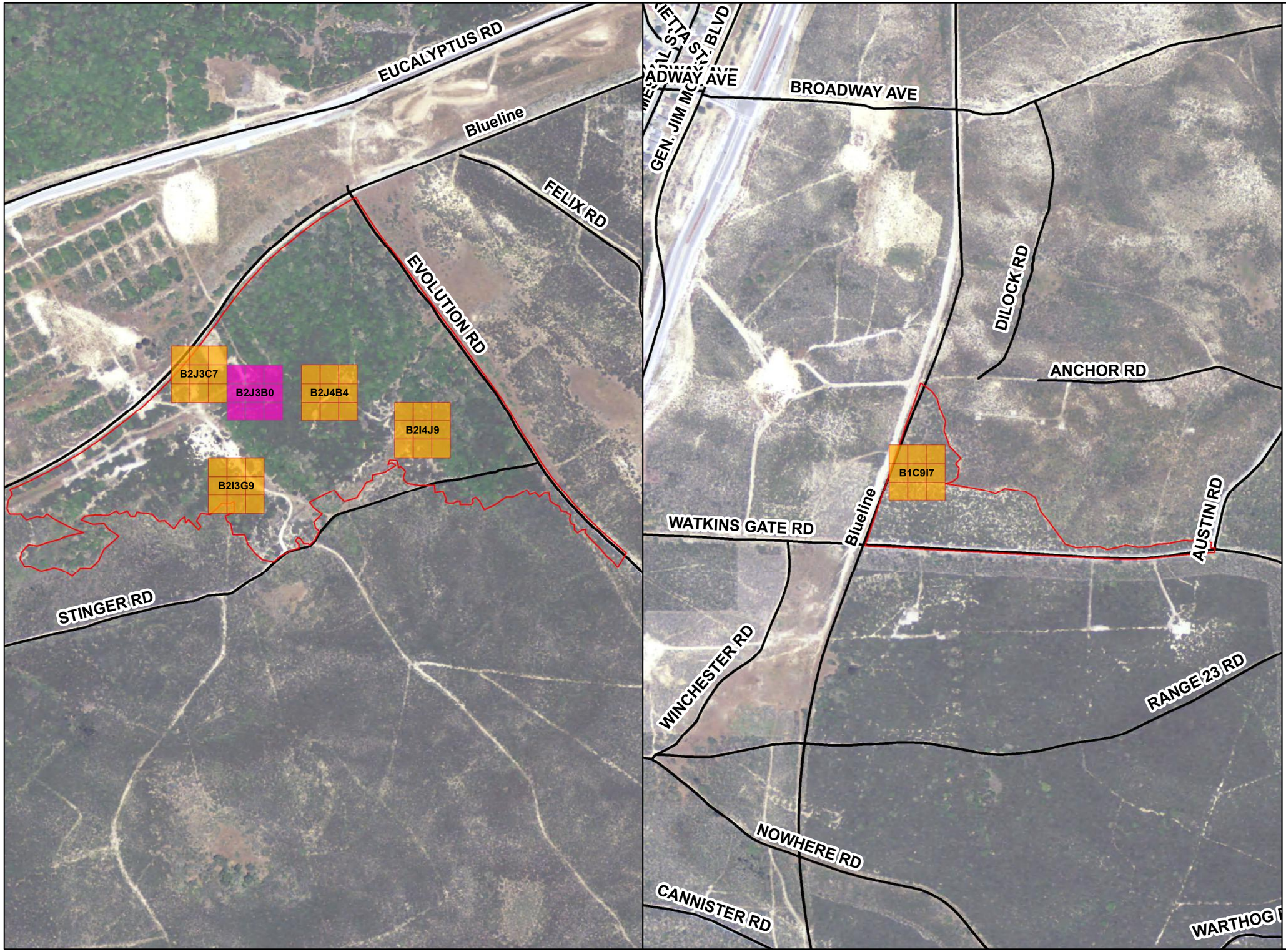
N

0 200 400 600 800 1,000

Feet

NORTHERN PORTION

SOUTHERN PORTION



Fort Ord
Watkins Gate Burn Area
(Unburned Portion)
Macroplot Locations
2016

Legend

- Alt Macroplots
- Macroplots
- Unit Boundary
- Road

Aerial image date 2012

N

0 200 400 600 800 1,000

Feet