White-tailed Prairie Dog Monitoring for the Pinedale Anticline Project Area 2010 Pilot Year

Final Report

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INTRODUCTION

In 2008, the BLM issued its Record of Decision for the Supplemental Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration and Development Project (BLM 2008), which included specific requirements for monitoring of wildlife populations which may be impacted by the development, including impacts to the white-tailed prairie dog (*Cynomys leucurus*). The specific monitoring components outlined by the Pinedale Anticline Project Office (PAPO) in the Wildlife Monitoring and Mitigation Matrix (Appendix B in 2008 BLM ROD) that would trigger mitigation for sensitive species (i.e., white-tailed prairie dog and pygmy rabbit [*Brachylagus idahoensis*]) included documentation of 3 consecutive years of decline in presence/absence, or an average of 15% decline in numbers of individuals each year over 3 years. The original methodology proposed for monitoring prairie dogs was to 1) identify white-tailed prairie dog towns on public lands within the Pinedale Anticline Project Area (PAPA) and Reference Areas, 2) monitor towns for white-tailed prairie dog presence/absence, and 3) monitor trends in relative abundance of prairie dogs.

Following a review of the Wildlife Monitoring and Mitigation Matrix by the University of Wyoming COOP Unit, the white-tailed prairie dog monitoring plan was modified to incorporate suggestions provided by the COOP. The objectives of the final study design for 2010 were to 1) implement a long-term monitoring protocol to assess changes in occupancy rates (MacKenzie et al. 2006) and active burrow density of white-tailed prairie dogs using the methods described in Andelt et al. (2009) and Biggins et al. (1993); and 2) conduct power analyses to evaluate the ability of the study design to detect significant changes in the parameters of interest (occupancy and abundance) from year to year. The following report details the final study design and results of the first year of monitoring for occupancy of white-tailed prairie dogs, along with recommendations for future work regarding white-tailed prairie dog monitoring on the PAPA and associated Reference Areas.

METHODS

Sampling Design

A grid of 500 m x 500 m plots comprised the sampling frame within the PAPA and each Reference Area, with a total of 3,113 plots in the sample frame for the PAPA and 634 in all three Reference Areas combined. From this grid, a sample of 99 plots within the PAPA and 30 plots within the Reference Areas was selected with a generalized random tessellation stratified (GRTS) sample using the R package ‘spsurvey’ (Figure 1; Kincaid and Olsen 2009). There was no stratification of the sample based on environmental variables (e.g., habitat type, elevation) during the 2010 pilot season; however, samples were stratified to the PAPA and Reference Areas.

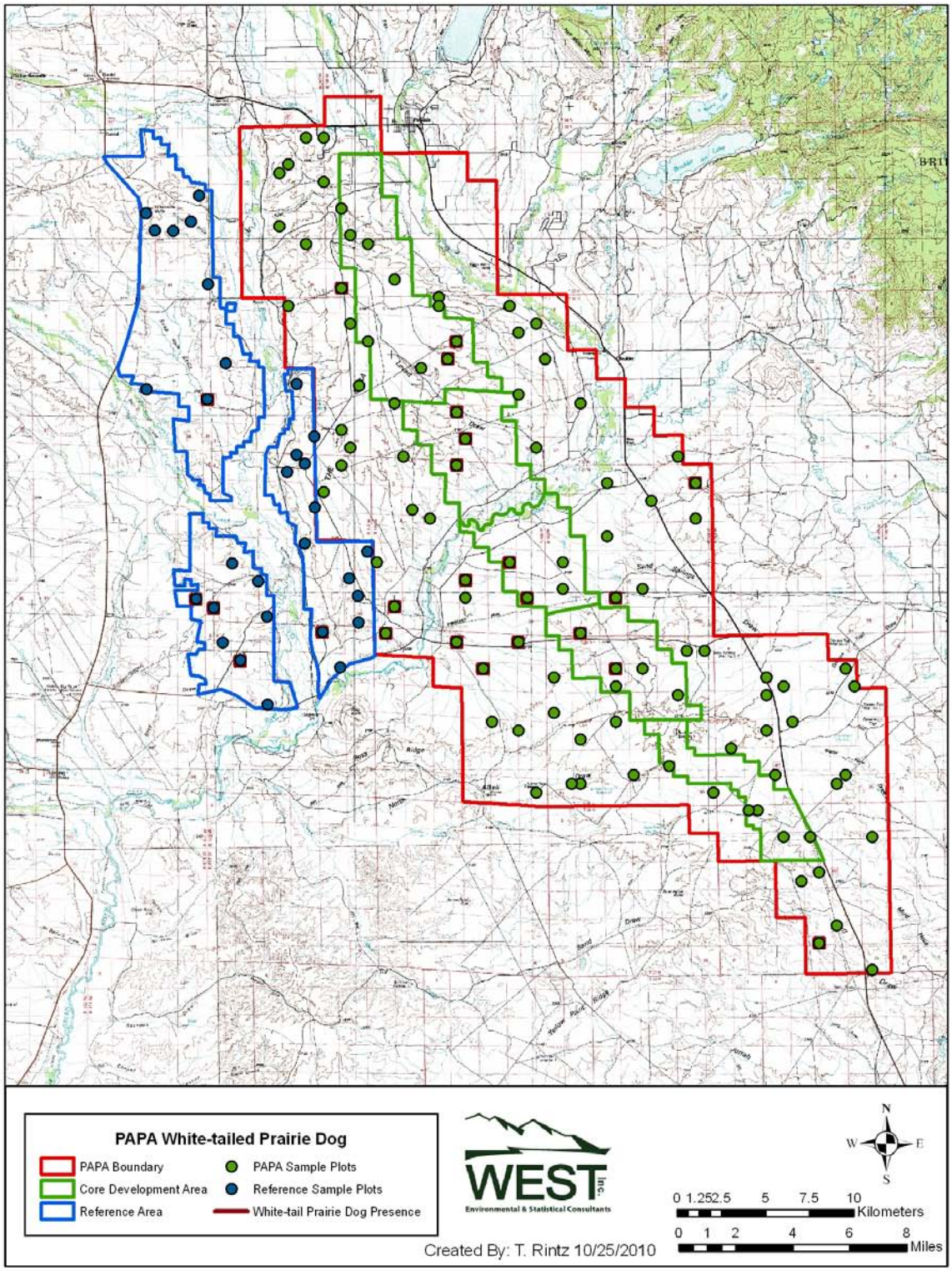

Figure 1. Sample plots for white-tailed prairie dog monitoring conducted in 2010 on the PAPA and Reference areas.

Field Methods

Occupancy Survey: Each sample plot was visited by two different qualified surveyors, with surveys separated by 3-5 days. Surveyors did not know if prairie dogs had been previously documented on the plot. During each visit to a sample plot, the surveyor walked the perimeter of the plot to document the presence or absence of white-tailed prairie dogs (Andelt et al. 2009). At each corner of each plot, the surveyor searched for prairie dogs for 5 minutes prior to proceeding to the next corner. Surveyors recorded the total number of prairie dog groups (i.e., one or more prairie dogs) and the total number of individual prairie dogs observed from each corner. In addition, surveyors documented if prairie dogs were observed inside the plot while walking the plot perimeter from corner to corner. The time spent from the beginning of the perimeter walk to the end was recorded along with temperature, precipitation, and Julian date.

Active Burrow Survey: At each plot where presence was recorded during the occupancy surveys, an additional visit was made to survey for active prairie dog burrows (index to relative abundance). Eight strip transects, spaced 60 m apart and oriented in a north-south direction, were surveyed in each of the occupied sample plots. Strip transects were 3 meters wide and extended the length of the sample plot (500 m). Burrows were defined as holes greater than 7 cm in diameter and deep enough that the end could not be seen. Burrows were identified as active or inactive based on the presence or absence of fresh scat within 0.5 m of the burrow entrance. All burrows identified within the strip transects were counted, with counts maintained for total number of burrows and number of active burrows. Burrows on the edge of transects were counted if more than half of the burrow entrance was located within the transect (Biggins et al. 1993).

Database Management

A Microsoft Access database was designed to enter and maintain the survey data. Quality assurance and quality control (QAQC) was conducted on all data collected and entered into the database. The QAQC procedures were documented along with all changes to the database. The study project manager reviewed data forms to insure completeness and legibility, and corrected problems which were detected.

Data Analysis

Patch Occupancy: Occupancy rates (ψ) and associated variances were calculated for each study area using the methods of MacKenzie et al. (2006). MacKenzie et al. (2002) introduced a method of estimating site occupancy, or the proportion of sites occupied by a species, when detection probabilities (p) were less than one. MacKenzie et al. (2002) described how site occupancy could be estimated given that 1) multiple surveys were conducted at a set of sites; 2) closure was assumed during the study period (i.e., sites stay either occupied or unoccupied by the species of interest across all surveys); 3) the species were never falsely detected; and 4) detection of the species at a site was independent of detection at all other sites.

Covariates were included in the patch occupancy model likelihood using the logistic model to increase precision and reduce bias. Covariates allow for the occupancy rate to be a function of site-specific characteristics, and allow the probability of detection to vary according to site- or survey-specific characteristics. One site-specific covariate was entered into the occupancy model, to generate estimates of occupancy by strata (i.e., the PAPA and the Reference Area). Three detection covariates and their quadratic terms were assessed for incorporation into the detection model: temperature, precipitation, and Julian date. Fifteen models were considered and AIC (Burnham and Anderson 2002) was used to rank

the models. Five-hundred bootstrap re-samples of the plots were used to estimate the confidence limits of ψ (Manly 2006).

Active Burrow Density: Active burrow density was calculated for each sample plot by dividing the number of active burrows observed in the plot by the area searched (3 m wide x 500 m long x 8 transects), with the variance of the estimate calculated across the sampled plots of the study area.

Recommendation for Sample Size

Estimating Occupancy with Precision: The number of sample plots and the number of surveys per plot needed to estimate annual occupancy rates with sufficient precision to detect year to year changes were evaluated with the methods of McKenzie and Royle (2005). The number of surveys was based on the observed estimate of occupancy and probability of detection resulting from the 2010 surveys. The number of sample plots needed was evaluated assuming occupancy has a standard error that is 20% of the estimate of occupancy rates in any given year.

Power to Detect Trends in Occupancy: A power analysis was designed and conducted to determine the appropriate number of sample plots to survey for detection of a significant trend in occupancy. The PAPA mitigation matrix states that 3 consecutive years of decline in occupancy (presence/absence) or an average 15% decline in numbers of individuals may trigger requirements for mitigation (Appendix B in 2008 BLM ROD). We assessed the 2010 data for its ability to detect a significant trend in occupancy rates over the long term since the criteria of 3 consecutive years of decline allows for the possibility of the long-term decline of a population with naturally fluctuating occupancy rates while never meeting the 3 consecutive-year threshold. For example, the long term trend in occupancy could be consistently downward, with slight increases every other year or two that could preclude ever seeing a significant decline for three consecutive years. Therefore, we conducted a power analysis to determine the sample size needed to detect a significant trend in occupancy over the long term. The 2010 data was used to estimate the number of samples needed to obtain adequate power to detect decreases of 15% and 25% in occupancy rates over 3 and 5 years, with 80% confidence. Using the observed estimates of occupancy and detectability from the PAPA in 2010, and 2 surveys conducted per plot, we generated simulations of the data while varying the sampling effort. Using the observed estimates of 0.26 for occupancy and 0.61 for detectability as the binomial proportions in two separate binomial distributions, we simulated 500 iterations of occupancy and detectability over the 3 to 5 survey years with declining trends of 15% and 25% and sample sizes from 50 to 500. Trend in the simulated occupancy rates was calculated for each iteration and power was estimated as the proportion of iterations for which the null hypothesis of no trend was rejected at the 0.20 level of significance. Setting alpha equal to 0.20 optimizes gains in power with minimal increases in Type I error (Field et al. 2005).

Power to Detect Trends in Burrow Density: A power analysis was designed to determine the appropriate number of sample plots to survey for detection of a significant trend in burrow density. The PAPA mitigation matrix states that an average 15% decline in number of individuals each year over 3 years may trigger requirements for mitigation (Appendix B in 2008 BLM ROD). Active burrow density was considered the surrogate for number of individuals for these calculations, as converting from active burrow density to number of individuals imparts more uncertainty in the final estimates, leading to

less power to detect significant differences. Again, we assessed the 2010 data for its ability to detect a significant trend in active burrow density over the long term. The 2010 data was used to estimate the number of sample surveys needed to obtain adequate power to detect decreases of 15% and 25% in active burrow density over 3 and 5 years, with 80% confidence. With the observed estimate of active burrow density, we generated simulations of the data while varying the sampling effort. Using the observed estimates of 102.70 for mean active burrow density and 124,833 for variance, we simulated 500 iterations of density from a normal distribution over the 3 to 5 survey years with declining trends of 15% and 25% and sample sizes from 50 to 500. Trend in the simulated density was calculated for each iteration and power was estimated as the proportion of iterations for which the null hypothesis of no trend was rejected at the 0.20 level of significance.

RESULTS

Occupancy Rates

When ψ and p are constant across sites and p is constant across surveys, the patch occupancy model likelihood for all sites can be written as (MacKenzie et al. 2002)

$$L(\psi, p) = \left[\psi^{n.} \prod_{t=1}^{T} p_t^{n_t} (1-p_t)^{n.-n_t} \right] \times \left[\psi \prod_{t=1}^{T} (1-p_t) + (1-\psi) \right]^{N-n.},$$

where N is the total number of surveyed sites, T the number of sampling occasions (surveys), n_t the number of sites where the species was detected at time t, and n is the total number of sites where the species was detected at least once. The best model for occupancy was identified by the lowest AIC score (Table 1). The final model included the one site-specific covariate of strata (indicator for PAPA) and temperature and Julian date for detection covariates. Covariates were included in the patch occupancy likelihood with the following logistic model for occupancy:

$$\psi = -1.5049 + 0.4443(I_{PAPA}),$$

and for detectability:

$$p = -4.607624 - 0.1062(\text{temperature}) + 0.0650(\text{Julian date})$$

where I_{PAPA} is an indicator variable equal to 1 for plot in the PAPA and 0 for plots in the Reference Areas. Occupancy rates estimated by this model were 0.26 (95% CI: 0.18 - 0.39) in the PAPA and 0.18 (95% CI: 0.07 - 0.32) in the Reference areas. Average probability of detection was estimated to be 0.61 for all plots (PAPA and Reference). The modeled relationships between probability of detection of white-tailed prairie dogs and temperature can be seen in Figure 2 and Julian date in Figure 3.

Table 1. Patch occupancy model results with stratum covariate and various combinations of detectability covariates (t=temperature, p=precipitation, and j=Julian date). Final model was selected by the lowest AIC score. Model predicts occupancy estimates for PAPA ($\hat{\psi}_{PAPA}$), reference area ($\hat{\psi}_{REF}$), and the average probability of detection across all sites ($\bar{\hat{p}}$).

Model	AIC	Δ_{AIC}	$\hat{\psi}_{PAPA}$	$\hat{\psi}_{REF}$	$\bar{\hat{p}}$
psi(stratum)p(t + j)	182.3	0.00	0.2572	0.1817	0.61
psi(stratum)p(t + t^2 + p + j)	183.0	0.75	0.2583	0.1767	0.62
psi(stratum)p(t)	183.2	0.88	0.2533	0.2041	0.57
psi(stratum)p(t + t^2 + j)	183.3	1.01	0.2550	0.1789	0.62
psi(stratum)p(t + t^2 + p + j + j^2)	183.6	1.28	0.2466	0.1729	0.66
psi(stratum)p(.)	183.9	1.64	0.2244	0.1851	0.68
psi(stratum)p(j)	184.5	2.20	0.2272	0.1742	0.71
psi(stratum)p(t + p)	184.5	2.22	0.2519	0.1997	0.58
psi(stratum)p(t + t^2)	185.1	2.85	0.2508	0.2026	0.58
psi(stratum)p(p + j)	185.5	3.18	0.2282	0.1723	0.71
psi(stratum)p(p)	185.5	3.25	0.2233	0.1828	0.69
psi(stratum)p(beta-mixture)	185.9	3.64	0.7125	0.5878	0.61
psi(stratum)p(j + j^2)	186.4	4.16	0.2270	0.1746	0.71
psi(stratum)p(t + t^2 + p)	186.5	4.21	0.2502	0.1988	0.58
psi(stratum)p(p + j + j^2)	187.4	5.16	0.2277	0.1726	0.71

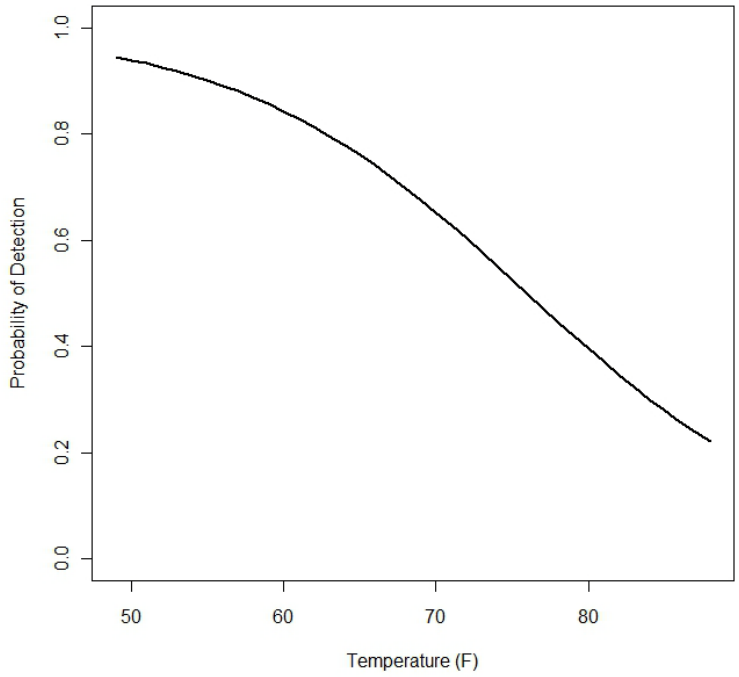

Figure 2. Detection of white-tailed prairie dogs in 2010 as a function of temperature.

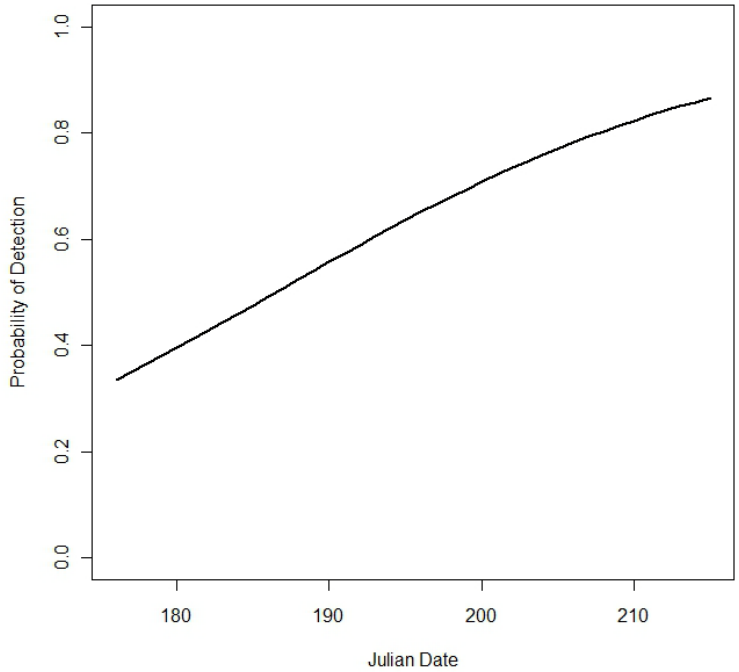

Figure 3. Detection of white-tailed prairie dogs in 2010 as a function of Julian date.

Active Burrow Density

Total burrow density was 276 burrows/km^2 (95% CI: 131 - 421) in the PAPA and 228 burrows/km^2 (95% CI: 0 - 470) in the Reference Areas. Active burrow density (index of relative abundance) was 103 active burrows/km^2 (95% CI: 32 - 173) in the PAPA and 72 active burrows/km^2 (95% CI: 0 - 165) in the Reference Area.

Recommendation for Sample Size

Two surveys (visits) per sample plot would be sufficient to estimate occupancy for this survey design based on the observed estimates of occupancy and detectability in 2010 (McKenzie and Royle 2005).

Estimating Occupancy with Precision: To estimate occupancy with adequate precision to detect significant annual differences between the PAPA and Reference areas, samples sizes of 99 plots in the PAPA and 154 plots in the Reference Areas would be required. A study design with this sampling intensity would result in an estimate of occupancy rates with precision equivalent to 20% of the estimate.

Power to Detect Trends in Occupancy: A sample of 500 plots in both the PAPA and Reference Areas (1,000 total plots) would result in only 50% power to detect a 15% decline over 3 years with 80% confidence (Figure 4). Alternatively, approximately 250 plots in each area would result in 80% power to detect a 25% declining trend over 5 years (Figure 4).

Power to Detect Trends in Burrow Density: Based on the 2010 data, 500 sample plots would be required to have 80% power to detect a 25% decline in active burrow density over a 5 year period with 80% confidence (Figure 5). More than 500 plots would be required to have 80% power to detect a 15% decline in active burrow density over a 3 year period with 80% confidence

Discussion

Given the results of the 2010 pilot study, we recommend that 2 surveys (visits) per sample plot would be sufficient for this survey design and the estimates of occupancy and detectability observed in 2010 (McKenzie and Royle 2005). Based on the 2010 estimates of occupancy and detectability, it is unreasonable to expect power to detect a 15% trend in occupancy over 3 years with a reasonable number of sample plots (Figure 4). There would be sufficient power to detect a larger effect, or to detect a 15% decline over a longer timeframe. A sample size of approximately 250 sample plots in each of the PAPA and Reference Areas (500 total plots) would result in 80% power to detect a declining trend in occupancy of 25% over 5 years with 80% confidence (Figure 4). Proposed sample plots to meet this objective are shown in Figures 6 and 7.

If BLM and WGFD are not interested in detecting significant trends, but would be satisfied with annual occupancy estimates with adequate precision to detect significant annual differences between the PAPA and Reference areas, then the required sample size would be 99 plots in the PAPA and 154 in the Reference Areas. The difference in the number of plots is due to the lower occupancy rates observed in 2010 in the Reference Area compared to the PAPA. This method would allow for comparisons of point

estimates from year to year, but would not allow for the detection of significant trends of 15-25% over the 3-5 year period as described in the previous section.

Due to the relatively low occupancy rates observed in the PAPA and Reference Areas in 2010, and the low number of plots with non-zero burrow densities, the estimates of active burrow density were imprecise (i.e., had very wide confidence intervals). The objective of estimating active burrow density was to assess its utility in monitoring long term trends in the relative abundance of white-tailed prairie dog numbers on the PAPA relative to Reference Areas. Monitoring occupancy rates using the methods of MacKenzie et al. (2006) and Andelt et al. (2009) resulted in estimates of active burrow density that are not sufficient to detect significant changes in density over a 3-5 year period.

It should be noted that the recommended number of plots needed to detect a declining trend in occupancy of 25% over 5-years would not allow for the precision needed to detect a 15% or 25% decline in active burrow density over the same 5-year period (Figures 4 and 5). Based on the 2010 data and the power analysis, 500 or more sample plots would be required to detect a 25% decline in active burrow density over a 3-5 year period (Figure 5); which, based on the 2010 occupancy rates of 18% in the Reference Areas and 26% in the PAPA, would suggest that 2,000 or more plots (an unreasonable number) would be needed in each area to get the 500 occupied plots needed to accurately assess changes in active burrow density. Additionally, there has been debate in the past regarding the utility of estimating active burrow density to calculate actual numbers of white-tailed prairie dogs (Biggins et al. 1993, 2006, Severson and Plumb 1998). Due to the lack of precision associated with calculating active burrow density with a survey protocol designed for occupancy estimation, in addition to the debated utility of using burrow density as an index to population size, we recommend that monitoring of active burrow density as an index of relative abundance of individuals be dropped from future white-tailed prairie dog monitoring, and that occupancy modeling be maintained as the primary method of monitoring the long term status of white-tailed prairie dogs on the PAPA. We further recommend that the primary objective of monitoring be to assess and detect a significant trend in prairie dog occupancy over five or ten years instead of a consecutive decline over a 3-year period.

In summary, beginning in 2011, we would recommend that occupancy surveys be implemented on the 500 plots identified in Figures 6 and 7. This sample size should provide adequate information for monitoring the long term trend in occupancy of white-tailed prairie dogs on the PAPA. Two visits to each plot should be adequate to estimate occupancy. In addition, we would recommend that surveys to determine active burrow densities (i.e., relative abundance of prairie dogs) be dropped from the monitoring program.

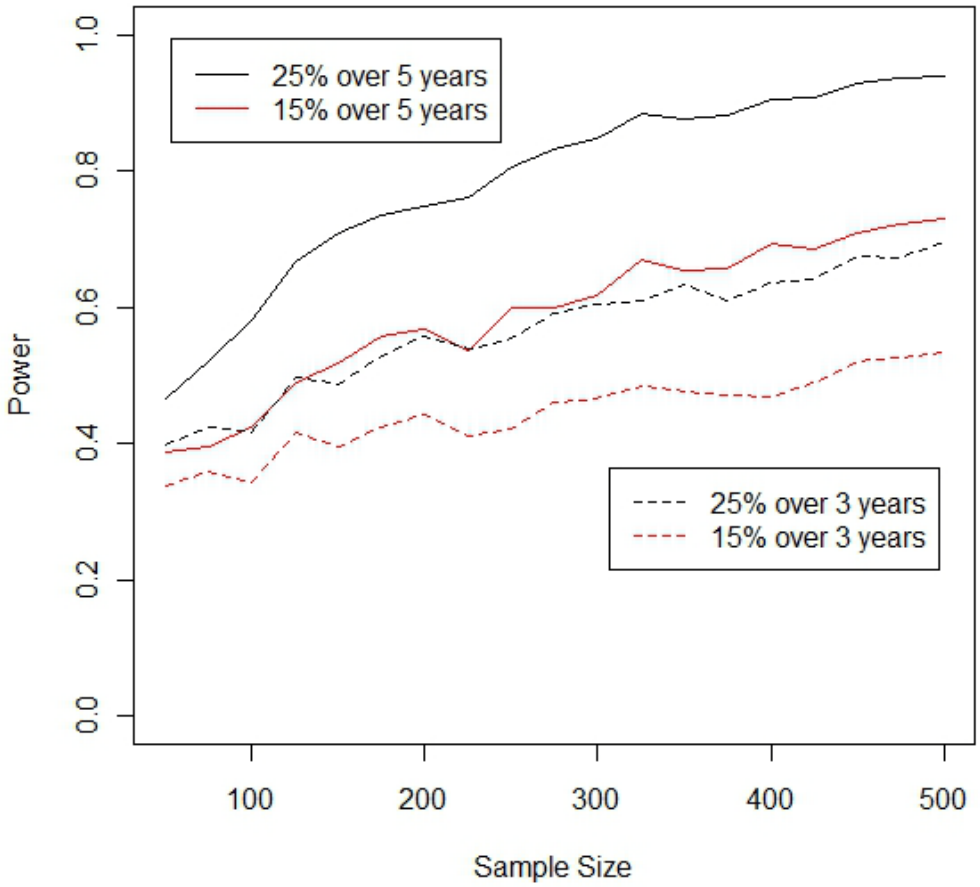

Figure 4. Power to detect trends in occupancy of white-tailed prairie dogs with 80% confidence in the PAPA for sample sizes from 50 to 500.

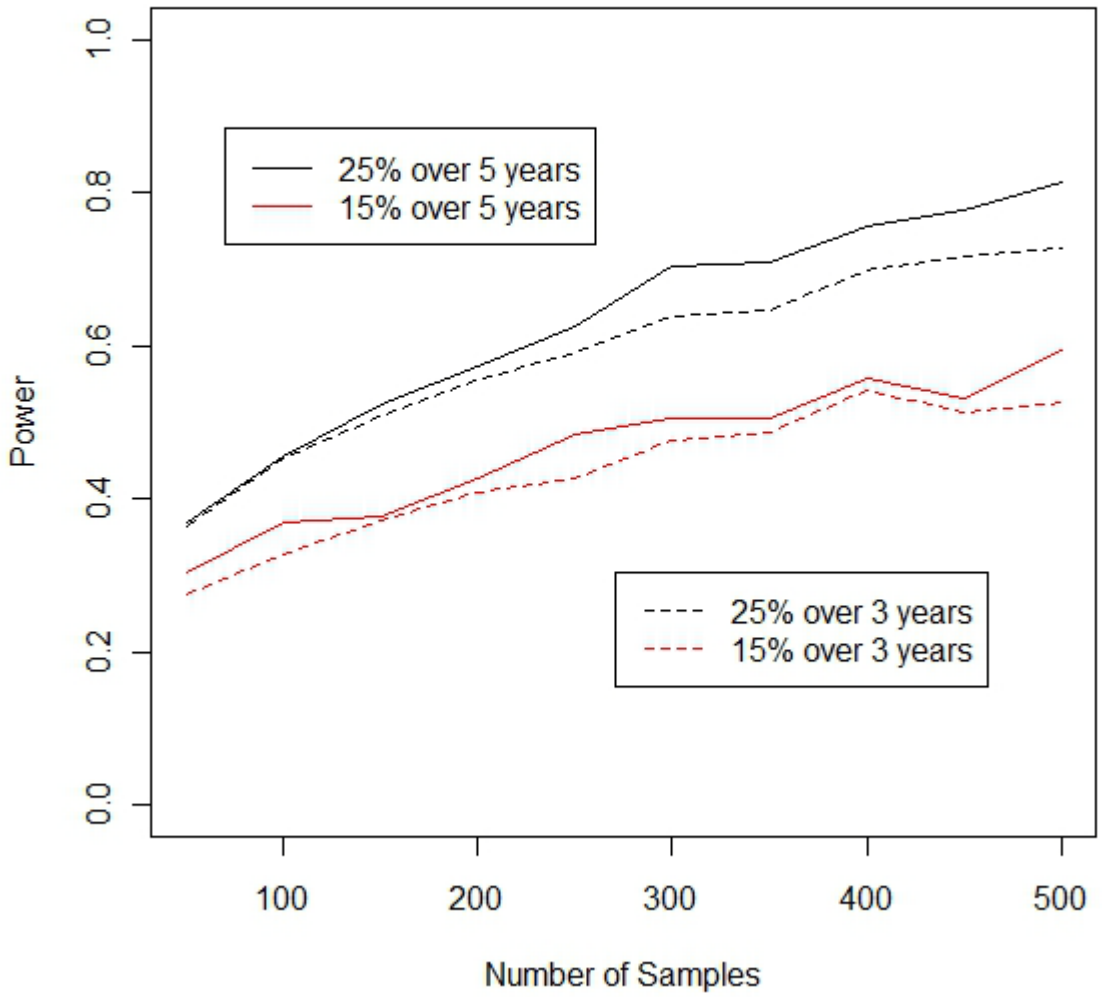

Figure 5. Power to detect trends in active burrow density with 80% confidence for sample sizes from 50 to 500.

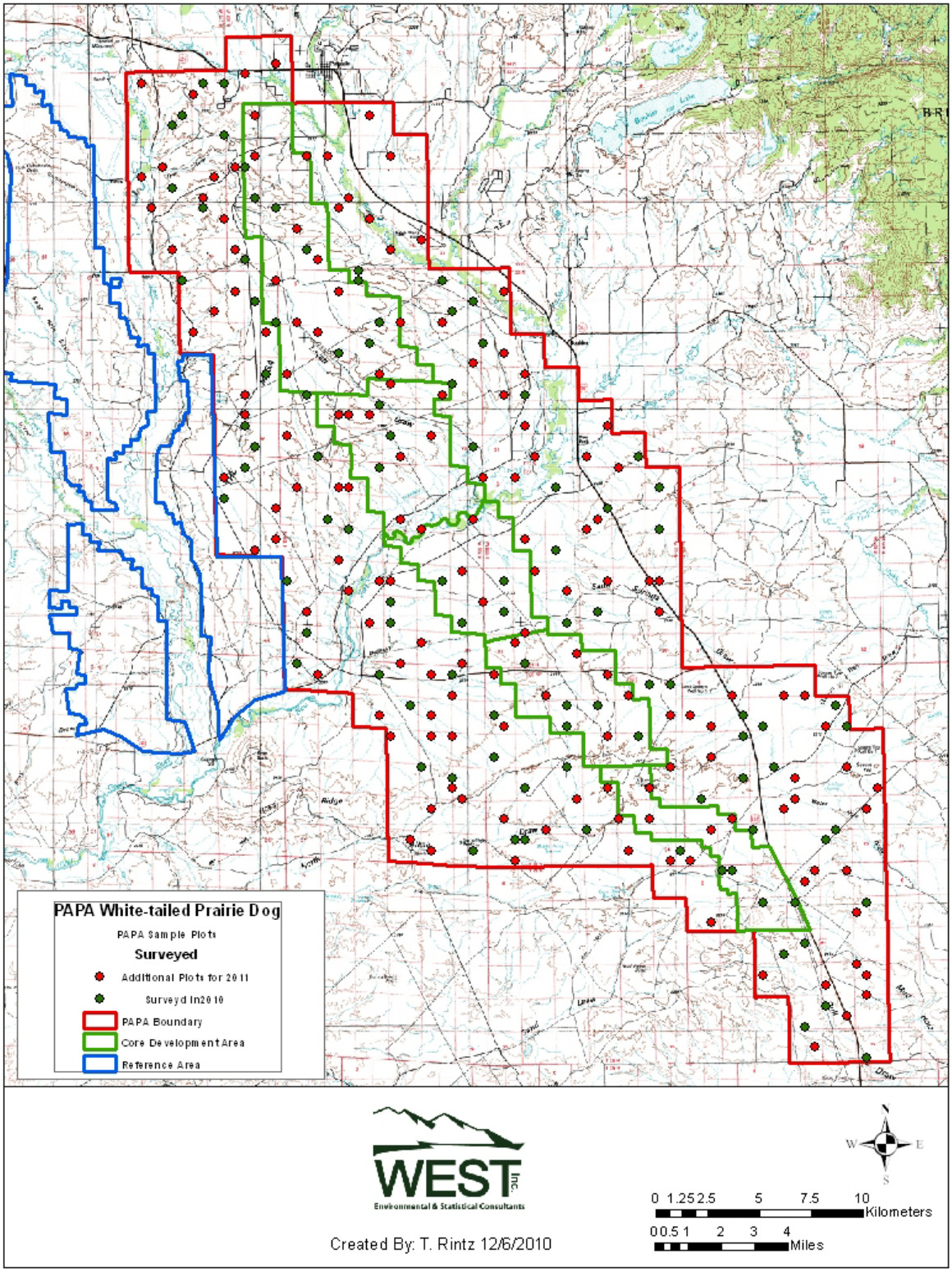

Figure 6. Proposed sample plots sufficient to detect trends over 5 years in occupancy of white-tailed prairie dogs on the PAPA.

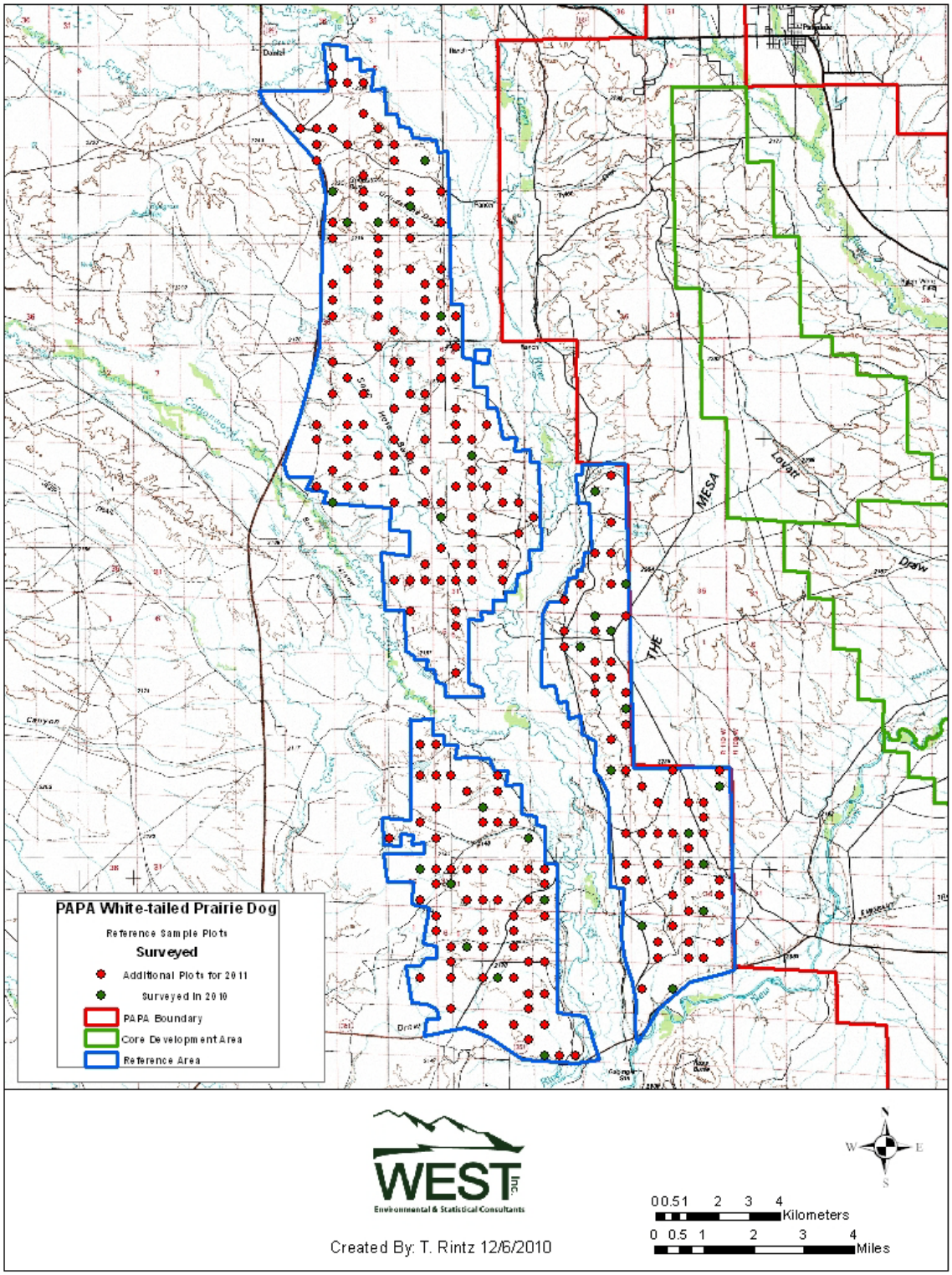

Figure 7. Proposed sample plots sufficient to detect trends over 5 years in occupancy of white-tailed prairie dogs on the Reference Areas.

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