Pygmy Rabbit Monitoring in the Pinedale Anticline Project Area Sublette County, Wyoming 2016

Report Prepared for:

Wyoming Game and Fish Department,
Pinedale Anticline Project Office, and
Bureau of Land Management
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2016

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INTRODUCTION

The 2008 *Record of Decision for the Supplemental Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration and Development Project* in Sublette County, Wyoming established requirements for annual monitoring of pygmy rabbit (*Brachylagus idahoensis*) populations (USDI-BLM 2008). The pygmy rabbit is on the Bureau of Land Management (BLM) Sensitive Species List and is a Wyoming Game and Fish Department (WGFD) species of concern largely due to the limited data on current population status, trends, and distribution within Wyoming (USDI-BLM 2010, WGFD 2010). Monitoring implemented under the 2008 Record of Decision (ROD) aims to protect and maintain pygmy rabbit populations throughout the Pinedale Anticline Project Area (PAPA). The *Wildlife Monitoring and Mitigation Matrix* (Appendix B-1, 2008 ROD) outlines the criteria, monitoring requirements, and mitigation triggers for pygmy rabbit populations within the PAPA. For pygmy rabbits, the matrix specifies the need to change mitigation if there are "three consecutive years of decline in presence or absence of a species, or an average of 15% decline in numbers of individuals each year over three years".

Occupancy analysis methods, based on the general concept of site-occupancy (locations where the species is present), have been used in many research applications and increasingly are favored by managing agencies engaged in population monitoring (MacKenzie et al. 2006, Bailey et al. 2007, Andelt et al. 2009). The benefits of robust methods of occupancy analysis were recognized by the University of Wyoming Cooperative Fish and Wildlife Unit in their review of the Pinedale Anticline Project Office's (PAPO) monitoring protocol. "Finally, the Committee notes that the ultimate goal of monitoring pygmy rabbits should be to place this monitoring activity into the context of occupancy modeling (MacKenzie et al. 2002, 2003, 2006) whereby detection rates can be estimated. This is the most powerful tool available for inferring changes in presence-absence, once a sound sampling design has been put into place." Site-occupancy based on sightings of pygmy rabbits, active burrows, or fresh pellets likely is a good metric reflecting the current status of pygmy rabbit populations because the number of sample units (sites) in which such sign is detected will provide a reliable index of current population size (MacKenzie 2005). Changes through time in the number or distribution of occupied sample units will provide insight into population cycles or distributional shifts, particularly in species that show cyclic change through time (Brown and Kodric-Brown 1977, Hanski 1999, Bailey et al. 2007). One important feature of occupancy sampling is that site occupancy and detection probability may be estimated simultaneously. Estimating detection is critical because non-detection at a given sample unit does not necessarily reflect absence. Failure to account for imperfect detection will bias estimates low, and variation in detection probability may be confounded with true population change. With occupancy sampling, inter-annual or observer differences in detection can be accounted for and do not bias the estimate of true population change.

Additional features to the open robust occupancy model are estimates of local extinction (or emigration) and colonization (or immigration). These estimates are commonly named the vital rates that influence changes in occupancy (MacKenzie et al. 2006). We define colonization as the probability of a site that is unoccupied in season t is occupied in season t+1; and extinction as the probability of a site that is occupied in season t is unoccupied in season t+1. There are two ways to measure these probabilities: inference from static detection (probability = 1) for single season data, or by inference from multiple seasons without the requirement of static detection probabilities (imperfect detection of a species). We follow the latter approach due to our multi-season data, and detection/non-detection is not static (probability < 1). The problem with estimating local extinction and colonization rates with varying detection probability is the inability to determine whether the species is actually present but not detected (false absences). This leads to biased local extinction and colonization probabilities.

As part of the pygmy rabbit monitoring effort, surveys in 2009 were conducted by the Wyoming Natural Diversity Database (WYNDD 2009). During 2010-2016, Hayden-Wing Associates, LLC (HWA 2010, 2011, 2012, 2013, 2014, and 2015) was contracted by the WGFD to determine and report site occupancy of pygmy rabbits within the PAPA and Boulder Reference Area. Analysis of annual site occupancy will be used to monitor inter-annual population change within the PAPA. The specific survey objectives of the 2016 field season were to: (1) determine pygmy rabbit site occupancy in 2016, and (2) compare occupancy dynamics across 2011-2016 in order to assess the need for mitigation according to the *Wildlife Monitoring and Mitigation Matrix* (Appendix B-1, 2008 ROD).

HWA has completed six years of consecutive monitoring of the complete study design (since 2011) for presence absence of pygmy rabbits within the PAPA and reference area.

PROJECT AREA

This study is conducted in Sublette County, Wyoming, on public land managed largely by BLM within the PAPA (198,037 acres) and Boulder Reference Area (42,012 acres). Elevation ranges from approximately 6,850 feet to 7,750 feet, and average annual precipitation is about 10-12 inches (USDA-NRCS 2009). The study area consists primarily of Wyoming big sage (*Artemisia tridentata wyomingensis*) land cover, with lesser amounts of mountain big sage (*A. tridentata vaseyana*), basin big sage (*A. tridentata tridentata*), mixed desert shrub, riparian woodland, and irrigated cropland.

METHODS

Study Design Background

Throughout public land in the PAPA and reference area, approximately two sites per section were selected by the BLM; 621 of the sites were randomly generated and 75 were selected specifically because of past observations of pygmy rabbits at those locations (mostly within the past ten years). Due to time and budget constraints WYNDD surveyed 444 of the 696 sites in 2009 (WYNDD 2009); in 2010 HWA surveyed only the 252 sites that were not surveyed in 2009.

In 2010, HWA performed a statistical power analysis following MacKenzie and Royle (2005) to estimate how many sites would be necessary to have a 95% probability of detecting a 15% annual decrease in occupancy within the PAPA relative to the reference area. Our results indicated 390 sites would be sufficient to achieve the monitoring objective of the PAPO, provided sites are relatively equally distributed between the PAPA and reference area. We also noted in the 2010 report (HWA 2010) that all 390 sites should be surveyed two times each year to determine probability of detection. During 2011-2016, we surveyed a total of 390 sites; 136 reference sites and a random sample of 254 of the original 582 PAPA sites. These 390 sites include 219 of the sites surveyed in 2009, 165 of the sites surveyed in 2010, and six randomly selected sites that were not included in the 2009 or 2010 sampling efforts.

Because sampled sites differed between 2009 and 2010, we do not recommend management decisions based on inferences reported during these periods. Inference should, instead, be drawn from 2011, 2012, 2013, 2014, 2015, and 2016 where complete data sets were/will be analyzed with the same number of sampled sites each year.

Field Methods

The following surveys were performed in accordance with the BLM's *Wildlife Survey Protocols – Pinedale Field Office, January 2011*. All spatial data described in this report were obtained using Trimble Juno SB Global Positioning System (GPS) units. ArcGIS® 10.2 ESRI software was used to generate maps and conduct spatial analyses.

Field surveys were conducted between August 2 and September 10, 2016. HWA surveyed 390 sites (each 400m x 400m); 254 were in the PAPA and 136 were in the reference area (Maps 1 and 2). Sites occurred in open, intermediate and dense sagebrush and mixed desert shrub habitats. At each site, eight 50-m wide belt transects were established in a north-south orientation. This provided a high degree of survey coverage within each site. A single biologist surveyed each site, beginning at the westernmost transect. Within each belt transect the biologist proceeded along the axis of the belt, freely deviating in between adjacent belts to focus search effort on the most promising habitat patches (e.g. sagebrush that was taller and denser than the matrix, such as that found along drainages, the lee side of mounds and ridges, and mima mounds). This maximized search time in apparently suitable habitats, and ensured adequate coverage of the matrix of habitat, regardless of appearance.

In 2016, we surveyed each site twice, similar to survey efforts during 2011-2015. More than one site-visit (survey) is necessary to estimate detection probability and generate unbiased estimates of occupancy. To ensure independence of the two surveys, the second survey was always conducted by a different observer than the first, and combinations of observers were randomized. Moreover, the second observer did not see data collected by the first observer. During the first and second surveys, presence/absence data were collected; if evidence of recent pygmy rabbit occupancy was found (i.e. fresh scat, individuals seen) the remainder of the site was not surveyed.

Biologists were trained in distinguishing between pygmy rabbit and juvenile mountain cottontail (*Sylvilagus nuttallii*) sign, based upon scat grouping, abundance, and distribution, as well as burrow characteristics. During the survey season, observers continually collected scat samples to discuss amongst the crew; this ensured consistency among observers in identification and aging of scat. Burrow entrance size was suggestive but not conclusive evidence, because pygmy rabbit burrows can erode over time. We also found evidence of pygmy rabbits using large, old, eroded Uinta ground squirrel (*Urocitellus armatus*) burrows. Ground squirrels, least chipmunks (*Neotamias minimus*), and white-tailed prairie dogs (*Cynomys leucurus*) commonly inhabit burrows at the base of shrubs; these may be confused with pygmy rabbit burrows. Therefore, burrows were assumed to belong to pygmy rabbits only if pygmy rabbit scat was present and rodent scat was scarce or absent. Scat size, abundance and distribution were used to determine species identification. Any sign that had characteristics intermediate between pygmy rabbit and cottontail was considered inconclusive (i.e., not ascribed to pygmy rabbit).

To maintain consistent search effort among sites, biologists paced themselves and aimed to spend approximately two hours surveying each site. Biologists kept a slow but steady pace while surveying; when they found sign, they spent 5 - 10 minutes in the area to search for more sign and document the complex characteristics (i.e. amount of fresh and old scat, and number of burrows) before moving on to the next site. During each survey, we recorded the time spent, and recorded a GPS-track (polyline) of our survey path. We spent an average of 14 minutes surveying (13 in 2015, 14 in 2014, 14 in 2013, 14 in 2012, and 15 in 2011) each belt transect (Standard Error [SE] = 0.28 minutes), and traveled an average of

508 meters (588 m in 2015, 617 m in 2014, 564 m in 2013, 588 m in 2012, and 468 m in 2011) within each belt (SE = 11.6 m).

Statistical Methods

The presence/absence data recorded on the two visits to each of the 390 sites were used to estimate site occupancy and detection probability. We analyzed 2011-2016 occupancy using the Robust Design Occupancy option (MacKenzie et al. 2003) in program MARK (White and Burnham 1999) for multi-year analyses.

Robust Design Occupancy was used to estimate inter-annual changes in occupancy (MacKenzie et al. 2003). Although estimation of changes in occupancy over multiple years could be accomplished by analyzing each year of data separately and then comparing occupancy rates among years, this would not be the best method. This naïve approach requires the assumption that the spatial distribution of pygmy rabbits varies randomly from one year to the next (i.e. the probability that a site is occupied in year *t* is the same regardless of whether the unit was occupied or unoccupied in year *t* - 1). Such an assumption is unlikely to be met, especially given the patchiness of suitable pygmy rabbit habitat (i.e. the most suitable patches are likely to be occupied year after year). Robust design occupancy estimation explicitly incorporates the processes of local extinction and colonization and derives estimates of occupancy as well as between-year changes in occupancy.

An important strength of occupancy analysis is the ability to account for detection probability that may or may not differ among groups, surveys, or as a function of other variables. We evaluated twelve *a priori* models in order to identify the most parsimonious models that still account for variation in detection probability. The candidate models were ranked and weighted using the corrected Akaike's Information Criterion (AIC_c). AIC_c is a standardized way of ranking the fit of each model to the data; the ranking favors simpler models except when more complex models (i.e. more estimated parameters) explain substantially more of the variation in the data. In all but three of the twelve models, separate occupancy rates were computed for the PAPA and the reference area because the difference in occupancy between the two study areas is of prime interest. The models accounted for potential effects on detection probability by group (i.e. a separate detection probability was computed for each of the two study areas) and year (2011, 2012, 2013, 2014, 2015, and 2016). We report model averaged parameter estimates of local extinction probability, colonization probability, detection probability, and occupancy. We also report model averaged parameter estimates from the minimum AIC_c model that contains effects of group, year, and survey on occupancy detection, local extinction, and colonization (see Burnham and Anderson [2002] for a thorough discourse on model selection and inference using such techniques). We did not include effects of individual observers in any model in 2016 because all observers received considerable training and oversight, and an examination of the data revealed little difference in apparent detection abilities among observers. It is unlikely that inclusion of the six individual observer effects would have improved the strength of our analysis.

RESULTS

Occupancy was influenced by group (PAPA and reference area; Table 1), but estimates were not substantially different between groups (Table 2). The minimum AIC_c model included an effect of occupancy, extinction, and detection probability that differed between groups; the second best model added the effect of group on immigration (Table 1). The third model included the effect of group occupancy and extinction. These three models received 99% of the weight of evidence (combined models 1, 2, and 3; AIC_cw = 0.99) among candidate models (Table 1). Because these top two models were competitive (ΔAIC_c values < 5), we conducted model averaging across all models and reported parameter estimates as model averaged estimates (Table 2). Models allowing occupancy to remain constant (models 6, 10, and 13; Table 1) competed poorly (best ΔAIC_c = 13.055, $AIC_c w$ = 0.001), indicating there was effect of group (PAPA or reference area) on occupancy.

Among sites visited during 2011-2016, occupancy was estimated at 48% in the PAPA (95% Confidence Interval [CI] = 42-54%) and 61% in the reference area (95% CI = 52-69%; Table 2). Detection probability during 2011-2016 during survey 1 was estimated at 87% in the PAPA (95% CI = 84-89%) and 92% in the reference area (95% CI = 89-94%). Detection probability during 2011-2016 during survey 2 was estimated at 89% in the PAPA (86-91%) and 91% in the reference area (95% CI = 88-93%).

Model averaged estimates for local extinction rates for 2011-2012 were 24% (95% CI = 17-33%) in the PAPA and 10% (95% CI = 5-19%) in the reference area (Table 2). Modeled averaged estimates for local extinction rates for 2012-2013 were 17% (95% CI = 12-25%) in the PAPA and 9% (95% CI = 4-17%) in the reference area. Modeled averaged estimates for local extinction rates for 2013-2014 were 17% (95% CI = 12-24%) in the PAPA and 6% (95% CI = 3-14%) in the reference area. Modeled averaged estimates for local extinction rates for 2014-2015 were 12% (95% CI = 8-19%) in the PAPA and 6% (95% CI = 2-13%) in the reference area. Modeled averaged estimates for local extinction rates for 2015-2016 were 14% (95% CI = 10-20%) in the PAPA and 18% (95% CI = 12-26%) in the reference area.

Colonization rates during 2011-2012 were 38% (95% CI = 31-46%) in the PAPA and 40% (95% CI = 31-49%) in the reference area. During 2012-2013, colonization rates were 39% (95% CI = 31-47%) in the PAPA and 38% (95% CI = 29-48%) in the reference area. During 2013-2014, colonization rates were 40% (95% CI = 31-49%) in the PAPA and 40% (95% CI = 30-50%) in the reference area. During 2014-2015, colonization rates were 54% (95% CI = 44-64%) in the PAPA and 52% (95% CI = 38-66%) in the reference area. During 2015-2016, colonization rates were 36% (95% CI = 26-49%) in the PAPA and 35% (95% CI = 23-49%) in the reference area.

Derived parameter estimates from our model averaged estimates include rate of change in occupancy, also referred to as lambda (λ). A lambda value equal to one represents a static level of occupancy and a lambda value greater than one represents an increasing rate of occupancy (Table 2). The rate in change of occupancy for our model averaged estimates between 2011 and 2012 field seasons was 1.18 (95% CI = 1.03-1.33) in the PAPA and 1.15 (95% CI = 1.03-1.27) for the reference area. The rate in change of occupancy for our model averaged estimates between 2012 and 2013 field seasons was 1.12 (95% CI = 1.01-1.24) in the PAPA and 1.08 (95% CI = 0.99-1.16) for the reference area. The rate in change of occupancy for our model averaged estimates between 2013 and 2014 field seasons was 1.06 (95% CI = 0.96-1.15) in the PAPA and 1.07 (95% CI = 1.00-1.14) for the reference area. The rate in change of occupancy for our model averaged estimates between 2014 and 2015 field seasons was 1.14 (95% CI = 1.04-1.24) in the PAPA and 1.07 (95% CI = 1.00-1.14) for the reference area. The rate in change of occupancy for our model averaged estimates between 2015 and 2016 field seasons was 0.97 (95% CI = 0.90-1.04) in the PAPA and 0.88 (95% CI = 0.80-0.95) for the reference area. The overall rate of change during 2011-2016 was 1.09 (SE=0.05) in the PAPA and 1.05 (SE=0.04) in the reference area. As the rate of change reaches 1.0, an equilibrium will be reached where the number of colonization events equals the number of extinction events. With a rate of change of 1.0, there are equal numbers of individuals entering or exiting the population.

DISCUSSION

Pygmy rabbit occupancy, local extinction and probability of detections were influenced by group (PAPA and reference area). The PAPA had a lower overall occupancy compared to the reference area (48% compared to 61% respectively) across 2011 through 2016 (Table 2). However, if we examine single season occupancy estimates (Table 3), occupancy in both the PAPA and reference area slowly increased until 2015 and in 2016 began to decrease (Figure 1). Probability of detection was consistent between each round of surveys in the PAPA and reference area during 2011-2016 (Table 3). Detection probabilities are similar due to minimal variation in survey efforts among years (i.e. extensive field training reduced variation among surveyors). The CIs for both occupancy and detection probability overlapped for the PAPA and reference area, suggesting no difference in detection probability within or between groups.

When analyzing multi-season occupancy (Table 2), the measures of local extinction and colonization can be estimated. Between 2011 and 2012, we found an approximate 14% higher rate of local extinction and a 2% lower rate of colonization in the PAPA compared to the reference area. Between 2012 and 2013, we found an approximate 8% higher rate of local extinction in the PAPA compared to the reference area. Unlike the year before, we found a 1% increase in the rate of colonization in the PAPA compared to the reference area. Between 2013 and 2014, we found an approximate 11% higher rate of local extinction in the PAPA compared to the reference area but a similar rate of colonization between the PAPA and reference area. Between 2014 and 2015, we found an approximate 7% higher rate of local extinction in the PAPA compared to the reference area and a 2% increase in the rate of colonization between the PAPA and reference area. Between 2015 and 2016, extinction rates increased in the reference area. We found an approximate 4% higher rate of local extinction in the reference area compared to the PAPA and a 1% increase in the rate of colonization between the PAPA and reference area. Extinction rates seem to be stabilizing in the PAPA (Figure 1). In 2016, extinction rates in the reference area were the largest over the 6 year period (since 2011). This suggests that a higher rate of individuals left the reference area during the time between 2015 and 2016 surveys compared to any other year since 2011. During 2016, a more similar rate of extinction occurred in both the PAPA and the reference area. Colonization rates are fairly similar in both the PAPA and reference area (Figure 1). As in previous years, 95% CIs of both estimates in the PAPA overlap the CIs of both estimates in the reference area, suggesting there is no statistical difference between colonization or local extinction rates within or between groups.

According to our model averaged occupancy growth rate estimates (λ), between 2011 and 2012, we found a possible rate of increase in occupancy in the PAPA (18%) and reference area (15%). Between 2012 and 2013, we found a possible rate of increase in occupancy in the PAPA (12%) and reference area (8%). Between 2013 and 2014, we found a possible rate of increase in occupancy in the PAPA (6%) and reference area (7%). Between 2014 and 2015, we found a possible rate of increase in occupancy in the PAPA (14%) and reference area (7%). Between 2015 and 2016, we found a possible rate of decrease in occupancy in the PAPA (-3%) and reference area (-12%). It seems that the reference area had a larger decrease in occupancy during 2015-2016, however the SE overlaps the PAPA, suggesting there is no statistical difference between the two survey areas.

Overall, the rate of change in occupancy has averaged an increase in the past six years for the PAPA and reference area. However, the rate of change in occupancy was highest in the reference area between 2011 and 2012 (Figure 1). For the first time in a 6 year period, we saw a rate of increase below 1 between surveys in 2015 and 2016. This suggests occupancy estimates are not stable in either study area. Future monitoring would assist in identifying whether this instability is due to fluctuating occupancy dynamics or a potential population cycle.

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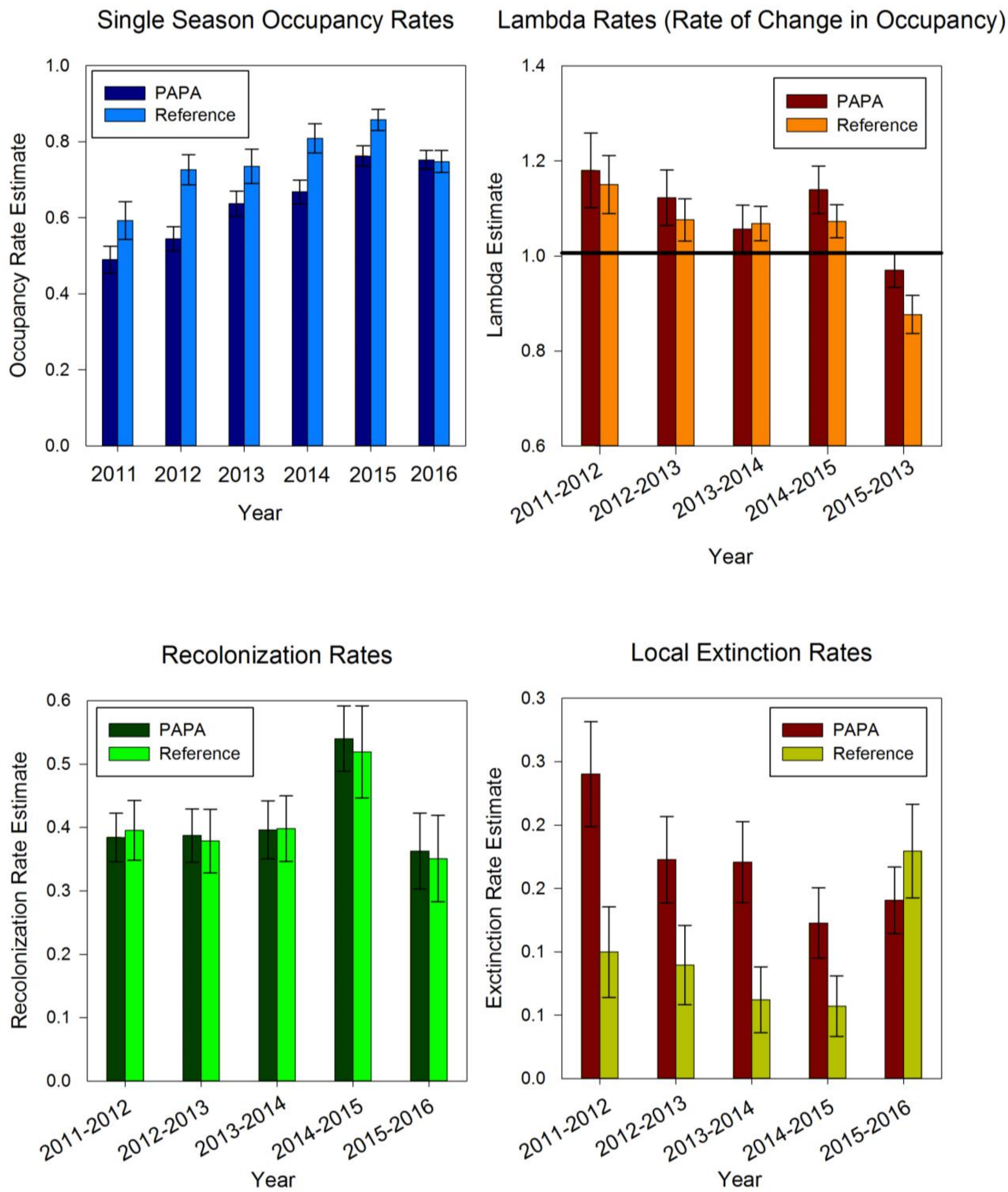


Figure 1. Occupancy dynamics for pygmy rabbits within the PAPA and Boulder Reference Area, Sublette County, Wyoming. Each graph estimates model-averaged occupancy dynamic rates with standard error bars during 2011-2016. Lambda rates are shown with a bar for the equilibrium rate of change (value of 1.0).

Table 1. Model selection results using corrected Akaike's Information Criteria (AIC_c) for estimation of site occupancy of pygmy rabbits within the PAPA and Boulder Reference Area, Sublette County, Wyoming during 2011-2016.

Model[1,2]	AIC_c	ΔAIC_c	AIC_c wt	No. Param	Deviance
{Ψ(group) ε(group) γ(.) p(group)}	4473.69	0.000	0.855	21	1305.83
{Ψ(group) ε(group) γ(group) p(group)}	4477.93	4.231	0.103	26	1299.86
{Ψ(group) ε(group) γ(.) p(.,.)}	4480.57	6.881	0.027	19	1316.78
{Ψ(group) ε(.) γ(.) p(group)}	4483.06	9.369	0.008	16	1325.37
{Ψ(group) ε(group) γ(group) p(.,.)}	4484.15	10.461	0.005	24	1310.17
{Ψ(.) ε(.) γ(.) p(group,.)}	4486.75	13.055	0.001	15	1331.08
{Ψ(group) ε(.) γ(group) p(group,.)}	4488.01	14.313	0.001	21	1320.15
{Ψ(group) ε(.) γ(.) p(.,.)}	4493.49	19.798	0.000	14	1339.85
{Ψ(group) ε(group) γ(.) p(year)}	4494.06	20.362	0.000	29	1309.84
{Ψ(.) ε(.) γ(.) p(.,.)}	4497.65	23.955	0.000	13	1346.03
{Ψ(group) ε(group) γ(group) p(year)}	4497.79	24.092	0.000	34	1303.29
{Ψ(group) ε(.) γ(.) p(year,.)}	4506.69	32.991	0.000	24	1332.70
{Ψ(.) ε(.) γ(.) p(year,.)}	4510.85	37.160	0.000	23	1338.91

[1] Standard notation: Ψ = probability of occupancy, ε = probability of extinction, γ= probability of recolonization, p = probability of detection

[2] Group = PAPA vs. Reference, year = 2011 vs. 2012 vs. 2013 vs. 2014 vs. 2015 vs. 2016

Table 2. Model averaged parameter estimates of probability of occupancy (Ψ), extinction (ε), recolonization (γ), probability of detection (p), and rate of change in occupancy (λ) of pygmy rabbits during 2011-2016 within the PAPA and Boulder Reference Area, Sublette County, Wyoming.

Parameter	Estimate	SE	95% CI Lower	95% CI Upper
Ψ PAPA 2011-2016	0.4794	0.0318	0.4176	0.5418
Ψ Reference 2011-2016	0.6080	0.0424	0.5225	0.6873
ε PAPA 2011-2012	0.2401	0.0414	0.1685	0.3302
ε PAPA 2012-2013	0.1727	0.0340	0.1157	0.2498
ε PAPA 2013-2014	0.1708	0.0319	0.1170	0.2427
ε PAPA 2014-2015	0.1227	0.0278	0.0778	0.1882
ε PAPA 2015-2016	0.1406	0.0263	0.0966	0.2003
ε Reference 2011-2012	0.0997	0.0358	0.0483	0.1947
ε Reference 2012-2013	0.0896	0.0313	0.0443	0.1726
ε Reference 2013-2014	0.0621	0.0260	0.0269	0.1369
ε Reference 2014-2015	0.0572	0.0238	0.0249	0.1261
ε Reference 2015-2016	0.1795	0.0368	0.1181	0.2632
γ PAPA 2011-2012	0.3840	0.0383	0.3122	0.4612
γ PAPA 2012-2013	0.3871	0.0419	0.3087	0.4718
γ PAPA 2013-2014	0.3961	0.0459	0.3105	0.4887
γ PAPA 2014-2015	0.5401	0.0516	0.4387	0.6384
γ PAPA 2015-2016	0.3629	0.0598	0.2555	0.4861
γ Reference 2011-2012	0.3952	0.0471	0.3075	0.4902
γ Reference 2012-2013	0.3784	0.0503	0.2860	0.4807
γ Reference 2013-2014	0.3982	0.0516	0.3026	0.5022
γ Reference 2014-2015	0.5193	0.0726	0.3791	0.6564
γ Reference 2015-2016	0.3509	0.0683	0.2310	0.4931
p PAPA survey 1 2011-2016	0.8672	0.0122	0.8415	0.8893
p PAPA survey 2 2011-2016	0.8871	0.0111	0.8636	0.9071
p Reference survey 1 2011-2016	0.9194	0.0129	0.8901	0.9413
p Reference survey 2 2011-2016	0.9085	0.0124	0.8811	0.9300
λ PAPA 2011-2012	1.1801	0.0783	1.0266	1.3336
λ Reference 2011-2012	1.1504	0.0611	1.0305	1.2702
λ PAPA 2012-2013	1.1227	0.0584	1.0082	1.2372
λ Reference 2012-2013	1.0761	0.0443	0.9894	1.1628

Table 2. Continued.

Parameter	Estimate	SE	95% CI Lower	95% CI Upper
λ PAPA 2013-2014	1.0569	0.0499	0.9592	1.1547
λ Reference 2013-2014	1.0685	0.0362	0.9975	1.1395
λ PAPA 2014-2015	1.1394	0.0499	1.0415	1.2373
λ Reference 2014-2015	1.0732	0.0348	1.0049	1.1414
λ PAPA 2015-2016	0.9702	0.0357	0.9003	1.0400
λ Reference 2015-2016	0.8771	0.0397	0.7993	0.9549
λ PAPA 2011-2016	1.0939	0.0544	0.9872	1.2006
λ Reference 2011-2016	1.0490	0.0432	0.9643	1.1338

Table 3. Model averaged parameter estimates of probability of occupancy (Ψ) and probability of detection (p) of pygmy rabbits modeled seperately by year during 2011-2016 within the PAPA and Boulder Reference Area, Sublette County, Wyoming.

2016

Parameter	Estimate	SE	95% CI Lower	95% CI Upper
Ψ PAPA	0.7526	0.0246	0.7014	0.7975
Ψ Reference	0.7478	0.0287	0.6876	0.7998
p PAPA survey 1	0.8582	0.0232	0.8064	0.8980
p PAPA survey 2	0.8805	0.0214	0.8319	0.9164
p Reference survey 1	0.8648	0.0259	0.8056	0.9080
p Reference survey 2	0.8819	0.0232	0.8284	0.9203

2015

Parameter	Estimate	SE	95% CI Lower	95% CI Upper
Ψ PAPA	0.7626	0.0268	0.7063	0.8111
Ψ Reference	0.8575	0.0278	0.7940	0.9038
p PAPA survey 1	0.8857	0.0241	0.8295	0.9251
p PAPA survey 2	0.8908	0.0236	0.8351	0.9293
p Reference survey 1	0.9333	0.0243	0.8667	0.9679
p Reference survey 2	0.9245	0.0257	0.8563	0.9618

2014

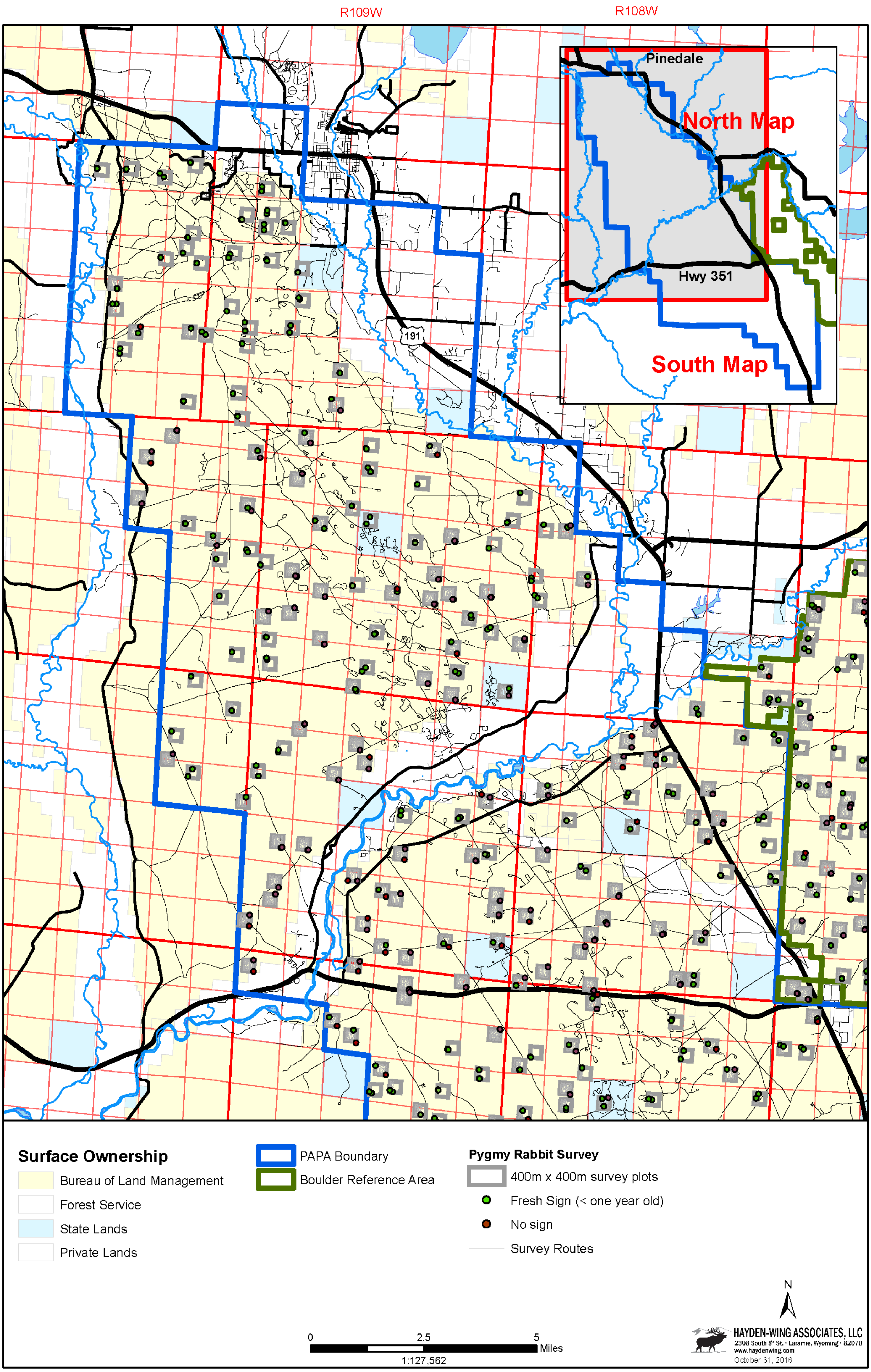
Parameter	Estimate	SE	95% CI Lower	95% CI Upper
Ψ PAPA	0.6682	0.0313	0.6042	0.7265
Ψ Reference	0.8087	0.0379	0.7234	0.8724
p PAPA survey 1	0.8739	0.0228	0.8220	0.9123
p PAPA survey 2	0.8906	0.0224	0.8385	0.9273
p Reference survey 1	0.8790	0.0240	0.8236	0.9187
p Reference survey 2	0.8988	0.0236	0.8422	0.9366

Table 3. Continued.

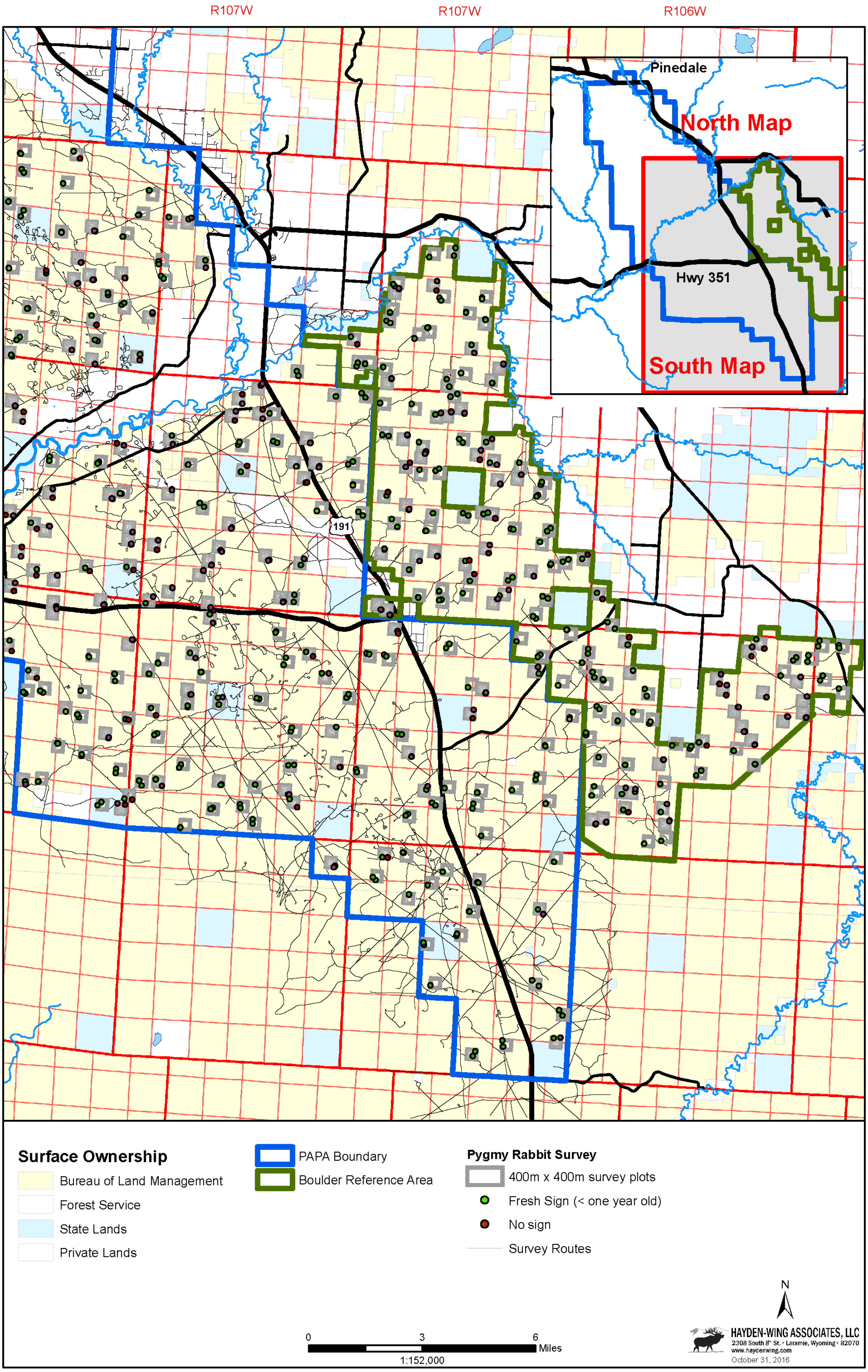
2013				
			95% CI	
Parameter	**Estimate**	**SE**	**Lower**	**Upper**
Ψ PAPA	0.6371	0.0332	0.5699	0.6993
Ψ Reference	0.7354	0.0452	0.6381	0.8142
p PAPA survey 1	0.9061	0.0231	0.8500	0.9427
p PAPA survey 2	0.9190	0.0196	0.8715	0.9500
p Reference survey 1	0.9233	0.0253	0.8567	0.9603
p Reference survey 2	0.9226	0.0209	0.8704	0.9548

2012				
			95% CI	
Parameter	**Estimate**	**SE**	**Lower**	**Upper**
Ψ PAPA	0.5445	0.0319	0.4816	0.6060
Ψ Reference	0.7261	0.0397	0.6419	0.7968
p PAPA survey 1	0.9052	0.0174	0.8651	0.9343
p PAPA survey 2	0.9074	0.0173	0.8674	0.9362
p Reference survey 1	0.9062	0.0175	0.8658	0.9354
p Reference survey 2	0.9096	0.0179	0.8678	0.9391

2011				
			95% CI	
Parameter	**Estimate**	**SE**	**Lower**	**Upper**
Ψ PAPA	0.4897	0.0354	0.4210	0.5587
Ψ Reference	0.5930	0.0497	0.4933	0.6856
p PAPA survey 1	0.8303	0.0386	0.7409	0.8932
p PAPA survey 2	0.8773	0.0323	0.7987	0.9279
p Reference survey 1	0.9593	0.0350	0.8022	0.9928
p Reference survey 2	0.8686	0.0392	0.7712	0.9284



Map 1 (North). Pygmy rabbit survey plots, survey routes, and detection points within the Pinedale Anticline Project Area (PAPA)and Boulder Reference Area during August - September 2016.



Map 2 (South). Pygmy rabbit survey plots, survey routes, and detection points within the Pinedale Anticline Project Area (PAPA)and Boulder Reference Area during August - September 2016.