WASHINGTON GROUND SQUIRREL DISTRIBUTION SAMPLING

BOARDMAN CONSERVATION AREA

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February 2015

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Introduction

The Boardman Conservation Area (BCA) includes 9163 ha (22,642 ac) of grassland and shrub-steppe habitat southwest of Boardman, Oregon, owned by Threemile Canyon Farms and managed by The Nature Conservancy (TNC). Under a Multi-Species Candidate Conservation Agreement (2003; MSCCAA); developed through a collaborative effort among Threemile Canyon Farms, The Nature Conservancy, Portland General Electric, the U.S. Fish and Wildlife Service, and the Oregon Department of Fish and Wildlife; conservation measures are stipulated for several species of concern. Included in these measures is a requirement that the number and distribution of Washington ground squirrel (*Urocitellus washingtoni*; WGS) sites on the BCA be determined through monitoring every two to five years.

WGS distribution mapping on the BCA was initiated in 1999 and completed in 2001. One-hundred and twenty-nine WGS sites were identified during this initial mapping effort. Subsequent monitoring consisted of revisiting each site to determine occupancy status, and new sites, identified during the course of field work, were included in subsequent monitoring efforts. However, given the high cost and effort of WGS distribution mapping, a complete reassessment of WGS distribution on the BCA has not been repeated. In an effort to reduce the cost and time involved with distribution mapping TNC implemented a pilot study in 2009 (Marr 2009) to estimate WGS density as a surrogate for distribution mapping. A distance-based point and transect sampling scheme at randomly selected points was used and seven sites were identified along transects during these surveys. The limited results of the 2009 pilot study have prompted us to seek alternative sampling methods to assess the distribution of Washington ground squirrels more efficiently.

There are three accepted factors used to confirm the presence of WGS: burrows with scat, calls, and visual observations of animals. Surveys of known WGS sites indicate that most detections are based on the observation of burrows with scat (Rosier 2013). Given this information, we implemented a pilot study to evaluate the use of scat detection dogs to map the distribution of WGS in areas outside of previously identified sites.

Methods

We contracted a detection dog team from the University of Washington's Center for Conservation Biology Conservation Canines program to survey WGS habitat on the BCA in the spring of 2014. Detection dog team training began in Washington State using ground squirrel scat samples from the BCA provided by TNC. The detection dog was trained to sit at the source of the odor allowing the dog handler to confirm and record the location of the sample. The dog was rewarded by playing fetch for a brief period and then instructed to find the next sample. Upon arrival in Boardman the dog team visited known ground squirrel locations to continue training before beginning surveys. Once the dog handler confirmed the dog's ability to detect the specific odor of WGS scat in ambient survey conditions the dog team began to search the BCA for ground squirrel presence. TNC staff assisted the dog team by providing maps of the survey area, navigational guidance, and confirmation of the identification of collected scat. The dog team provided GPS locations of ground squirrel scat detections, GPS track logs of the areas surveyed by the team, and samples of the ground squirrel scat collected in the field. In addition to the WGS distribution surveys implemented on the BCA, we also conducted a trial to compare rates of detection and efficiency of the detection dog team as compared to human observers. This trial was conducted in conjunction with on-going survey work on the adjacent Naval Weapons Systems Training Facility Boardman (NWSTF Boardman).

Distribution Mapping on the BCA

We used a detection dog team to assess the distribution of WGS outside of known monitoring points on the BCA in the spring of 2014 (Cotterill 2014). We used 65 ha (160 ac; ¼ section) sampling units for consistency with prior surveys by Morgan and Nugent (1999). Nearly all of the BCA is considered potential WGS habitat; however, in order to increase survey efficiency, we eliminated sampling units in which occupied WGS monitoring points were identified in 2013 surveys (Rosier 2013; Fig. 1). Occupied sites were buffered by 300m and intersecting sampling units were removed from the survey area. The 300m buffer was selected based on findings from telemetry space-use studies and field observations which indicate much of the annual WGS activity is concentrated within 300m of an activity site (Delavan 2008, Marr 2009). Detection dogs depend on wind-born scent to find the target, thus they are most efficient when sampling large areas (i.e. 100 ha (≥ 247 ac); H. Smith, Conservation Canines, personal communication). To accommodate the use of detection dogs we surveyed two sampling units (130 ha (320 ac)), a sampling block, simultaneously. We also eliminated all partial sampling units, resulting from the irregular shape of the BCA, < 12.1 ha (30 ac) in size for logistical reasons. The initial sampling unit of each sampling block was randomly selected. The second sampling unit comprising the sampling block was an adjacent, unsurveyed, unit. The dog handler determined the best search pattern to ensure complete coverage of the sampling block based on ambient environmental conditions. In general, the search pattern consisted of the dog team walking through each sampling block four times at approximately equally spaced intervals and generally proceeding north and south. The dog and handler did not adhere to transect lines but rather the dog was allowed to pursue scent at will resulting in sinuous survey paths (Cotterill 2014). Surveys were terminated when winds were ≥ 24km/h (15 miles/h).

Detection dog effectiveness

Detection dogs have been used to survey for a wide variety of wildlife species in a diversity of habitats (Cablk and Heaton 2006). The efficacy of detection dogs as a survey tool varies by target species, habitat, environmental conditions, dog-handler relationship, and sampling strategy, among other factors (Wasser 2004, Cablk and Heaton 2006). To our knowledge, detection dog surveys have never been conducted for WGS. Therefore, we conducted a pilot study to assess the field effectiveness, that is "the accuracy of the dogs under natural conditions" (Cablk and Heaton 2006) in the spring of 2014. Human survey teams from Northwest Wildlife Consultants LLC (NWWC) were contracted to survey the southern portion of NWSTF Boardman in the spring of 2014 using the standard pedestrian survey protocol (Morgan and Nugent 1999; standard surveys). We used these standard surveys as the baseline for comparison with dog surveys. We compared status (i.e. occupied or vacant), number of WGS detections per unit, mean survey effort (time), cost, and transect or dog track length as a measure of search effort. For consistency with historic surveys we used 65 ha (160 ac, ¼ section) sampling units. We selected 10 sampling units on NWSTF Boardman (Fig. 2). Sampling units were not randomly selected due to logistical constraints. Rather, we selected units which were historically occupied by WGS (most since 2005-2006) and adjacent to one another. Sampling order and search patterns within each sampling unit were determined by the dog handler and survey crew leader during respective surveys. For instance, human surveyors sampled several units together using long transect lines rather than stopping at sampling unit boundaries for each pass (Gerhardt and Anderson, 2014). Similarly, the dog handler determined the best search pattern to ensure complete coverage of the sampling unit(s) based on environmental conditions (Cotterill 2014).

Survey effort (mean time and distance per sampling unit) was calculated from GPS tracklogs from the detection dog and NWWC surveyors. The dog team carried two GPS units, one embedded in the dog's harness (860E GPS data logger; TranSystems Inc. Taiwan), and a second carried by the dog handler (Columbus 900 GPS data logger; Victory Technology Co. Ltd.). NWWC recorded each surveyor's tracklog using handheld GPS units. Distance and time intervals were calculated using the movement.pathmetric script in Geospatial Modeling Environment (v 0.7.2.1) or directly from transect line shapefiles generated from GPS tracklogs. Data points which fell outside of sampling units were excluded.

Detections were defined as confirmed evidence of WGS presence (i.e. scat and burrows, audio or visual observation) ≥30 m apart, one half the distance between transect lines. For observations <30 m apart we calculated the mean geographic center point using the mean center tool in ArcGIS (v10.1; ESRI Redlands, CA). The resulting location was considered a single detection.

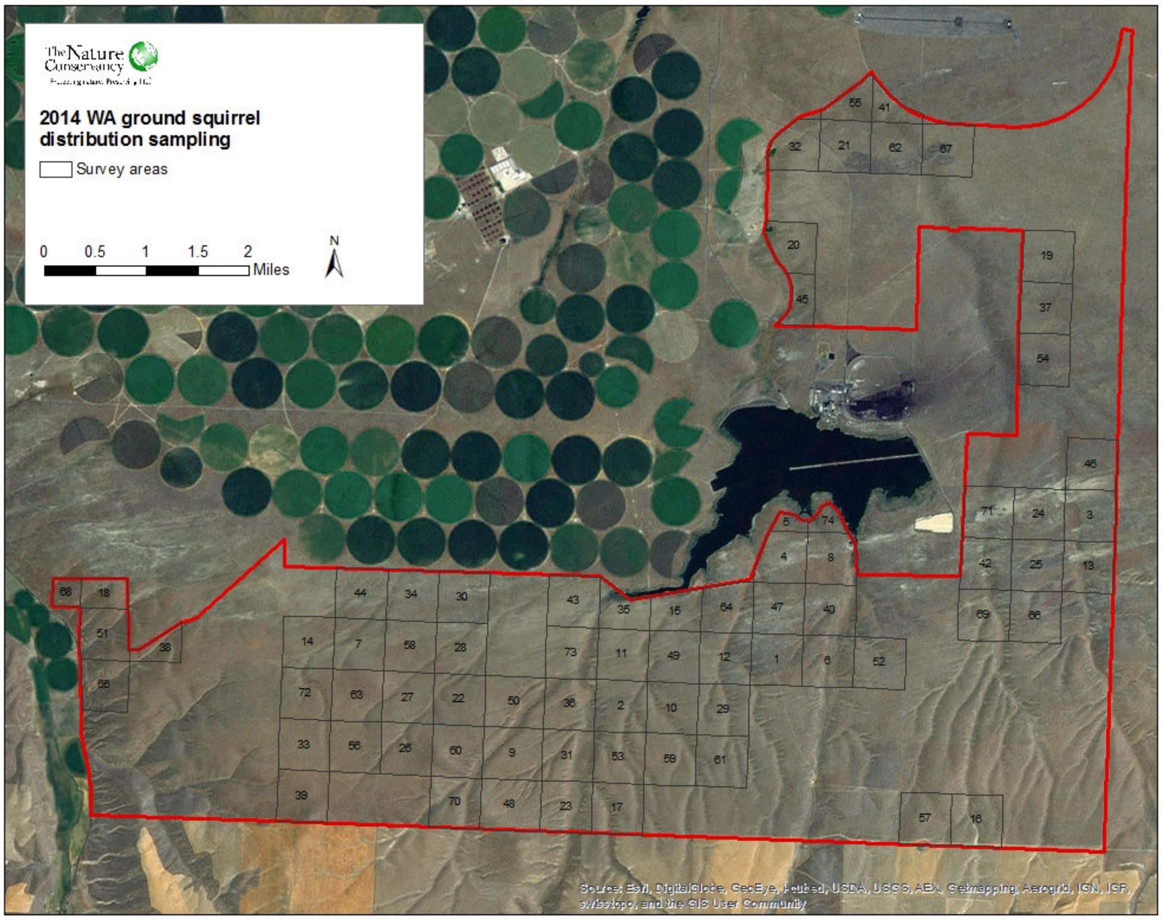

Figure 1. We selected sampling units on the BCA based on the results of the 2013 WGS survey. All quarter section sampling units which were unoccupied or not sampled in 2013 were randomly ordered and considered potential sampling areas in 2014.

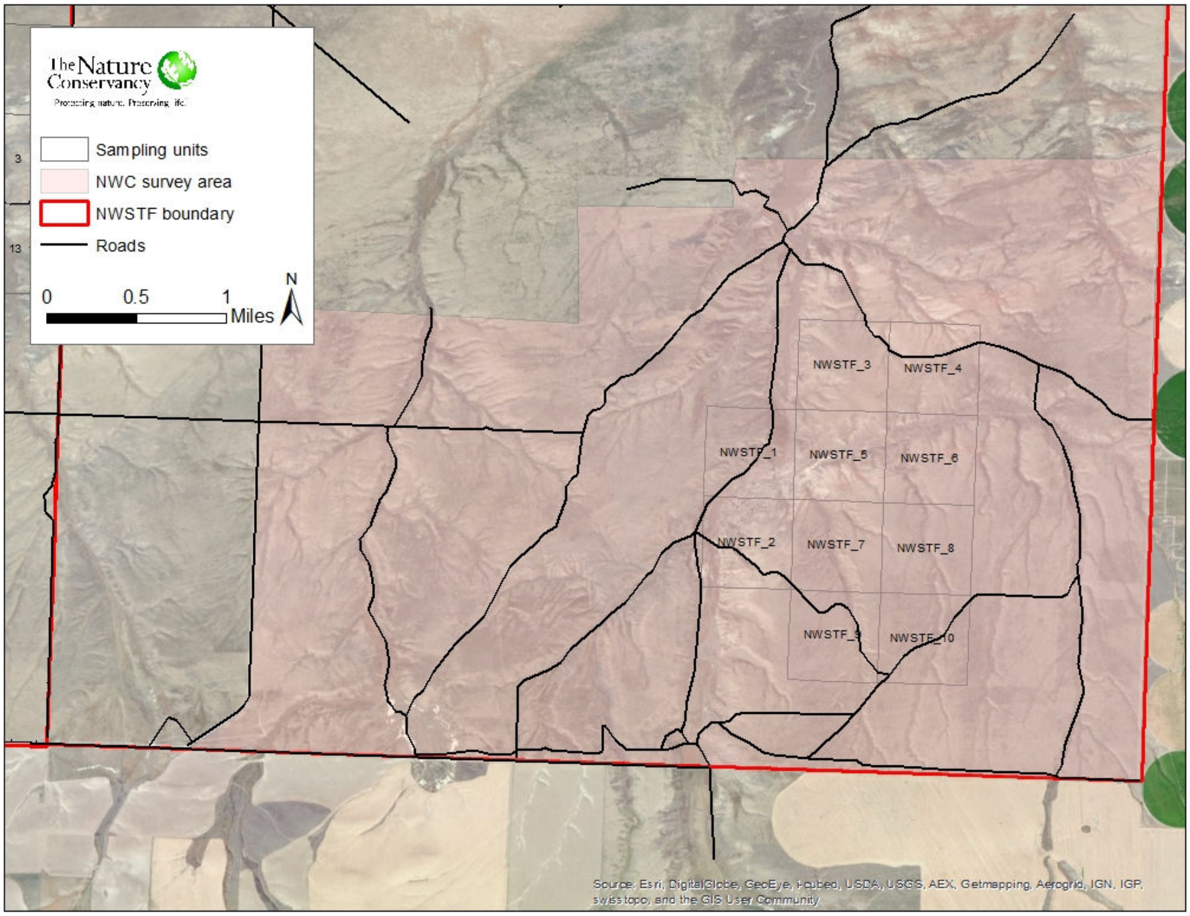

Figure 2. We conducted a trial, comparing canine and human survey results, on NWSTF Boardman in the spring of 2014. All sampling units were surveyed by both the detection dog team and the human surveyors.

Results

Distribution Mapping on the BCA

Detection dog surveys were conducted on 15 days between March 18 and April 16, 2014 on the BCA. During this time period the dog team surveyed 31 of 74 sampling units (42%) encompassing 1795 ha. Detection rates were low. WGS were detected at only 4 locations resulting in an occupancy estimate of 10% (2 detections occurred within the same sampling unit; Fig 3). These detections ranged from 349m to 854m ($\bar{x}$=564m) from historic WGS activity sites. We calculated mean track length (m/ha) and survey time (min/ha) per sampling unit as measures of survey effort. On average, the dog team covered 167 m/ha (SE = 8.3, n=31) and spent 2.4 min/ha (SE = 0.1, n=31). However, midway through the survey period additional training sites became available for the dog team and were visited on March 31 and April 2. Based on the dog team's performance at these sites we modified the search protocol by increasing the number of passes per sampling block from 4 to 8-10, thus reducing the spacing between passes to approximately 100m (Cotterill 2014). As a result of this modification mean survey effort increased from 163 m/ha (SE=9.4, n=22) and 2.2 min/ha (SE=0.1, n=22) prior to the modification to 176 m/ha (SE=17.4, n=9) and 3.1 min/ha (SE=0.3, n=9) following the change.

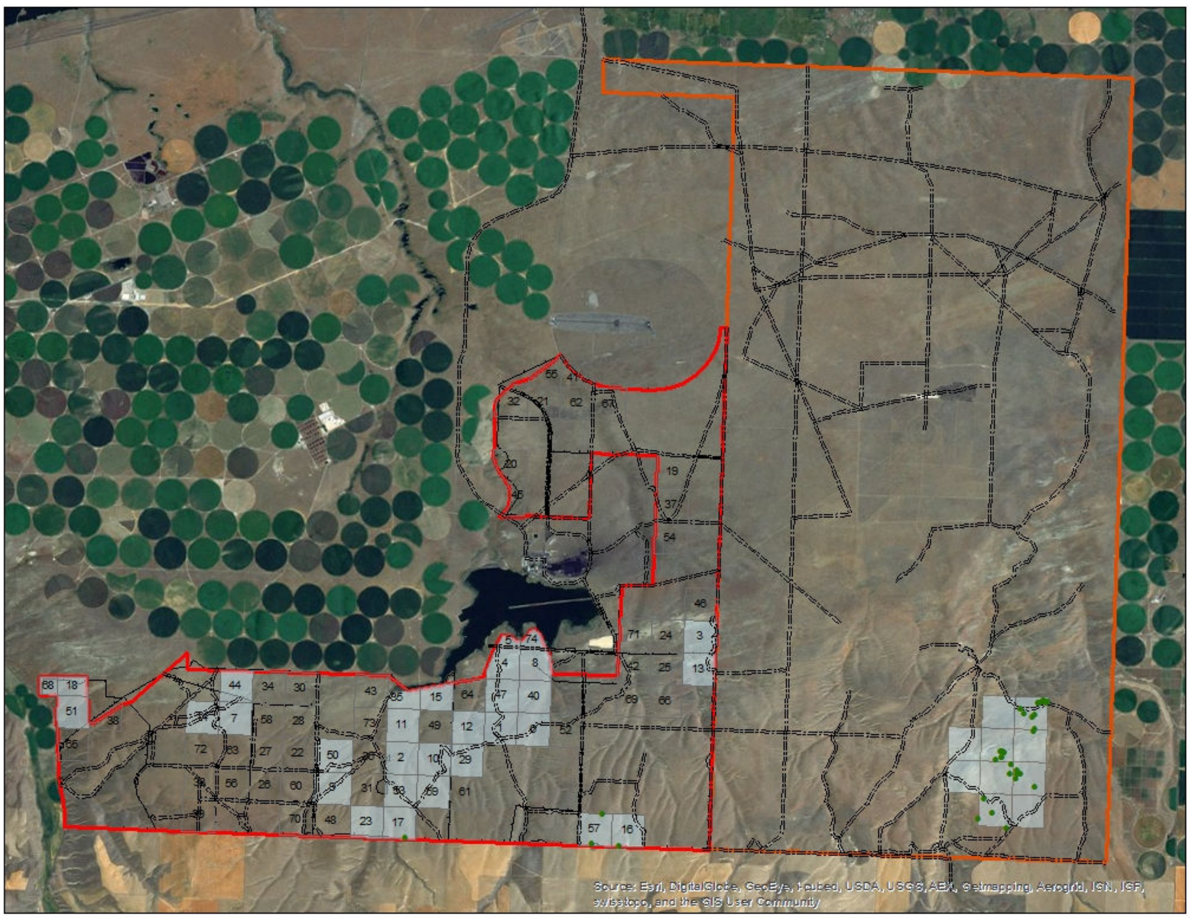

Figure 3. The detection dog team surveyed a total of 41 sampling units (indicated in gray) on the BCA and NWSTF Boardman in the spring of 2014. Few detections, depicted as green points, occurred on the BCA.

Detection dog effectiveness

Detection dog surveys were conducted on NWSTF Boardman on 5 days between April 1 and April 11, 2014, covering 10 sampling units (650 ha). WGS were detected at 24 locations in 6 of 10 sampling units (60%; Fig. 4). Standard surveys occurred from March 5 – 6, 2014 and were repeated from May 7-13, 2014. WGS were detected at a total of 30 locations (9 locations in the 1st survey period and 21 in the 2nd) in 7 of 10 sampling units (70%; Fig. 5). The number of detections per sampling unit were similar between survey methods (Fig. 6) and the status of 9 of 10 (90%) sampling units were correctly classified (i.e. occupied or vacant) after a single detection dog survey as compared with results of both standard surveys.

We calculated mean track length (m/ha) and survey time (min/ha) per sampling unit as measures of survey effort for both the detection dog and standard surveys. On April 3, 2014 the dog's GPS failed so no data points were collected. Rather than excluding this survey effort from the analysis we chose to use the dog handler's tracklog for this date. These data are likely representative of the survey effort; however, they may underestimate the survey distance covered by the dog. Additionally, human surveyors failed to include a time/date field for some tracklog files during the second survey period (east/west transects); therefore survey duration was calculated for the first survey period only. On average, the detection dog track length was 197 m/ha (SE = 12.9m) and average time 3.8 min/ha (SE = 0.4 min) compared with an average track length of 173 m/ha (SE = 1.1 m) and an average time of 2.7 min/ha (SE = 0.1 min) for a single survey by human surveyors (Figs. 7 and 8). Further, the dog team's survey effort was comparable between the effectiveness trials and surveys conducted on the BCA after the search protocol modification (min/ha p=0.2364, m/ha p=0.2703)

Finally, we also estimated survey cost for each method. Detection dog surveys cost approximately $5 / ha or $3,200 for a single survey of the trial area, whereas standard surveys cost approximately $6.50 / ha for a single survey or $13 / ha for both surveys prescribed by Morgan and Nugent (1999), for a total cost of approximately $8,300 for the trial area.

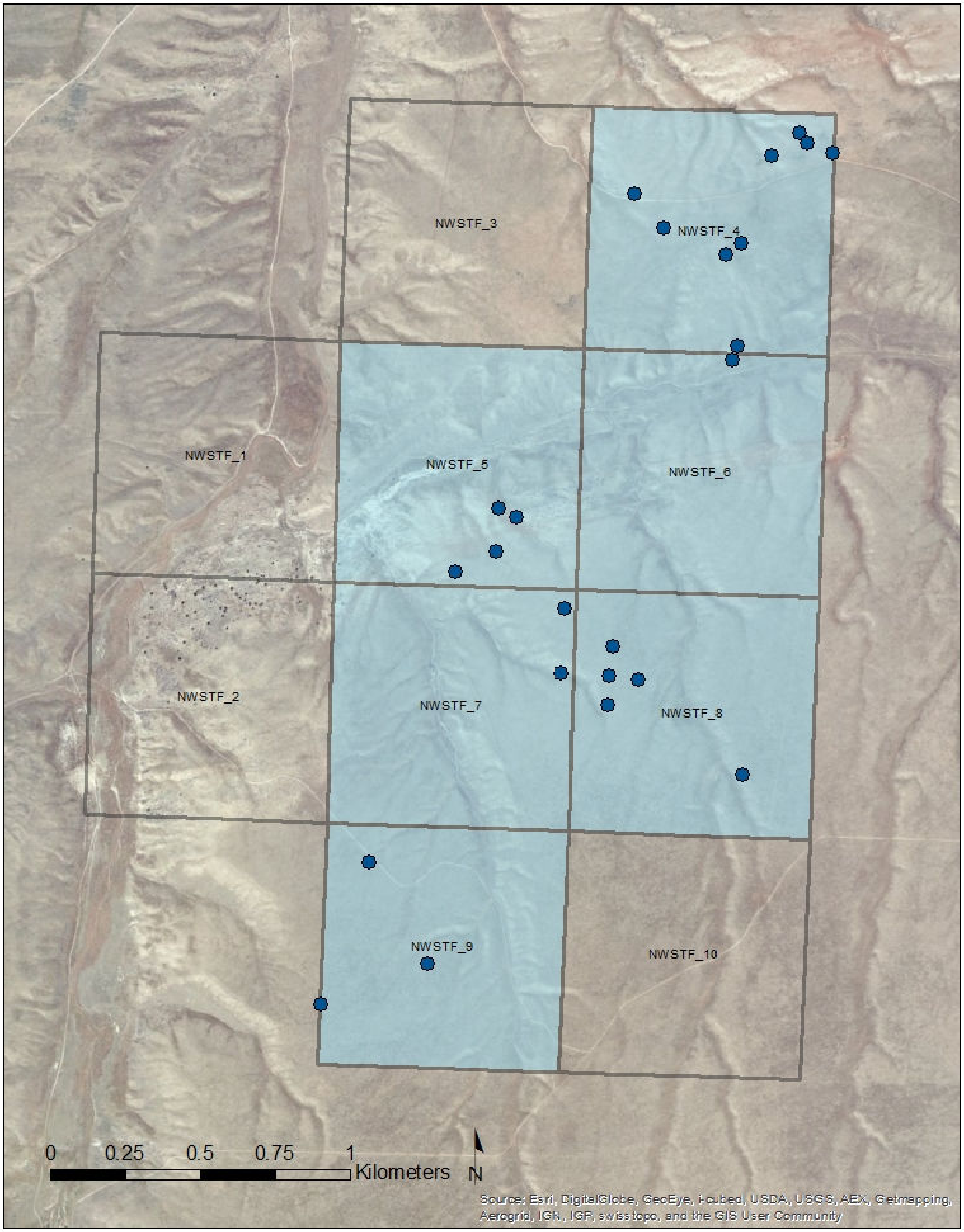

Figure 4. The detection dog team detected WGS in 6 of 10 sampling units and correctly classified 9 of 10 sampling units (i.e. occupied or vacant) as compared with standard survey results.

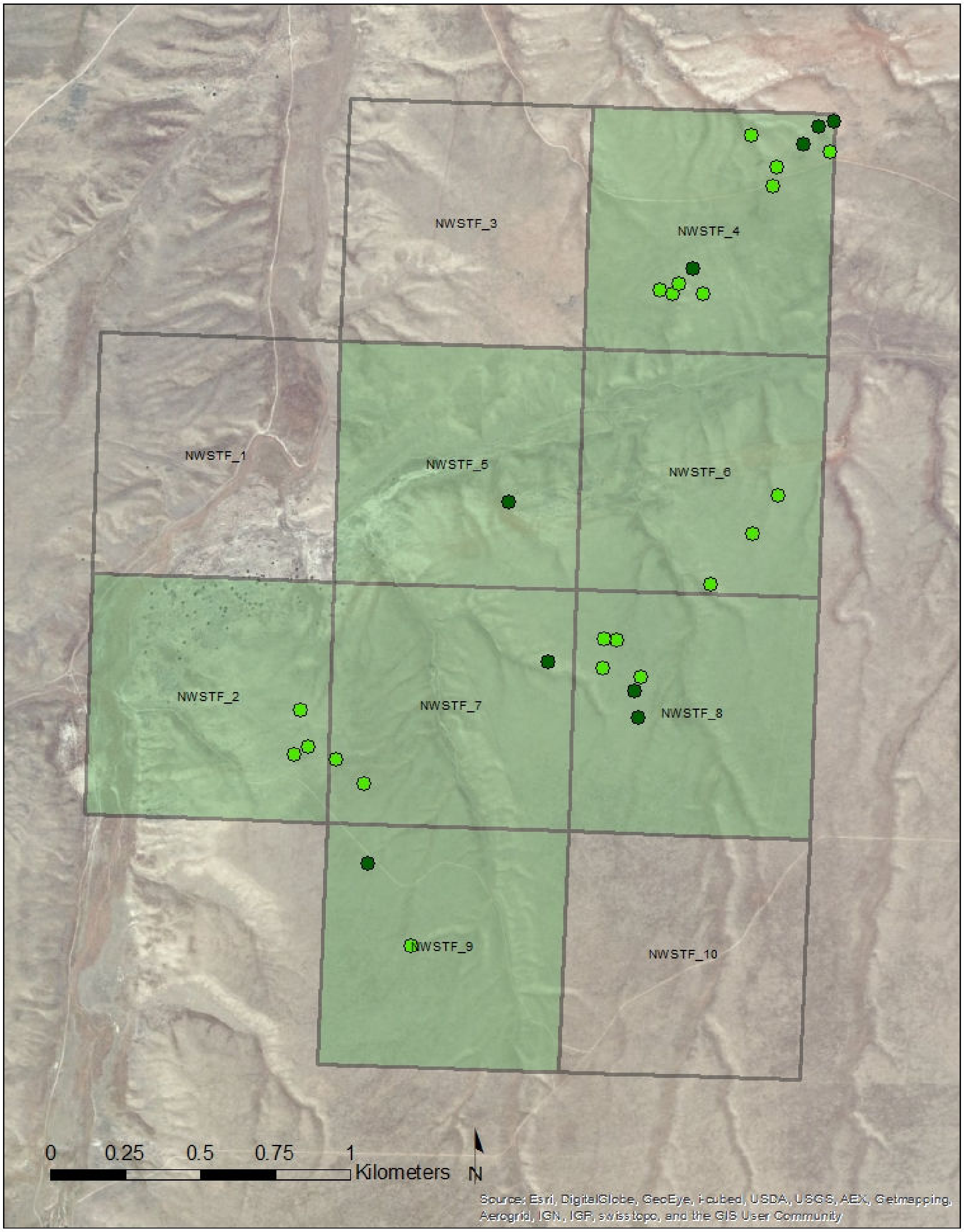

Figure 5. Human surveyors sampled the trial area 2 times. Bright green symbols indicate detection locations from the 1st survey and dark green from the 2nd. Note that some sampling units were occupied during a single survey period only.

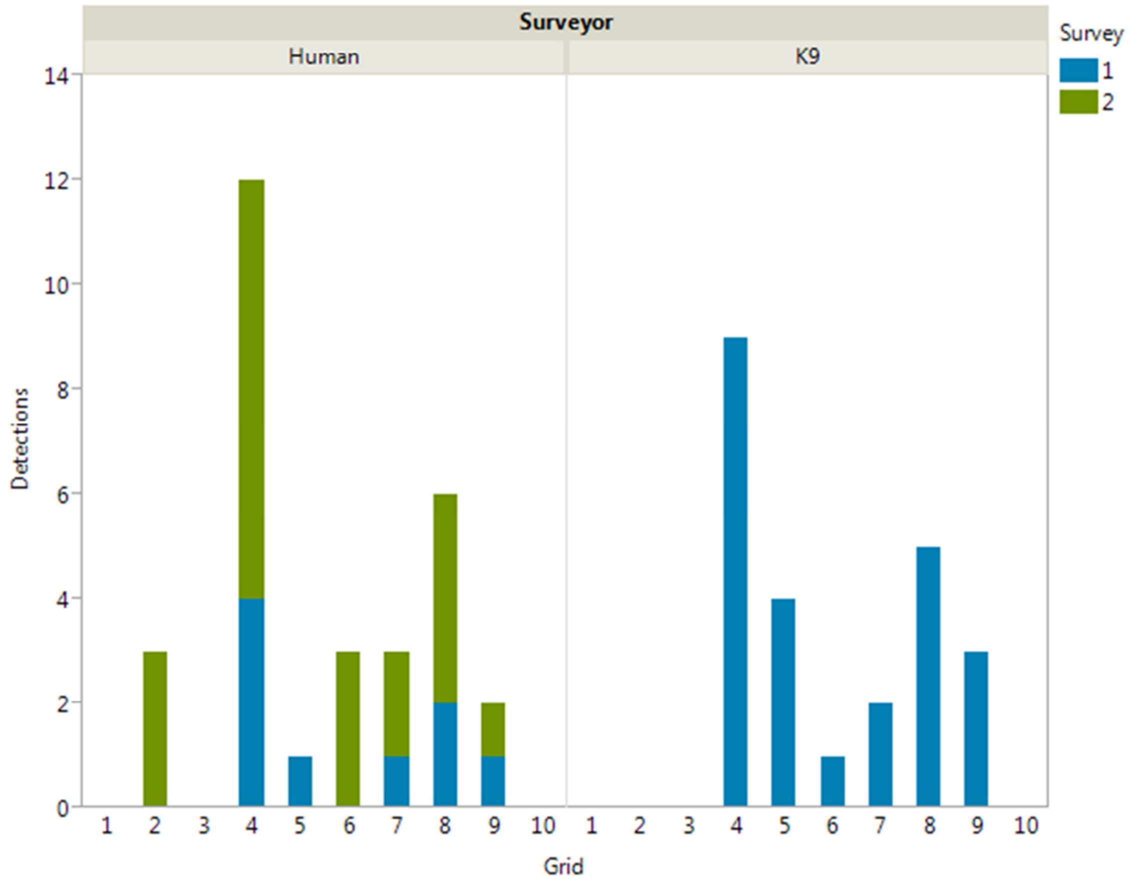

Figure 6. The number of detections per sampling unit was similar between surveyors (note: K9 = detection dogs).

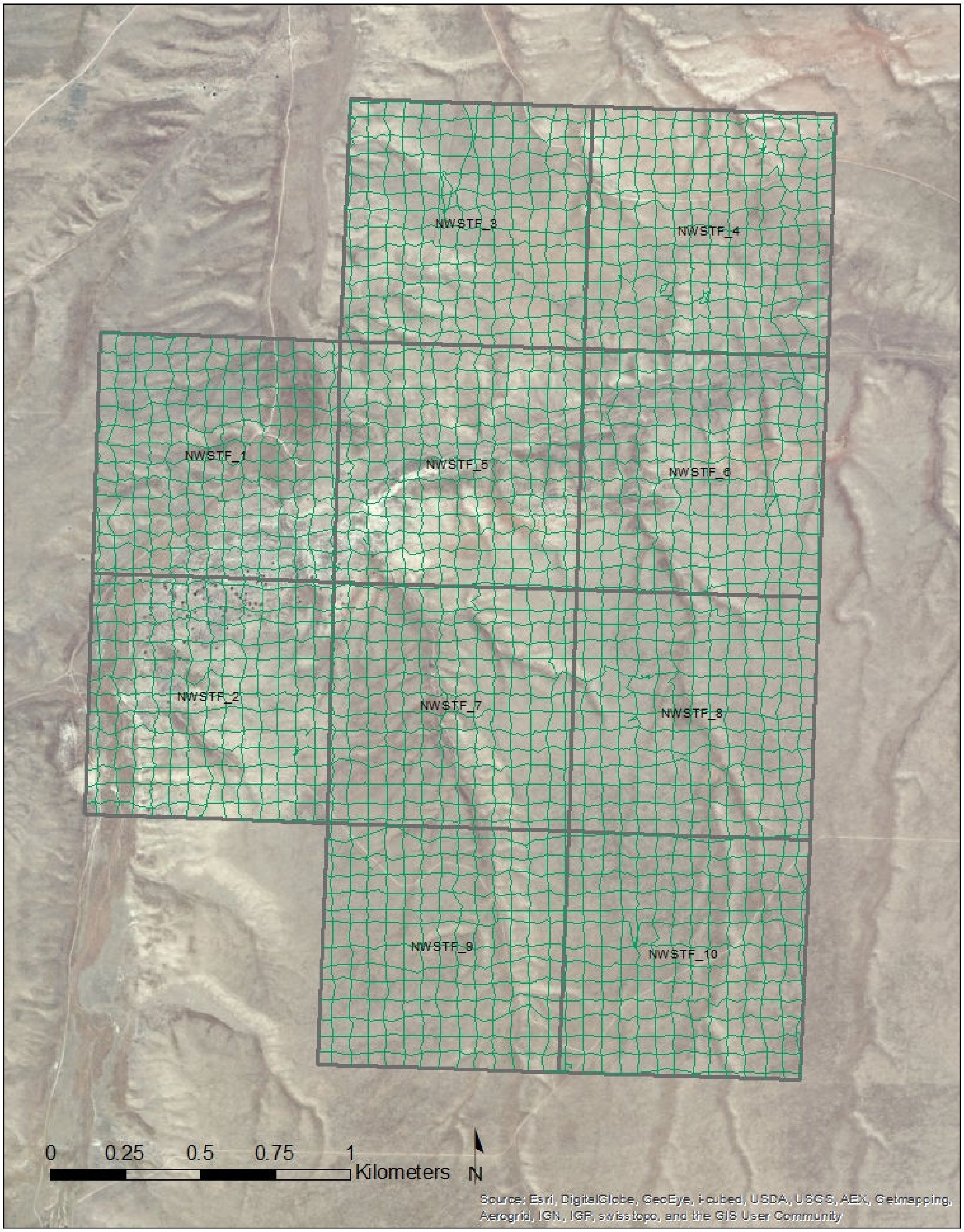

Figure 7. As anticipated, tracklogs from human surveyor demonstrate more consistency in survey effort (length and survey duration) compared with detection dog surveys. This figure represents human tracklogs from both survey periods.

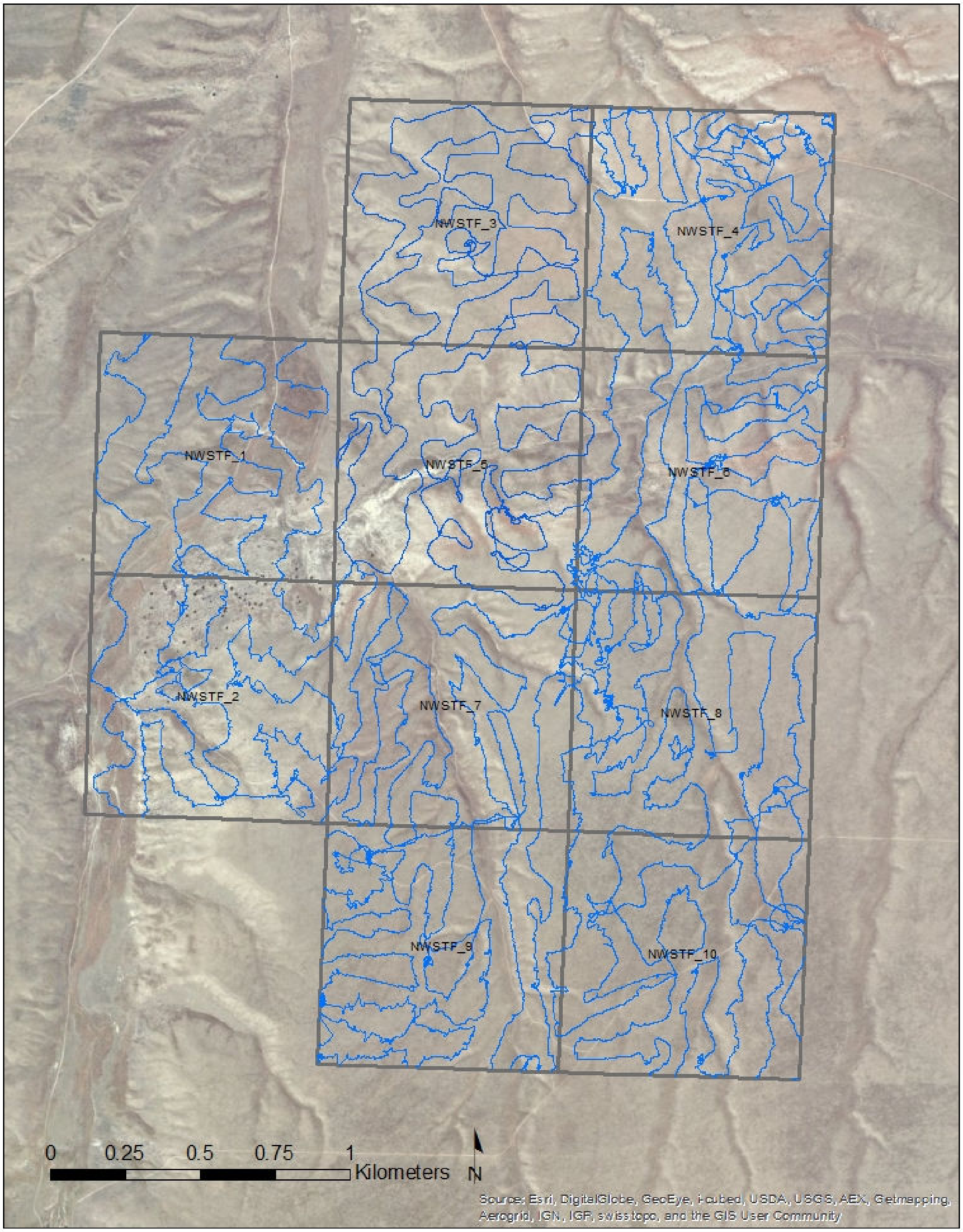

Figure 8. Detection dog tracklogs depict the greater variability in search effort as compared with human surveyor. However, both survey length and duration were higher on average for detection dogs. This figure depicts detection dog tracklogs for a single survey period.

Discussion
The cryptic nature, small stature, and semi-fossorial habits of WGS in combination with a broad distribution across the expansive landscape of the BCA make WGS a challenging species to monitor. Current monitoring methods are labor intensive and expensive to implement, prompting us to explore alternative survey options. As an alternative method, detection dogs seemed well suited to this task as they are trained to locate scat, one of the three factors used to confirm WGS presence, and can cover large tracts of land rapidly.

Results of our evaluation of detection dogs as an alternative to human surveyors indicate that detection dogs are a viable option for WGS surveys and may offer substantial cost savings over traditional survey methods. However, standard surveys do offer some advantages. For example, standard surveys were less variable in both length and time per survey unit and human surveyors are more tolerant of high temperatures encountered during field surveys. Also, with minor adjustments to field data collection methods, standard survey data could be used to estimate WGS densities using DISTANCE estimators (Buckland et al. 1993, Greene and Anthony 2009, Marr 2009). We believe most of these shortcomings could be addressed through minor changes to field methods for detection dog surveys. Standardizing search time and adhering to a general search pattern could reduce variability in effort among sampling units. Further, adjusting survey timing to compensate for high temperature by resting the dog during the heat of the day allowed surveys to continue during periods of high temperature encountered during the 2014 surveys (Cotterill 2014). However, generating WGS density estimates which account for detection probability would likely be challenging using detection dogs.

Detection rates on the BCA were low, similar to results observed in 2009. However, we believe this effort differed from the 2009 pilot study in important ways. First, we did not attempt to estimate WGS density, but rather we assessed distribution by determining WGS presence/absence across randomly selected sampling units. In our opinion detection dogs are well suited for this task as they are capable of surveying large tracts of land rapidly and cost effectively, important considerations when monitoring low density, widely dispersed animals. Further, the results of the comparison between standard surveys and detection dog surveys indicated the two were comparable. Finally, we intentionally sampled locations which were unoccupied or not assessed in 2013 to better understand the distribution of WGS outside of historic activity sites. WGS have never been detected in some of these areas, which may, in part, account for the low rates of detection we observed.

Other factors may have also contributed to the low number of detections we observed on the BCA in 2014 including: survey timing, inexperience of the dog team, and overall low abundance of WGS. Survey timing, relative to WGS above-ground activity periods, plays an important role in survey outcome. Marr (2009) indicates “that prior to emergence of litters, little calling occurred and adult females spent about 80% of morning daylight hours under ground, making them difficult to detect”. TNC and NWWC staff, conducting standard WGS surveys on NWSTF Boardman also noted low WGS activity in March of 2014. Timing detection dog surveys to correspond with peak periods of above-ground WGS activity would likely increase detection rates. Based on conditions observed in 2014, we recommend beginning surveys on April 1 (Cotterill 2014). The inexperience of the dog team with WGS likely contributed to low detection rates on the BCA during the initial two weeks of surveys. Although we allowed several days of on-site training at known WGS activity sites prior to the start of surveys, further training at new locations mid-season resulted in protocol modifications. Identifying WGS activity sites and allowing several days of on-site training prior to the start of surveys is critical to survey outcome. Also, we found that slowing the dog helped conserve the dog’s energy level and likely reduced the chances of missing

WGS (Cotterill 2014). Finally, based on recent survey results (Marr 2009, Rosier 2013 and 2014) and antidotal observations, WGS abundance on both the BCA and NWSTF Boardman appears to be low, likely resulting in decreased detection rates. Only 71 of 238 (30%) known WGS sites on NWSTF Boardman were occupied in 2014 and 40 of 100 (40%) sampled sites on the BCA were occupied in 2013.

Additional WGS monitoring and analyses

In addition to the WGS monitoring described above, TNC staff and a contractor, Northwest Wildlife Consultants (NWWC), conducted WGS surveys on NWSTF Boardman in the spring of 2014 (Gerhardt and Anderson 2014, Rosier 2014). Some of the key findings of that work may help refine future monitoring efforts on the BCA and therefore we have included the following summary.

NWWC completed systematic transect surveys on 3885 ha in the SE portion of NWSTF Boardman between March 4, 2014 and May 15, 2014 resulting in 106 WGS detections (Gerhardt and Anderson 2014). Using these results we evaluated the minimum distance between detection locations and historic WGS sites located within the survey area. The relationship is highly skewed and ranged from 45 m to 1704 m (n=106, median = 427m, IQR = 188 – 624 m). Importantly, only 36 detections (34%) were ≤ 300 m, the search area used at historic sites in 2014, and only 50 detections (47%) were ≤ 400 m, the search area used in surveys prior to 2014. These results indicate a potential limitation of using a sampling scheme based on visiting historic sites. In a large, contiguous grassland with few apparent barriers to dispersal, animal movement is likely confounded with demographic changes. Although we cannot attribute these results directly to animal movement, they do suggest historic site surveys may not be representative of WGS occupancy. Further, we found that historic monitoring sites were located closer to linear features (i.e. roads, trails, and fire breaks) than transect detections and random points and therefore may not be representative of the entire study area (Rosier 2014). A similar situation may exist on the BCA, particularly with monitoring sites added after initial surveys were completed in 2001. Therefore, we do not recommend using the historic WGS sites identified after 2001 when assessing spatial relationships due to this bias.

Finally, we used the results of the NWWC systematic transects to evaluate the relationship between WGS detections and published soil texture information for the 2014 survey area on NWSTF Boardman. We simplified this analysis by combining soil types into 2 soil texture classes, silt loam and sandy loam, which covered 86% and 12% of the survey area respectively. The results of this analysis indicated WGS detections by soil texture differed little from expected and soil texture at detection locations varied little from those at random locations (Rosier 2014). The results of this analysis prompted us to conduct a similar analysis for the BCA using WGS locations identified during the 1999 and 2001 systematic transect surveys.

To assess the relationship between soil characteristics at occupied WGS sites and random locations on the BCA we used published soil information (USDA NRCS 2015) and survey results from systematic surveys completed in 1999 and 2001 (Morgan and Nugent 1999). We compared percent silt content, by soil horizon, at occupied WGS sites and randomly selected sites >300m from occupied sites. We selected the parameter percent silt content based on the findings of Greene and Anthony (2009) and we eliminated other textural classes (i.e. sand and clay) from this analysis because they are highly correlated (e.g. r^2 = 0.95 for percent sand and silt in horizon 1). The 300m buffer was selected based on findings from telemetry space-use studies and field observations which indicate much of the annual WGS activity is concentrated within 300m of an activity site (Delavan 2008, Marr 2009). Further, we included soil horizons, which represent physical boundaries (i.e. changes in texture or structure) within a soil profile, to assess textural changes with depth. We used nonparametric Wilcoxon/Kruskal-Wallis test in JMP 11.1.1 (SAS Institute Inc. Cary, NC) to evaluate these relationships. Results of this analysis indicated soils at occupied sites had slightly higher silt content compared with random locations for all horizons; however, overlapping confidence intervals demonstrate the relationship between WGS occupancy and soil texture is uncertain (Table 1, Fig. 9). The largest difference was observed in horizon 3 where mean silt content was 2.4% higher for occupied sites than at random sites. The biological importance of this small increase, if any, is unknown as both occupied and random sites have relatively high silt content in horizon 3 ($\bar{x}$ = 47.96 and $\bar{x}$ = 45.59 respectively) and the variability in the data indicate a high degree of overlap. Our results contrast with the findings of Greene and Anthony (2009) which indicate WGS select sites with higher silt content. Field soil measurements, rather than reliance on published soil data, may produce different results. However, based on this evaluation, soil texture does not differ greatly between occupied and random sites on the BCA.

Table1. Results of the nonparametric Wilcoxon/Kruskal-Wallis test and summary statistics indicate silt content was slightly higher at occupied versus random sites; however, overlapping confidence intervals demonstrate this relationship is uncertain. Depth (cm) indicates the range of depths a soil horizon could occupy. Note: sample size varied between soil horizons and category (occupied vs. random) because some soils lack all horizons.

		WGS sites			Random points			
Horizon	Depth (cm)	n	$\bar{x}$	95% CI	n	$\bar{x}$	95% CI	*p*
H1	0-152.4	128	27.41	1.6641	128	26.95	1.6641	0.469
H2	7.6-152.4	128	28.41	1.2491	127	27.97	1.2535	0.447
H3	17.8-177.8	119	47.96	2.441	118	45.59	2.4512	0.017

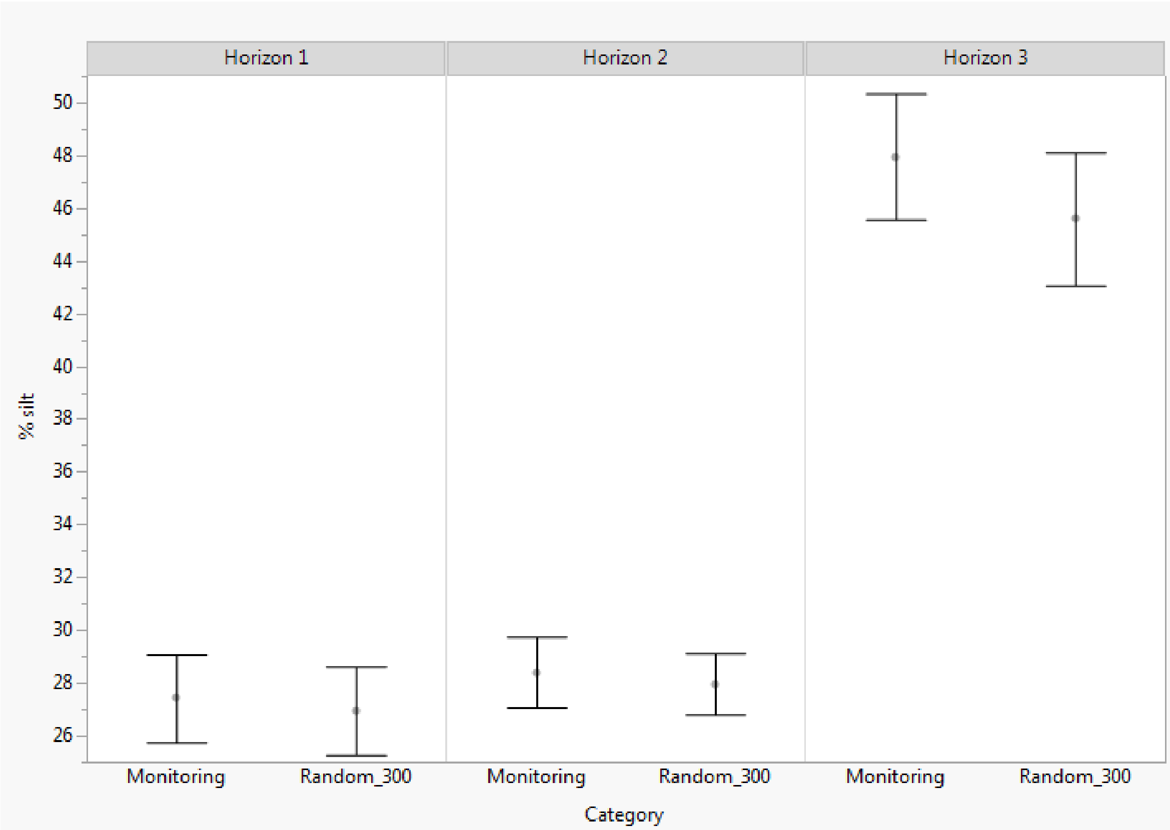

Figure 9. Mean silt content (± 95% CI) was slightly higher at WGS sites (monitoring), for all horizons, than at random locations (random_300); however, overlapping confidence intervals demonstrate the relationship between WGS occupancy and soil texture is uncertain.

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