Monitoring Occupancy of Delmarva Peninsula Fox Squirrels at Blackwater National Wildlife Refuge Using Motion-Triggered Cameras

Blackwater National Wildlife Refuge

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Purpose: This document was prepared to explain the methods and results of a 3-year Delmarva Peninsula fox squirrel monitoring effort in sufficient detail to enable other refuges to consider this approach.

Executive Summary: The Delmarva Peninsula fox squirrel (DFS) is an endemic subspecies of the eastern fox squirrel found only on the Delmarva Peninsula. Blackwater National Wildlife Refuge is known to support a large population of the species and has played an important role in studying and sustaining local populations. In 2016, a 3-year monitoring effort was initiated for the purpose of developing an occupancy estimate for DFS on the refuge. Occupancy modeling accounts for imperfect detection and produces an unbiased estimate of occupancy (i.e. occurrence) across the sampling area. Motion-triggered cameras were placed in 55 sampling units across the refuge, representing a total of 1,792.2 ha (4,428.6 ac) of potential habitat. Of the 55 cells sampled, 31 detected DFS, resulting in a naive occupancy estimate of 0.5636. Using the single season model in the program PRESENCE, occupancy is estimated to be 0.5755 (standard error 0.0684, 95 percent CI 0.4391-0.7013). Overall, we consider this monitoring plan to provide a reasonably good assessment of the occupancy of Delmarva fox squirrels across the refuge. If this study is replicated in the future, it may be possible to detect changes in site occupancy that occur from factors that we cannot easily see or predict like disease, predation, weather events, or combinations of these factors.

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Monitoring occupancy of Delmarva Peninsula fox squirrels at Blackwater National Wildlife Refuge using motion-triggered cameras

1. Introduction

The Delmarva Peninsula fox squirrel (*Sciurus niger cinereus*), commonly called the Delmarva fox squirrel (DFS), is a subspecies of the eastern fox squirrel found only on the Delmarva Peninsula. For decades it was listed as endangered on the Federal List of Endangered and Threatened Wildlife. It inhabits mature forests of mixed hardwoods and pines within the agricultural landscapes of the peninsula. Historically, this subspecies had a patchy distribution throughout most of the Delmarva Peninsula and into southern Pennsylvania. By the time of its listing in 1967, remnant populations occurred in only four Maryland counties, including Blackwater National Wildlife Refuge (Blackwater NWR) (Taylor 1976). After listing, recovery efforts focused on expanding the squirrel's distribution through translocations, many of which succeeded, and new populations have been discovered since then. Eventually the DFS was determined to be sufficiently abundant and well-distributed enough to withstand foreseeable threats. The subspecies was removed from the Federal List of Endangered and Threatened Wildlife, effective December 16, 2015 (Federal Register Vol. 80, No. 220, November 16, 2015).

Blackwater NWR is at the heart of the species' range and has supported a large population of Delmarva fox squirrels throughout the recovery effort. Ensuring the persistence of the DFS at the Refuge is a key concern for managers, who make decisions on an annual basis regarding habitat management priorities. Some of these decisions, such as forest management operations, treatment of gypsy moth outbreaks, or land acquisition priorities have the potential to affect DFS populations on the Refuge. Because of the squirrel's secretive nature, qualitative or opportunistic monitoring is insufficient. A dedicated monitoring program is required to provide decision makers the necessary information to manage the species on the Refuge. Monitoring the DFS at Blackwater NWR will also contribute to the post-delisting monitoring for this species (USFWS 2015).

Over the years, Delmarva fox squirrels have been monitored using a variety of approaches. In the 1990s the Recovery Team chose seven benchmark sites for detailed population monitoring across the range; two sites (Egypt and Jarrett tract) were located on Blackwater NWR. Populations at these sites were monitored through nest box surveys and trapping (USFWS 2015). This resulted in detailed and useful information about two small areas on the Refuge (Dueser 1999, Mullen and Lindberg 2014), but it did not provide estimates for Refuge-wide populations.

Since 2000, the U.S. Fish and Wildlife Service (Service) has been developing the use of remotely triggered wildlife cameras for DFS monitoring. Morris (2006) used cameras placed on a monitoring grid across the Refuge to develop a habitat model of forest variables that predict DFS

presence. These data were also used to test a Light Detection and Ranging (LiDAR) model for DFS habitat (USFWS 2012; Appendix E). Cameras have been used annually since 2010 to monitor DFS on Blackwater NWR and these studies provide data on seasonal detection rates, comparisons to trapping data, and overall indicate that occupancy analysis and cameras are a good approach for monitoring DFS on the Refuge. As summarized in the Post-delisting Monitoring Plan (USFWS 2015; Appendix C) there are many life history features of the DFS that contributes to this suitability. For example, DFS have high site fidelity and do not leave their home range easily (Paglione 1996), they tend to be persistent on the landscape, they do not move frequently or far, and their population numbers are not erratic but appear to be a function of their current population distribution and habitat. Thus, persistence and extirpations detected by cameras are likely to reflect true changes in the distribution.

Camera data, combined with occupancy modeling (MacKenzie et al. 2006, entire), provides a robust method of DFS population monitoring on the Refuge. The purpose of this project is not to monitor DFS response to any particular event or management practice, but to obtain a Refuge-wide estimate of DFS occupancy of forested habitats. If this study is replicated in the future, it may be possible to detect changes in site occupancy that occur from factors that we cannot easily see or predict like disease, predation, weather events, or combinations of these factors. The more obvious effects of habitat loss from relative sea level rise will be monitored using aerial imagery, GIS layers, and other specific studies. The objective of this monitoring effort is to obtain an overall occupancy rate estimate for DFS on Blackwater NWR.

2. Sampling Design Considerations

Description of occupancy modeling approach: When properly implemented, occupancy modeling overcomes many limitations of previous methods to determine the distribution of a species and changes in that distribution over time. We know that rarely are all individuals detected in one survey, regardless of field techniques used (MacKenzie 2005). Given that detectability of the species is unlikely to be 100 percent, a non-detection does not necessarily imply the absence of a species in the sample unit. Imperfect detectability has been a challenge in interpreting and analyzing occupancy-related data, which prior to occupancy modeling was often modeled with binary logistic regression, an analytical approach that does not account for imperfect detectability. Multiple visits to a site are intended to overcome the challenges of imperfect detection and thus many past analyses using logistic regression or other techniques may be perfectly reliable, but they cannot quantify the issue of imperfect detection without a specific analysis of detectability.

In addition, there may be considerable variation in detectability among study sites, influenced by site characteristics, like vegetation, and survey conditions among days or years caused by weather. Because of variation in detectability, bias is invoked when analyzing detection/non-detection data while assuming it is presence/absence data (as were analyses conducted using logistic regression). The use of occupancy modeling addresses this bias.

MacKenzie et al. (2002, 2003, 2004*a,b*) pioneered the development of occupancy modeling as an approach for solving the problem of imperfect detectability (i.e. the probability of detecting a site occupant) associated with assessing distribution patterns of wildlife populations. Fundamental to occupancy modeling is determining detectability from repeated use of a monitoring protocol and determining the probability of detection in any one survey or detection opportunity (e.g., days of camera-trap monitoring, number of visits to a site for bird surveys). A survey period is comprised of individual survey events. For example, a survey period for camera traps at Blackwater NWR is a 12-day session of camera deployment, with each day being an opportunity for a detection; for bird surveys, a spring survey period may involve three visits to the site with each visit being an opportunity for detection. Observations are recorded for each survey event – a day for cameras, a visit for bird surveys, but survey periods and the number of survey events are ultimately defined by the species, project goals, and logistical constraints. Variation in detectability may be caused by site characteristics (e.g., habitat variables) or survey characteristics (e.g., weather conditions), but occupancy relates only to site characteristics. Assessing the influence of site and habitat covariates on detectability is important in interpreting differences in detectability and associated estimates of the probability of occupancy, but including such covariates is not necessary for occupancy modeling.

Occupancy assessment will not provide some information that is obtained from mark-recapture data that trap, handle, and mark individual animals. Mark-recapture studies can provide detailed information on sex ratios, reproductive status, estimates of longevity, and other parameters important for population modeling. However, mark-recapture studies are time and labor intensive and can only be accomplished over small areas. They are also limited to seasons where temperatures are not too hot or cold for trapped animals. The benchmark sites monitored previously (USFWS 1993) used trapping and mark-recapture but this could only be done for two small areas on the Refuge and could not provide a Refuge-wide assessment of populations. Occupancy modeling will allow a more efficient assessment of distribution and changes in the distribution throughout a much larger area. From a practical standpoint, the use of cameras, rather than trapping and handling animals, allowed volunteers to take a much larger role in collecting data for informing DFS conservation. This provides a more realistic and achievable monitoring program given declining budgets and reduced staff on many refuges.

Population to be estimated: We want to describe the population of DFS occupying the forested areas on the Refuge that are expected to be resilient to relative sea level rise for at least the next 25 years (Figure 1). Forested areas that are experiencing the effects of sea level rise now, or in the near future, will not be sampled because the habitat changes, and subsequent population declines, in these locations are clear. Specific questions regarding the response of DFS or other wildlife species to sea level rise could be pursued with other studies – but not surveillance monitoring. Some small isolated upland islands or ridges were not sampled because they were too small.

The sample unit or site: The sampling unit as described in MacKenzie et al. 2006 (p. 157) is a 16 hectare (39.5 acre) area of forest. We chose a 16-hectare area because this reflects the average home range of the DFS (USFWS 2012; p. 11). Home range sizes can vary considerably, but

values in Dorchester County were typically 30 to 40 acres (Paglione 1996). DFS home ranges overlap so an area of this size may contain more than one individual DFS. As described by MacKenzie 2005 (p. 851), when the sampling unit is the approximate size of a home range, we can appropriately describe the site as occupied or not occupied, and the presence of the animal likely indicates they are always in that area. If we chose a smaller area, we would be estimating the relative use of a smaller portion of a home range. If we chose a larger area, our sample size of potential grid cells will be too small, and we will not be able to ensure that every individual DFS has a chance to be detected (Karanth et al. 2011, p.104).

Therefore, the sampling frame is a grid of 16-hectare sampling units, or square cells, superimposed using GIS over the forested area to be monitored. Cells that intersected the boundary of the monitoring area were trimmed to only include the monitoring area of the cell. Trimmed cells that resulted in a remaining area less than 8 hectare were discarded. This process resulted in 131 potential sample units totaling 1,792.2 hectares (4,428.6 acres) (Figure 1).

Figure 1. Management areas sampled on Blackwater NWR 2016 to 2018.

A sample of grid cells were selected for surveys by randomly identifying an initial grid cell, and then systematically selecting grid cells at least one cell apart from other selected cells to increase the independence of each sample unit (Figure 2). In some areas, cells that were diagonally adjacent to one another were selected in order to obtain a sufficient total sample size. This sample unit spacing was done to reduce the likelihood that we were sampling the same animal in multiple cells. We did not want the presence or absence of DFS in one sampled cell to influence the presence or absence of DFS in another sampled cell. A total of 55 cells were selected from the 131 potential cells.

Survey methods: Once a cell was selected for sampling, two cameras were placed in the best DFS habitat within that cell. Best available DFS habitat was determined using the LiDAR model (USFWS 2012) as well as the technician's knowledge of appropriate DFS habitat. Cameras within each sample unit were placed greater than 100 meters apart in most instances. Placing cameras in the best available DFS habitat, as well as using two cameras in each sample unit, was done to maximize the likelihood of detecting DFS in that sample unit. The two cameras in each cell equate to one sample unit (i.e. the cell is the sample unit, not the individual camera). Each camera was placed on a tree approximately 10 to 15 feet from the bait site. Each site was baited with field corn every 2 to 3 days during the sampling period. Appendix A provides details on camera set up.

The spacing of cells, and more importantly the distance between cameras in adjacent cells, helps ensure the independence of each sample unit. Distance between nearest camera locations in adjacent sample units was >500 meters in most cases and always >300 meters. These guidelines were derived using unpublished data provided by Dr. Carol Bocetti (California University of Pennsylvania). Dr. Bocetti has conducted mark and recapture surveys of DFS on and adjacent to the Refuge. She sampled three trapping grids that cover approximately 125 hectares (309 acres). An analysis of Dr. Bocetti's data indicates the average point to point distance between within-season recapture points was 184 meters (both genders). The maximum distance was 415 meters and 75 percent of the recaptures were 239 meters or less. This is based on 59 within-season recapture events during spring sampling (March through May). Additionally, the radius of a 16-hectare home range is 227 meters (Paglione 1996, Pednault-Willett 2002). Therefore, we feel confident that cameras placed >500 meters apart are highly unlikely to detect the same individual during a sampling period and cameras placed >300 meters apart are also likely to be independent.

Sample size and sampling allocation: Outcomes of occupancy modeling based on previous camera-trap data at Blackwater NWR were used to determine a sample size that would enhance the likelihood of predicting occupancy with a reasonably low standard error (+/- 0.06). Parameters estimated from this occupancy modeling were used to determine detection probabilities, the number of days a camera should remain in the field, and the sample size of grid cells needed to provide reasonable estimates for the Refuge occupancy.

Using previous data, we used the following equation developed by Mackenzie and Royle (2005) to estimate sample size:

$$var(\hat{\psi}) = \frac{\psi}{s}\left[(1-\psi) + \frac{(1-p^*)}{p^* - Kp(1-p)^{K-1}}\right]$$

Where,

$p^* = 1 - (1 - p)^K$ = the probability of detecting the species at least once during K surveys of an occupied site (note: in this case a survey represents a single day that a camera-trap is maintained at a site; hence, the number of surveys at a camera-trap site is the number of continuous days the camera-trap was maintained at the site), s = sample size, p = probability of detection, and Ψ = occupancy rate.

The probability of detection for a 12-day survey was determined from previous data and the following parameters were then used to determine the sample size of grids to be surveyed:

- $\psi = 0.77$,
- $p_1 = 0.42$
- K = 12 (days)
- SE = 0.06
- $p^* = 0.999$

Inserting these values in the equation from Mackenzie and Royle (2005) resulted in a sample size estimate of:

$$s = \frac{0.5}{0.06^2}\left[(1-0.05) + \frac{(1-0.999)}{0.996 - 12 \times 0.37(1-0.37)^{12-1}}\right] \approx 49,$$

Thus, our sample size calculation suggested that a survey protocol that deployed cameras for 12 days should include at least 49 cells to obtain a standard error of 0.06. (Note: values for ψ and p were derived from occupancy modeling of pilot data collected during other sampling events on the Refuge).

Assumptions of occupancy modeling: Long-term, landscape-level assessments can be constrained by logistical and financial realities, often resulting in the need to supplant an "ideal" survey with one that is merely adequate. Occupancy modeling generally contributes robust outcomes, even when survey designs deviate from the ideal. However, there are four basic assumptions that are expected to be met for occupancy modeling to contribute unbiased outcomes over a survey period. The following is a brief review of each of these assumptions and rationale for why the respective assumptions are anticipated to be met by this monitoring project.

Assumption 1: Occupancy state is "closed" (i.e., individuals of the species being studied do not leave the area encompassing the sampling site during the sampling period), and occupancy of a site does not change during the sampling period (i.e., an occupied sited does not become unoccupied).

Fulfilling Assumption-1: In the relatively brief 12-day survey period, we do not anticipate changes in DFS occupancy of these 16-hectare areas. Movement patterns of DFS determined by radio-telemetry studies and trapping, support this perspective. Also, most females are rearing young during spring and movement is restricted to areas near dens, further limiting the likelihood of surveys sites experiencing extensive changes in occupancy.

Assumption 2: Sites are independent. Detecting individuals of the target species at one site is independent of them being detected at other sites (i.e., individual animals should not occupy multiple survey sites).

Fulfilling Assumption-2: Cameras in adjacent sample cells will usually be >500 meters apart and always >300 meters apart. Based on the analysis of Dr. Bocetti's data discussed earlier, this spacing should be sufficient to ensure sample unit independence. As with Assumption-1, the relatively short survey period and restricted movement of many females when surveys are conducted contribute to meeting Assumption 2.

Assumption 3: No unexplained heterogeneity in occupancy (i.e., the probability of occupancy is consistent across sites, or deviations can be explained by site characteristics (covariates) included in the model.

Fulfilling Assumption-3: Blackwater NWR is a relatively small area, with many suitable habitats occupied by DFS. The density of DFS is anticipated to vary among regions, which is likely influenced by overall forest maturity within a region and this may influence occupancy. However, camera-traps will be placed in what is considered "best" DFS habitat in a sampling unit according to the LiDAR model (i.e., habitat conditions will be similar among sampling sites), which should minimize variation in occupancy regardless of differences in DFS density among regions.

Assumption 4: No unexplained heterogeneity in detectability (i.e., as with occupancy, detectability is expected to be consistent across occupied sites, or deviations can be explained by site and/or survey characteristics included in the model).

Fulfilling Assumption-4: Camera-traps are deployed and baited in a consistent manner throughout the project (see Appendix A). Two cameras were deployed within each sample cell to enhance the likelihood of comparable detection patterns among occupied sites. Additionally, cameras will be placed in the best habitat available within each cell, following the LiDAR habitat model, to minimize variation in detectability between sample units.

3. Final Methods for Blackwater NWR Monitoring

Sample selection: From the total of 131 potential grid cells on the Refuge we selected a sample of 55 grid cells, slightly more than the 49 cells suggested by the sample size calculated to produce an estimate with 0.06 SE.

Cameras were deployed for 12 full sampling days. The day the camera was deployed and the day the camera was retrieved did not count as a sample day since they were not full days. Sample size calculations presented earlier in this document indicate 12 sampling days will give us high

probability of detection at a grid cell (0.99) based on previous data. Reconyx model RC55 and HC600 cameras were used throughout the project.

All sampling was done between early March and mid-April. An analysis of pilot data collected at three locations on the Refuge during 2010 and 2011 indicate probability of detections are slightly lower in the spring than fall, but both were equal to or higher than summer and winter (Appendix B). Spring sampling was selected over fall to avoid conflicts with deer hunting.

All 55 sample units could not logistically be sampled in a single year given various fiscal and practical constraints. To minimize logistics associated with time and travel, the grid was portioned into three sampling regions. Greenbriar Swamp was sampled in 2016, Kentuck Swamp and Buttons Neck was sampled in 2017, and Units S, T, and M1 were sampled in 2018 (Figure 2). Two 12-day sampling periods were needed to survey all of the sample cells each year. In any given year, half of the sample cells were surveyed during the first 12-day period. The cameras were retrieved, data downloaded, batteries checked, and the cameras were redeployed in the second half of the cells for a second 12-day period.

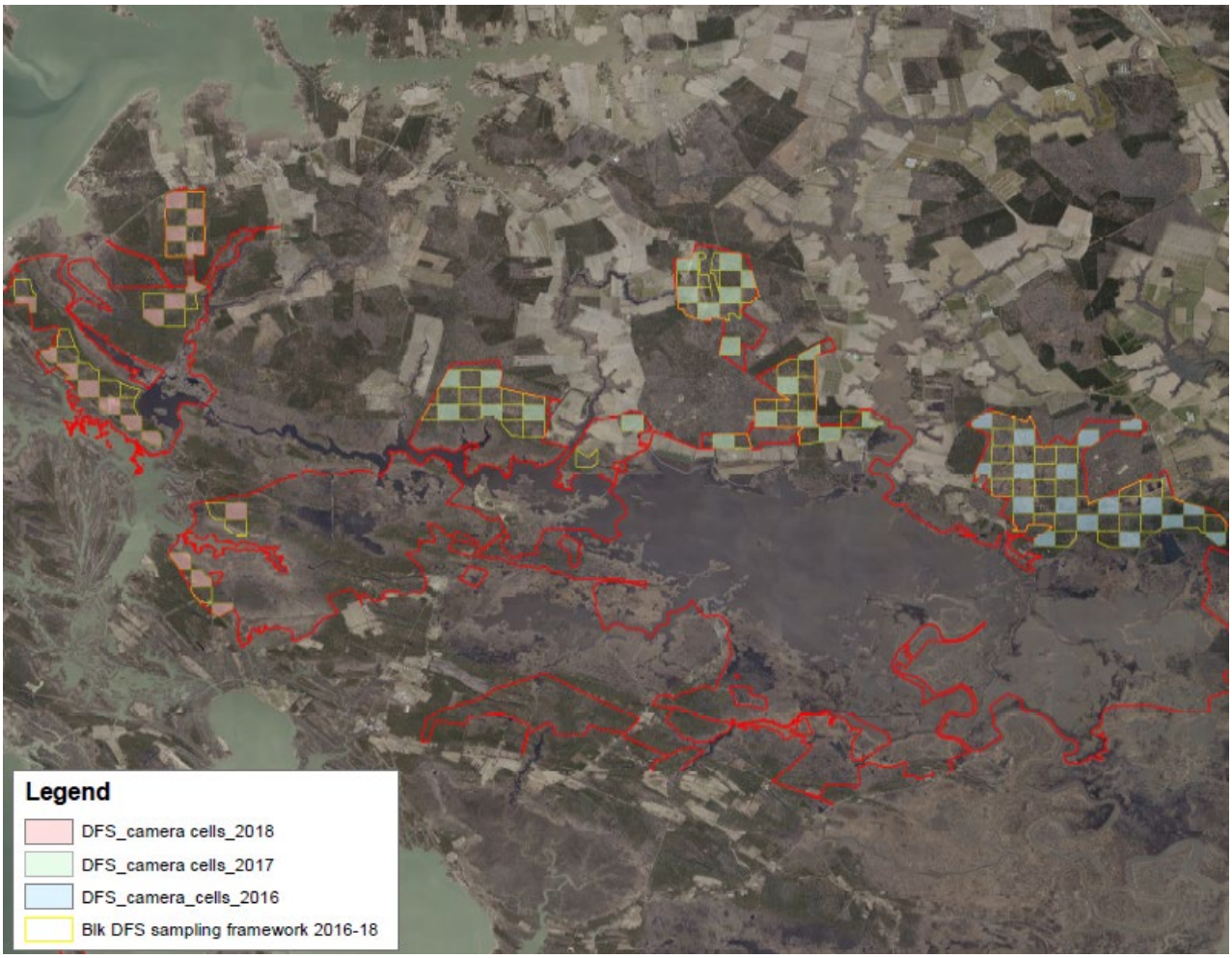


Figure 2. Grid of the 131 cells across the refuge sampling area and the sample of 55 cells selected for DFS surveys.

The cameras were retrieved and images were examined for DFS detections. A 'detection history' was generated by recording whether a DFS was detected at that camera on a given day. Detections and non-detections are sequentially recorded as 1s or 0s, respectively, for each day the camera was deployed (Appendix E). Data from the two cameras within each cell were then merged; *thus if one or both cameras* in the grid detected a DFS on that day, the result was a 1, indicating presence. If *neither of the two cameras* detected a DFS on that day, the result was recorded as a 0. These 1's and 0's recorded sequentially provide the detection history for that cell. Data were analyzed using the single-season occupancy models in program PRESENCE.

4. Results and Discussion

Summary Results: A total of 55 cells were sampled over the 3-year period (Table 1). Point 22B had a camera malfunction during deployment, so detections at cell 22 were based on only one functional camera. No other operational problems were encountered. Maps showing camera placement and detection results are presented in Appendix D. Of the 55 cells sampled, 31 detected DFS, resulting in a naive occupancy estimate of 0.5636. Using the single season model in program PRESENCE occupancy is estimated to be 0.5755 (standard error 0.0684, 95 percent CI 0.4391-0.7013, Appendix C). The naive estimate of occupancy and that determined by the program PRESENCE are very similar. We attribute this to a protocol that tried to maximize detections (e.g. length of time the cameras were out, two cameras vs. one camera) and using the LiDAR habitat model in placing cameras.

Table 1. Sampling work on Blackwater NWR 2016-2018

Sampling region	**No. cells sampled**	**Sampling timeframe**	**Number of occupied cells [a]**		
			Both cameras	1 camera (A)	1 camera (B)
Greenbriar Swamp	17	3/17/2016 - 4/13/2016	9	5	5
Kentuck Swamp and Buttons Neck	20	3/6/2017 - 4/3/2017	13	11	11
Areas S, T, and M2	18	3/8/2018 - 4/9/2018	9	5	7

[a] as determined by 1 or more photos of DFS in a cell over a 12-day period.

Two cameras versus one: Not surprisingly, the number of cells found to be occupied was higher using two cameras in a cell than if we used only one camera in each cell (Table 1). Note that in Greenbriar and Kentuck Swamp, though each camera detected the same total number of occupied cells, these were not the same cells, thus using two cameras the total is higher. The estimated occupancy was 0.39 and 0.46 using either camera A or B alone, but 0.58 using the summed results of both cameras (Figure 3). This result suggests that DFS may not be moving around the entire 16-hectare cell during the 12-day sampling period and that two cameras are better able to determine true occupancy of the sampling cell. Interestingly, the probability of detection was better in the A cameras than the B cameras (0.29 and 0.19 respectively; Figure 3).

The protocol has biologists going to a grid cell and picking the best site they can find and placing the first camera at that site (Camera A); and then finding the next best site within the cell for the second camera (Camera B). Apparently, the biologists' assessment of the best site (Camera A) and the second best site (Camera B) were correct. And while the second best site may not have been as good as the first, both cameras provided a better estimate than either camera alone (e.g. using both cameras, we detected occupancy of more grid cells than using either camera alone).

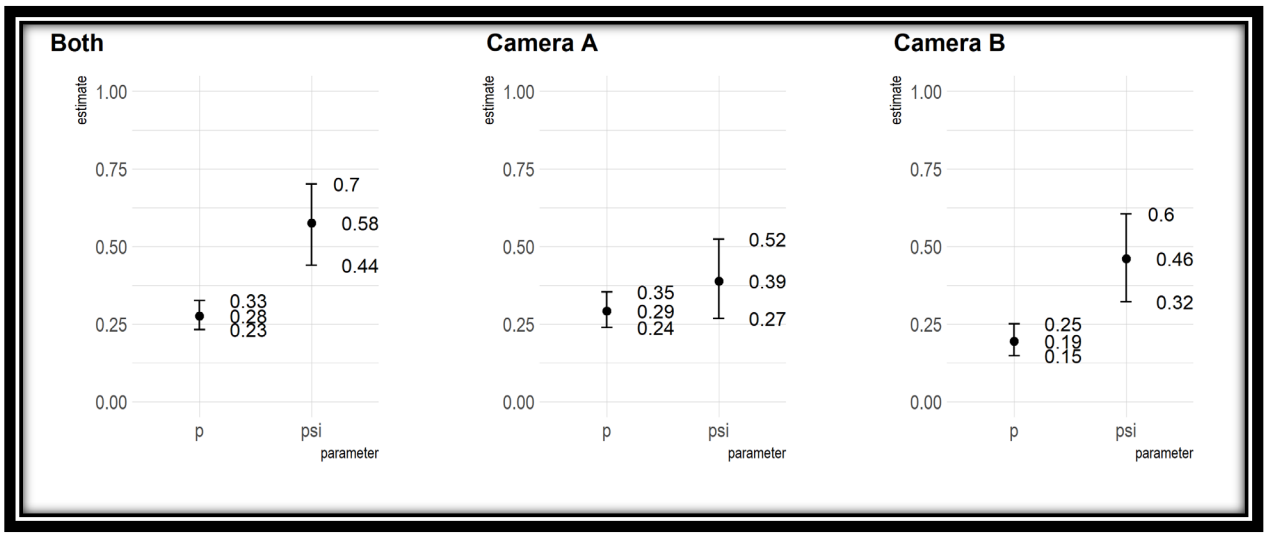


Figure 3. Results of occupancy analysis comparing probability of detection (p) and occupancy estimate (psi) using both cameras in a cell or only one camera per cell.

The number of days required to obtain first detections of DFS was longer than expected. Of the 31 cells that detected DFS, first detections occurred on the first day of sampling at 6 (19 percent) sample cells and within the first 6 days at 18 (58 percent) cells. This was less than the 47 percent and 75 percent, respectively, predicted by the pilot data. The number of cells detecting DFS increased rather evenly throughout the 12-day sampling period (Figure 4). This indicates longer than expected periods of time required to detect DFS in the sampling cells and may warrant extending the sampling period for future studies.

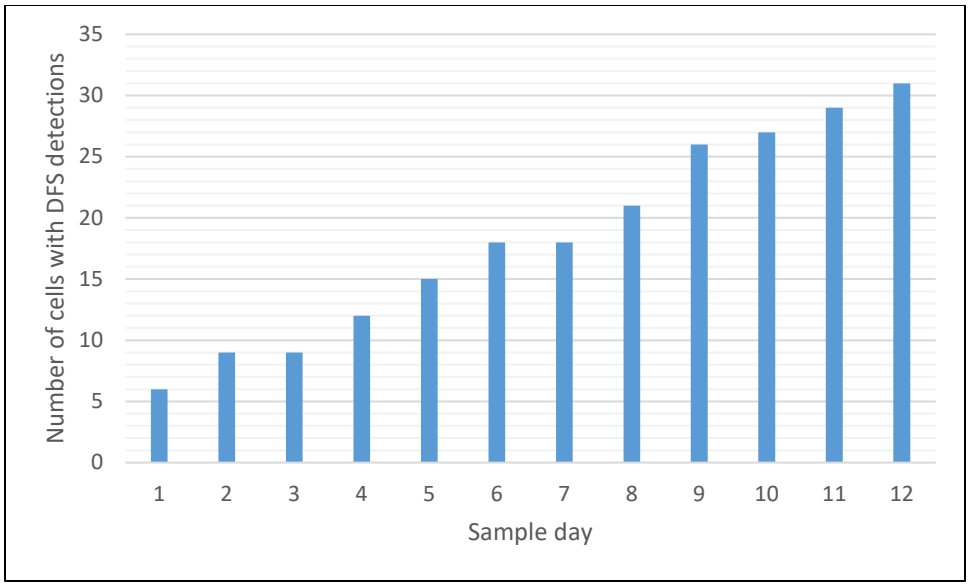


Figure 4. Days to first detection at sample cells that detected DFS at Blackwater NWR 2016-18.

Where DFS were detected, the number of days during the 12-day period that DFS were encountered varied greatly among sample cells (Figure 5). Only one cell (3 percent of successful cells) detected DFS every day during sampling, whereas in 11 (34 percent) of the successful cells, DFS were detected only one day. A number of factors could contribute to this variability, including local DFS density, proximity of the camera to den sites, proximity of the camera to other frequently used foraging areas, weather, and overall food availability.

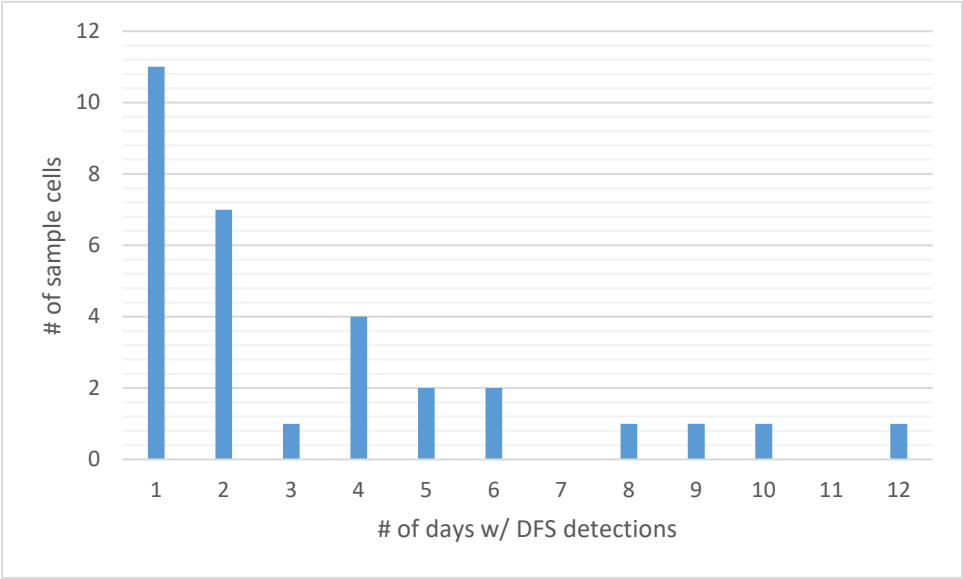


Figure 5. Number of grid cells (of the 31 that detected DFS) where DFS detections occurred in only 1 of the 12 days to all 12 of the 12 days that cameras were deployed. These are the

combined results of two cameras per cell. Data were collected at Blackwater NWR during spring of 2016, 2017, and 2018.

Relationship between detections and the amount of DFS habitat present: As mentioned above, a habitat model for DFS was developed using LiDAR data and a shapefile of suitable habitat was created from that model (USFWS 2012). We compared the percent of the sample grid area that contained suitable DFS habitat in grids with DFS detection, versus grids without DFS detection. The 31 grid cells occupied by DFS averaged 66 percent suitable habitat while the 24 cells that were not occupied by DFS averaged 29 percent suitable habitat.

Overall, we consider this monitoring plan to provide a reasonably good assessment of the occupancy of Delmarva fox squirrels across a large area. The use of cameras, rather than trapping and handling animals, allowed volunteers to take a much larger role in carrying out fieldwork. Using a randomly selected grid and then placing the cameras in suitable habitat held the advantage of enabling the cameras to maximize detection opportunities. Overall, this monitoring plan provides for a more realistic and achievable monitoring program given declining budgets and reduced staff on many refuges.

5. Citations

Dueser, R. D. 1999. Analysis of Delmarva fox squirrel (*Sciurus niger cinereus*) benchmark population data (1991-1998). Report to USFWS, Chesapeake Bay Field Office, Annapolis, MD. Contract 5141070512A.

Karanth, K. U., J. D. Nichols and N.S. Kumar. 2011. Estimating tiger abundance from camera trap data: field surveys and analytical issues. Pages 97-117, In: Camera traps in animal ecology. O'Connell, A.F., J.D. Nichols and K.U. Karanth (eds). Springer. 271pp.

MacKenzie, D. I. 2005. What are the issues with presence-absence data for wildlife managers? Journal of Wildlife Management 69:849-860.

MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83:2248-2255.

MacKenzie, D. I., J. D. Nichols, J. E. Hines, M. G. Knutson and A. B. Franklin. 2003. Estimating site occupancy, colonization and local extinction probabilities when a species is detected imperfectly. Ecology 84:2200-2207.

MacKenzie, D. I., L. L. Bailey and J. D. Nichols. 2004*a*. Investigating species co-occurrence patterns when species are detected imperfectly. Journal of Animal Ecology 73: 546-555.

MacKenzie, D. I. and L. L. Bailey. 2004*b*. Assessing the fit of site occupancy models. Journal of Agricultural, Biological and Environmental Statistics 9:300-318.

MacKenzie, D. I. and J. A. Royle. 2005. Designing occupancy studies: general advice and allocating survey effort Journal of Applied Ecology 42:1105–1114.

MacKenzie, D. I., J. D. Nichols, J.A. Royle, K.H. Pollock, L.L. Bailey, and J.E. Hines. 2006. Occupancy Estimation and Modeling: Inferring Patterns and Dynamics of Species Occurrence. Elsevier, Amsterdam. 324 pp.

Morris, C. M. 2006. Building a predictive model of Delmarva fox squirrel (*Sciurus niger cinereus*) occurrence using infrared photomonitors. MS thesis, Virginia Polytechnic Institute and State University, Blackburg, Virginia. 132 pp.

Mullen, R. and M. Lindberg. 2014. Survival and abundance of Delmarva fox squirrels at Blackwater National Wildlife Refuge. University of Alaska, Fairbanks, AK. 38 pp.

Paglione, L. 1996. Population status and habitat management of Delmarva fox squirrels. MS thesis, Department of Forestry and Wildlife Management, Univ. of Mass, Amherst, MA. 97 pp.

Pednault-Willet, K. D. 2002. Determining the population size and habitat use of the endangered Delmarva fox squirrel (*Sciurus niger cinereus*) following an infestation of the southern pine beetle (*Dendroctonus frontalis*) at Chincoteague National Wildlife Refuge. MS thesis, Univ. of Maryland, Eastern Shore. 160 pp.

Taylor, G. J. 1976. Range determination and habitat description of the Delmarva fox squirrel in Maryland. MS thesis, University of Maryland, College Park. 76 pp.

U.S. Fish and Wildlife Service. 1993. Delmarva fox squirrel (*Sciurus niger cinereus*) recovery plan, second revision. Prepared by Delmarva fox squirrel recovery team for Northeast Region, U.S. Fish and Wildlife Service, Hadley, MA. 69 pp. plus appendices (available at https://www.fws.gov/chesapeakebay/PDF/endangered/DFS/recoveryplan.pdf).

U.S. Fish and Wildlife Service. 2012. The Delmarva Peninsula Fox Squirrel (*Sciurus niger cinereus*): 5-year Status Review. Chesapeake Bay Field Office, Annapolis, MD. 75 pp. (available at https://www.fws.gov/chesapeakebay/PDF/endangered/DFS/5-year-review.pdf).

U.S. Fish and Wildlife Service. 2015. Post-delisting Monitorinig Plan for the Delmarva Peninsula Fox Squirrel (*Sciurus niger cinereus*). Chesapeake Bay Field Office, Annapolis, MD. 39 pp. (available at https://www.fws.gov/chesapeakebay/PDF/endangered/DFS/20140911_DFSPostDelistingMonitoringPlanDraftforReview.pdf).

Appendix A. Protocol for Delmarva Fox Squirrel Photomonitoring at Blackwater National Wildlife Refuge

Updated 13 May 2014

Camera setup

Setup should be the same for both models of Reconyx camera (RC55 and HC600). With the camera turned on, toggle through the main menu to **CHANGE SETUP** and click **OK**. Select **ADVANCED** and then select **TRIGGER**. Toggling through the different options, **MOTION SENSOR** should be set to **"ON"**, **SENSITIVITY** should be set to **"HIGH"**, **PICS PER TRIGGER** should be set to **"3"**, **PICTURE INTERVAL** should be set to **"RAPIDFIRE"**, and **QUIET PERIOD** should be set to **"1 MINUTE"**.

Check to make sure time and date are correct. If time and date are incorrect select **CHANGE SETUP** from the main menu. Select **ADVANCED** and toggle to **DATE/TIME** (RC55) or **DATE/TIME/TEMP** (HC600). Toggle through the different options to make sure all are correct.

Check memory cards for each camera ensuring that the memory card is empty before deploying camera in the field. If there is data on the memory card make sure that data has already been uploaded. When certain the data has been properly uploaded, the memory card data can be deleted by selecting **ERASE CARD** from the main menu. The camera should now be ready for deployment.

Trap selection

6"x6"x19" single-door live-traps should be used for photomonitoring. Door should be secured open with wire or zip-tie. This will allow for animals to freely enter and exit the trap.

Bait

Each camera site should be baited with two to three pieces of field corn (approximately 1/3 of a cob each). Corn can be collected from agriculture fields around the Refuge and stored in stainless steel trash bins located in the research building. Should the corn supply be depleted more corn can be purchased at a local seed and feed store.

Camera and Trap Setup

1. Navigate to the photomonitoring survey point. Choose a camera deployment location as close to the predetermined photomonitoring point as possible. If the suitable location is further than 20 feet from a permanently marked point (i.e. trapping transect), tie a section of red or pink flagging at least 2 feet long to the tree which the camera is secured. This flagging should be removed with the gear at the end of the sampling period.
2. Attach the camera to a tree so that the camera is facing approximately north. The tree should be large enough for the camera to sit securely against the trunk of the tree but not so large of a tree that the cable lock cannot be secured.
3. Camera and trap should be positioned between 10 to 15 feet apart. HC600 and RC55 models can detect motion as far away as 100 feet depending on weather conditions. Infrared detection on both cameras is 50 feet. These camera models should detect a

squirrel sized animal out to approximately 20 feet, farther if temperatures are low (Reconyx, pers. com. 2011). **Cameras should not be any less than 10 feet or any more than 15 feet from the trap** (Photo 1). Placing a camera too close to the trap reduces motion detection and field of view (Photo 2).

4. Use the **WALKTEST** feature on the camera to determine whether the camera is detecting motion around the entrance of the trap. Once it is determined that the camera is detecting motion, **ARM** camera and take a series of photos by walking around trap. Once the camera has taken photos of the trap use the viewfinder to make sure the trap is framed properly. Always disarm and shut off power to the camera before removing the memory card. Remove the memory card from the camera and insert the card into the viewfinder. View the photos.
5. Trap should be centered in the bottom third of the photo image (Photo 1). The mouth of the trap should be located as close to the center of the camera image as possible. When possible the trap should be placed near the base of a large tree (DBH > 12”).
6. The trap should be secured to the ground to prevent raccoons or other animals from moving it. A short grey fiberglass or pvc rod works well.
7. With setup complete and the trap centered appropriately, arm the camera again, secure with a cable lock without altering orientation of camera, and leave set for the duration of the photomonitoring period.

Motion detection

The cameras motion detection is activated by sensing an animal’s body heat as well as its movement. As background temperature approaches the temperature of the animal’s, the strength of the signal decreases and the range goes down accordingly. The camera has six (6) motion detection zones (Photo 3). Movement that occurs outside of these detection zones will not trigger the camera.

Photo Examples

Photo 1. Ideal setup. Trap centered in bottom 1/3 of image, mouth of trap centered, trap located far enough from camera, and log securing trap without obscuring view of the mouth of the trap.

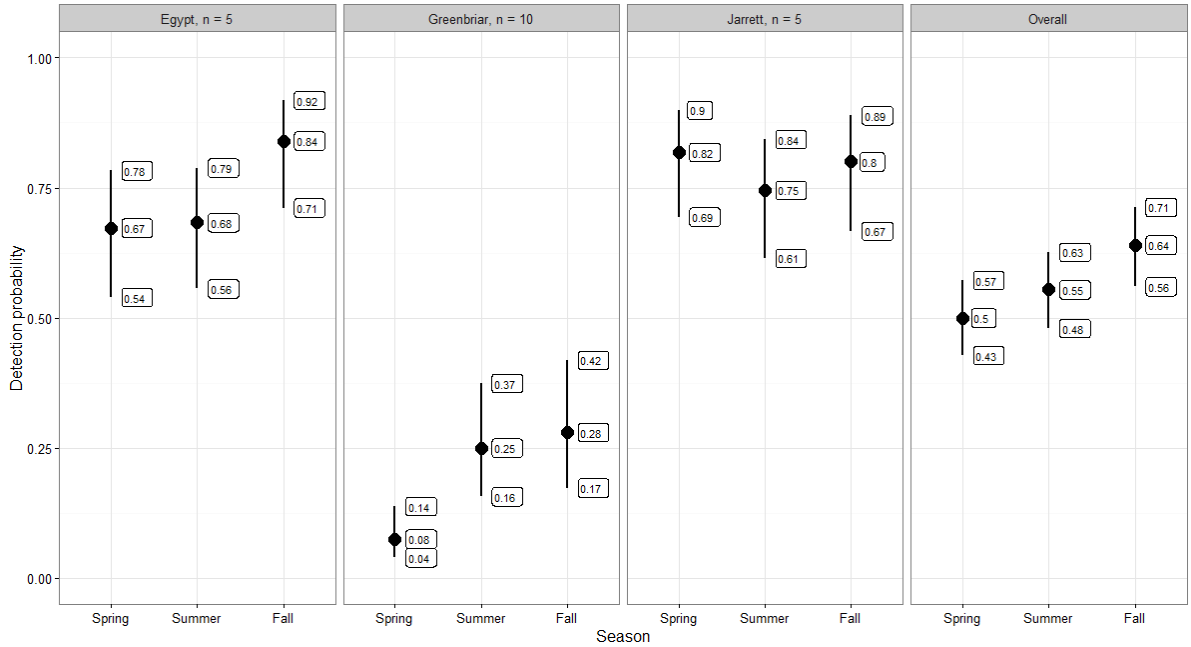
Photo 2. Trap too close to camera (note gray squirrel in trap).

Photo 3. Example of motion detection zones for Reconyx over an INCORRECTLY placed cage. Cage should be in bottom 1/3 of image for best detection.

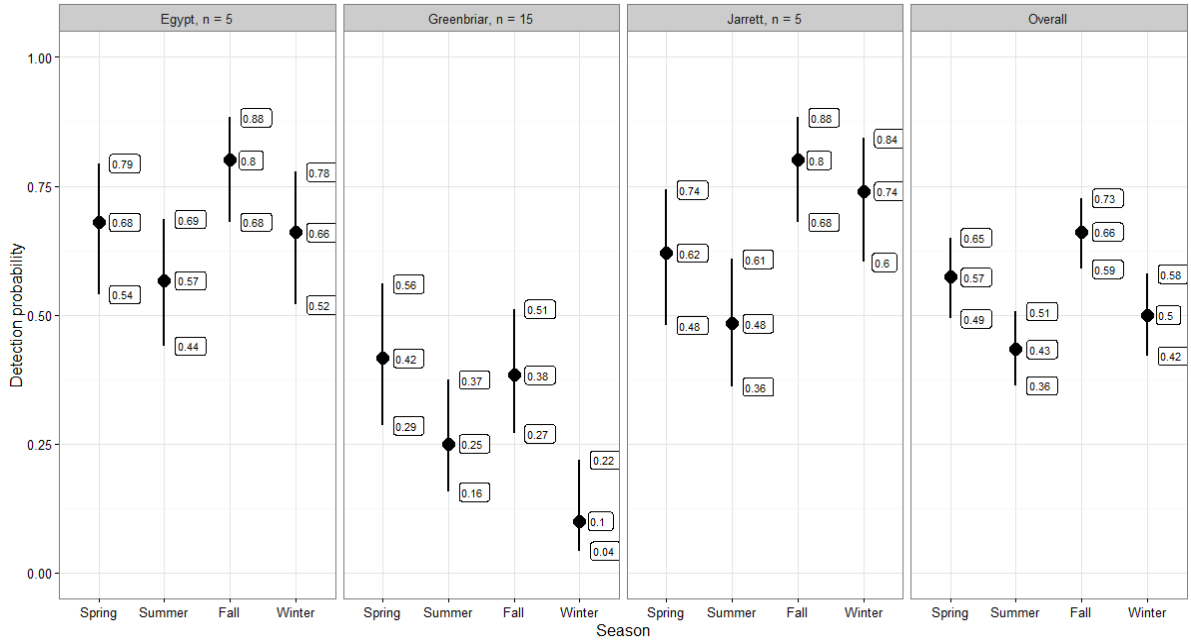
Appendix B. Seasonal detection patterns based on analysis of pilot data

Seasonal camera-trap detection patterns of Delmarva fox squirrels at Egypt, Greenbriar, and Jarrett sampling areas during 2010-2012 at Blackwater National Wildlife Refuge Maryland, USA

2010



2011



Appendix C. Modeled occupancy output using program PRESENCE

```
PRESENCE - Presence/Absence-Site Occupancy data analysis
Thu Apr 12 11:11:00 2018,       Version 10.2_151210
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
==>i=dfs nocovar 2016-18.pao
==>l=pres_psi(.)_p(.).out
==>name=psi(.),p(.)
==>j=p:\biology\dfs\photo monitoring\presence runs\dfs nocovar 2016-18_project\dfs nocovar
2016-18.dm
varcov: nsig=6 eps=1.000000e-002
no model name N,T-->55,12

********* Input Data summary *******
Number of sites              = 55
Number of sampling occasions   = 12
Number of missing observations = 0
Data checksum = 18693

NSiteCovs-->0
NSampCovs-->0
Primary periods=1 Secondary periods: 12
Naive occupancy estimate       = 0.5636

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 DFS nocovar 2016-18
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
N=55 T=12 Groups=1 bootstraps=0

-->1-12
Matrix 1: rows=2, cols=2
          -,a1,
psi          1
=========================

Matrix 2: rows=13, cols=2
          -,b1,
P[1]         1
P[2]         1
P[3]         1
P[4]         1
P[5]         1
```

```
P[6]        1
P[7]        1
P[8]        1
P[9]        1
P[10]       1
P[11]       1
P[12]       1
=========================

Matrix 3: rows=0, cols=0
=========================

Matrix 4: rows=0, cols=0
=========================

Matrix 5: rows=0, cols=0
=========================

Matrix 6: rows=0, cols=0
=========================

modtype=1

Custom Model:

Number of significant digits   =   7.4

Model has been fit using the logistic link.


Number of parameters          = 2
Number of function calls          = 75
-2log(likelihood)             = 516.8601
AIC                           = 520.8601

Untransformed Estimates of coefficients for covariates (Beta's)
=====================================================================
                                  estimate    std.error
A1   psi                        :   0.304267    0.280183
B1   P[1]                       :  -0.962157    0.120692
=============================================================

   Individual Site estimates of <psi>
```

	Site	estimate	Std.err	95% conf. interval
psi	1 1	: 0.5755	0.0684	0.4391 - 0.7013

==========

Individual Site estimates of <P[1]>

	Site	estimate	Std.err	95% conf. interval
P[1]	1 1	: 0.2764	0.0241	0.2317 - 0.3262
P[2]	1 1	: 0.2764	0.0241	0.2317 - 0.3262
P[3]	1 1	: 0.2764	0.0241	0.2317 - 0.3262
P[4]	1 1	: 0.2764	0.0241	0.2317 - 0.3262
P[5]	1 1	: 0.2764	0.0241	0.2317 - 0.3262
P[6]	1 1	: 0.2764	0.0241	0.2317 - 0.3262
P[7]	1 1	: 0.2764	0.0241	0.2317 - 0.3262
P[8]	1 1	: 0.2764	0.0241	0.2317 - 0.3262
P[9]	1 1	: 0.2764	0.0241	0.2317 - 0.3262
P[10]	1 1	: 0.2764	0.0241	0.2317 - 0.3262
P[11]	1 1	: 0.2764	0.0241	0.2317 - 0.3262
P[12]	1 1	: 0.2764	0.0241	0.2317 - 0.3262

==========

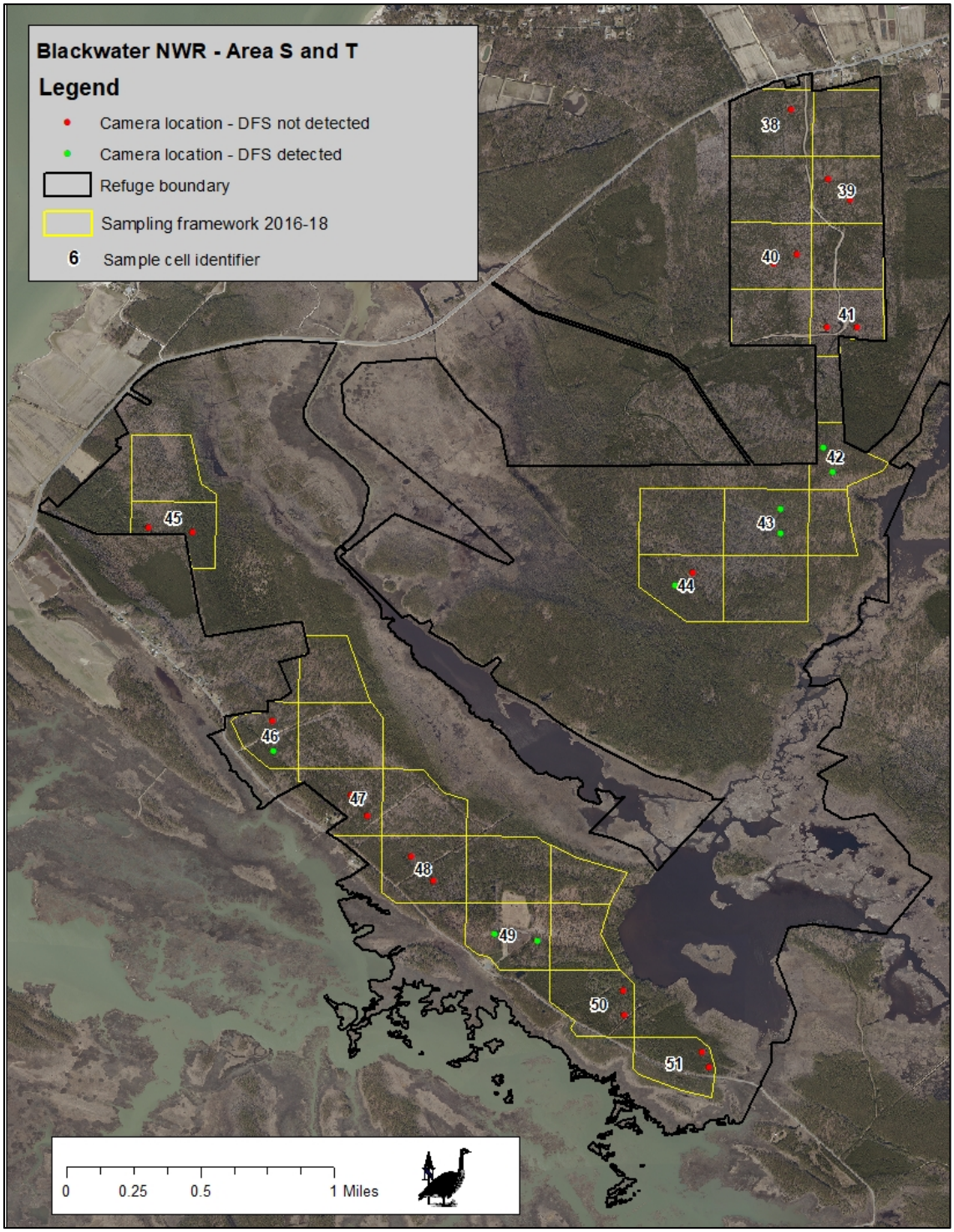
DERIVED parameter - Psi-conditional = [Pr(occ | detection history)]

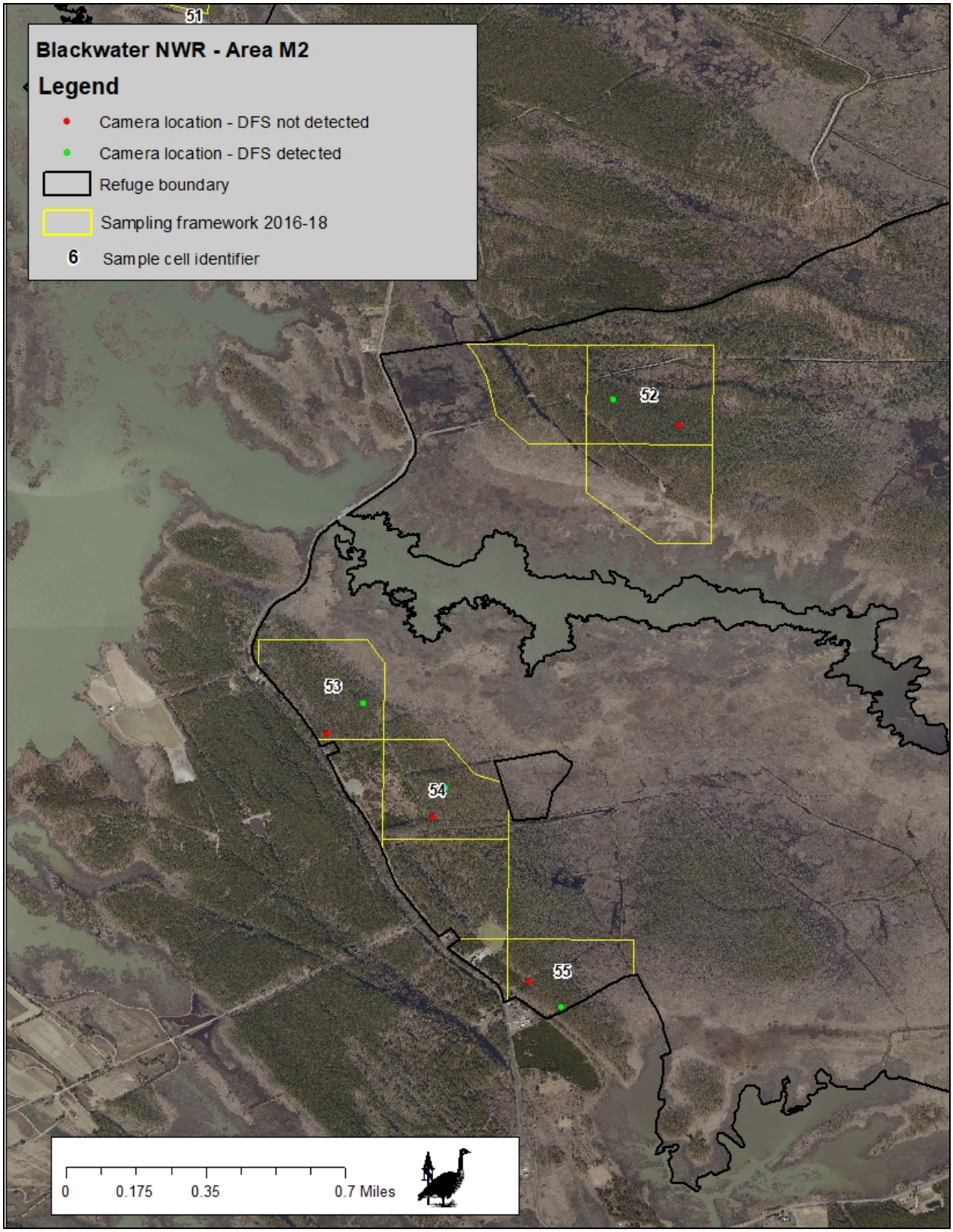
Site		psi-cond	Std.err	95% conf. interval
1	1	0.0272	0.0133	0.0103 - 0.0698
2	2	0.0272	0.0133	0.0103 - 0.0698
3	3	0.0272	0.0133	0.0103 - 0.0698
4	4	0.0272	0.0133	0.0103 - 0.0698
5	5	1.0000	0.0000	1.0000 - 1.0000
6	6	1.0000	0.0000	1.0000 - 1.0000
7	7	0.0272	0.0133	0.0103 - 0.0698
8	8	1.0000	0.0000	1.0000 - 1.0000
9	9	1.0000	0.0000	1.0000 - 1.0000
10	10	1.0000	0.0000	1.0000 - 1.0000
11	11	1.0000	0.0000	1.0000 - 1.0000
12	12	0.0272	0.0133	0.0103 - 0.0698
13	13	0.0272	0.0133	0.0103 - 0.0698
14	14	1.0000	0.0000	1.0000 - 1.0000
15	15	0.0272	0.0133	0.0103 - 0.0698
16	16	1.0000	0.0000	1.0000 - 1.0000
17	17	1.0000	0.0000	1.0000 - 1.0000

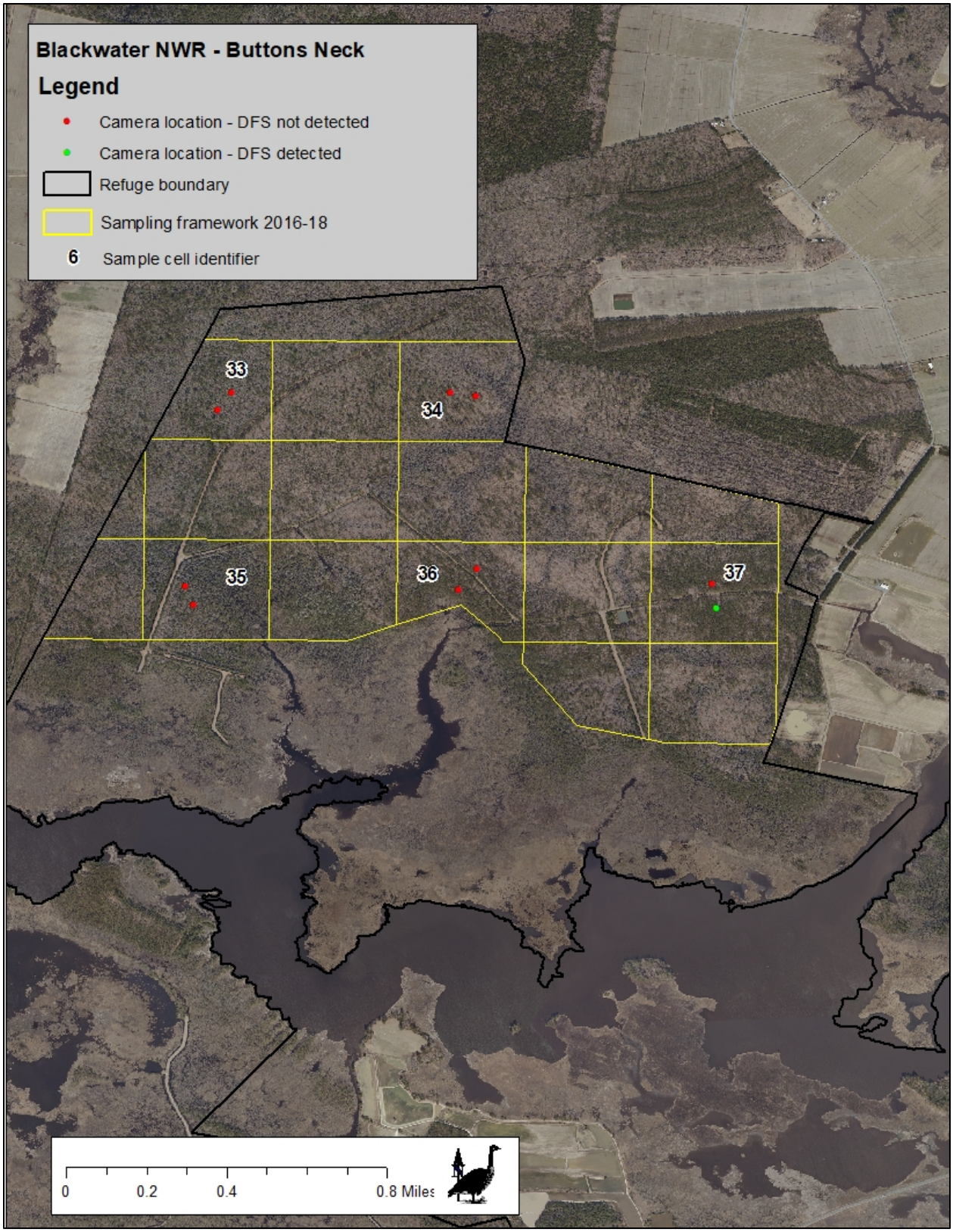
18	18	1.0000	0.0000	1.0000 - 1.0000
19	19	1.0000	0.0000	1.0000 - 1.0000
20	20	1.0000	0.0000	1.0000 - 1.0000
21	21	1.0000	0.0000	1.0000 - 1.0000
22	22	0.0272	0.0133	0.0103 - 0.0698
23	23	1.0000	0.0000	1.0000 - 1.0000
24	24	1.0000	0.0000	1.0000 - 1.0000
25	25	1.0000	0.0000	1.0000 - 1.0000
26	26	0.0272	0.0133	0.0103 - 0.0698
27	27	1.0000	0.0000	1.0000 - 1.0000
28	28	0.0272	0.0133	0.0103 - 0.0698
29	29	1.0000	0.0000	1.0000 - 1.0000
30	30	1.0000	0.0000	1.0000 - 1.0000
31	31	1.0000	0.0000	1.0000 - 1.0000
32	32	1.0000	0.0000	1.0000 - 1.0000
33	33	0.0272	0.0133	0.0103 - 0.0698
34	34	0.0272	0.0133	0.0103 - 0.0698
35	35	0.0272	0.0133	0.0103 - 0.0698
36	36	0.0272	0.0133	0.0103 - 0.0698
37	37	1.0000	0.0000	1.0000 - 1.0000
38	38	0.0272	0.0133	0.0103 - 0.0698
39	39	0.0272	0.0133	0.0103 - 0.0698
40	40	0.0272	0.0133	0.0103 - 0.0698
41	41	0.0272	0.0133	0.0103 - 0.0698
42	42	1.0000	0.0000	1.0000 - 1.0000
43	43	1.0000	0.0000	1.0000 - 1.0000
44	44	1.0000	0.0000	1.0000 - 1.0000
45	45	0.0272	0.0133	0.0103 - 0.0698
46	46	1.0000	0.0000	1.0000 - 1.0000
47	47	0.0272	0.0133	0.0103 - 0.0698
48	48	0.0272	0.0133	0.0103 - 0.0698
49	49	1.0000	0.0000	1.0000 - 1.0000
50	50	0.0272	0.0133	0.0103 - 0.0698
51	51	0.0272	0.0133	0.0103 - 0.0698
52	52	1.0000	0.0000	1.0000 - 1.0000
53	53	1.0000	0.0000	1.0000 - 1.0000
54	54	1.0000	0.0000	1.0000 - 1.0000
55	55	1.0000	0.0000	1.0000 - 1.0000

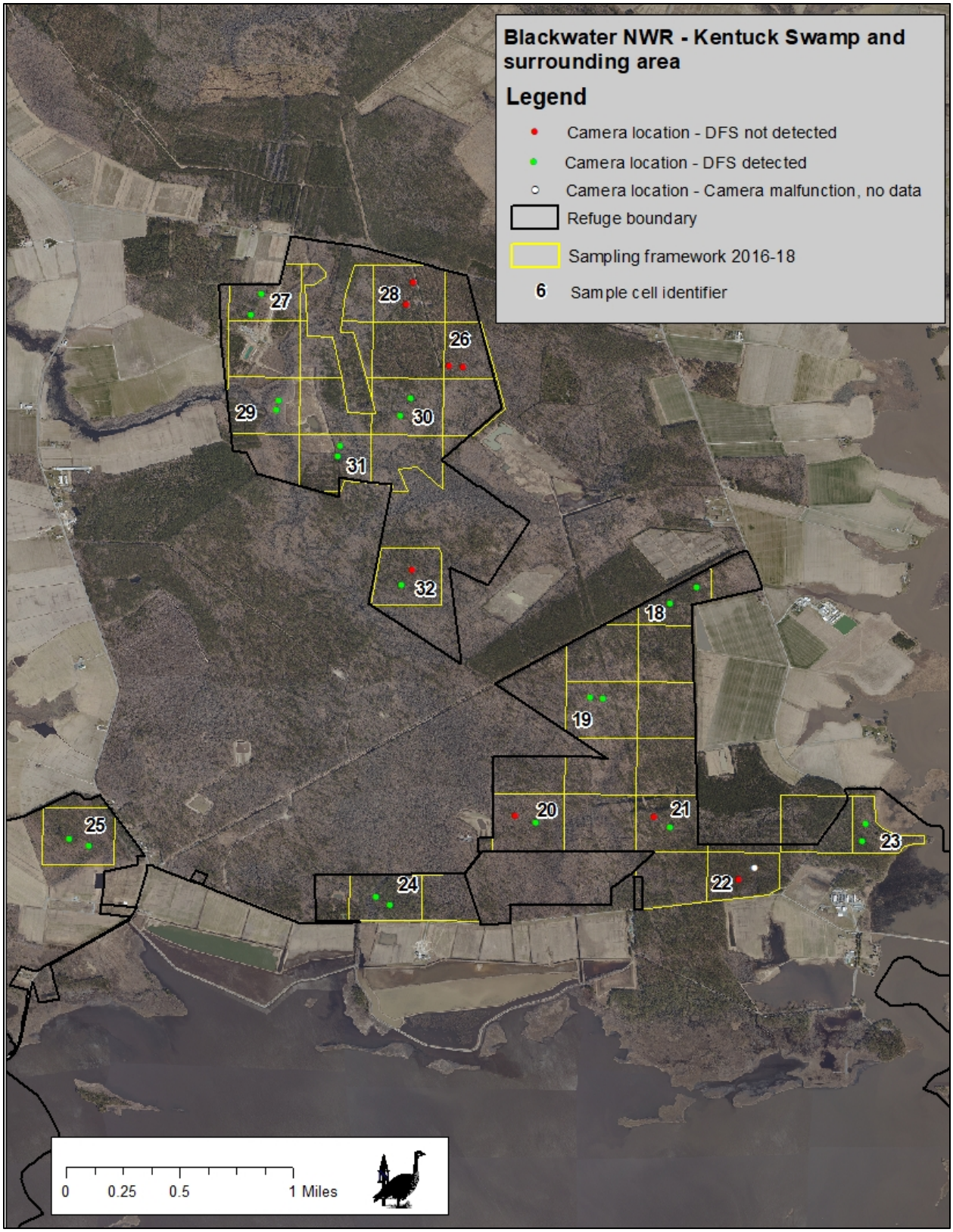
CPU time= 0 seconds (0.00 min)

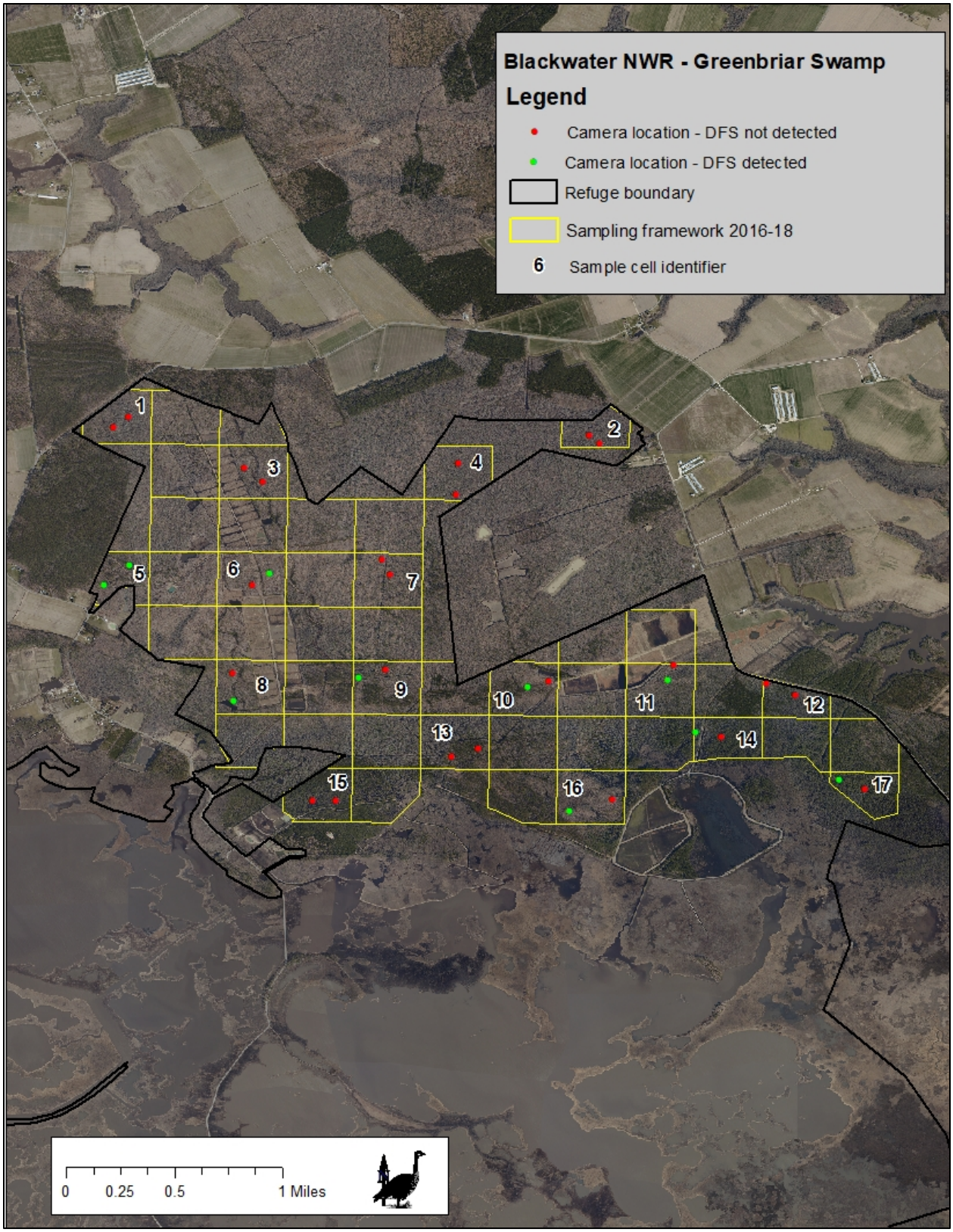
Appendix D. Sample site maps




Blackwater NWR - Area M2
Legend
Camera location - DFS not detected
Camera location - DFS detected
Refuge boundary
Sampling framework 2016-18
6 Sample cell identifier
51
52
53
54
55
0
0.175
0.35
0.7 Miles


Blackwater NWR - Buttons Neck
Legend
Camera location - DFS not detected
Camera location - DFS detected
Refuge boundary
Sampling framework 2016-18
6 Sample cell identifier
33
34
35
36
37
0
0.2
0.4
0.8 Miles


Blackwater NWR - Kentuck Swamp and surrounding area
Legend
Camera location - DFS not detected
Camera location - DFS detected
Camera location - Camera malfunction, no data
Refuge boundary
Sampling framework 2016-18
6 Sample cell identifier
27
28
26
29
30
31
32
18
19
20
21
23
22
24
25
0
0.25
0.5
1 Miles


Blackwater NWR - Greenbriar Swamp
Legend
Camera location - DFS not detected
Camera location - DFS detected
Refuge boundary
Sampling framework 2016-18
6 Sample cell identifier
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
0 0.25 0.5 1 Miles

Appendix E. Detection history tables and raw detection data

Delmarva fox squirrel detection history data formatted for program PRESENCE 2016-2018

Cell	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	1	0	0	0	0	1	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	1	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	1	0	0	0	0
9	1	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	1	1	1	0	0	1	0	0
11	0	0	0	0	0	0	0	1	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	1
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	1	0
17	0	0	0	0	0	0	0	1	0	1	0	0
18	0	1	1	0	0	0	1	1	0	1	1	0
19	1	0	0	0	0	0	0	0	1	1	1	0
20	0	0	0	1	0	1	0	0	0	1	1	1
21	0	0	0	0	0	0	0	0	1	1	1	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	1	0	1	1	0	0	1	1	1
24	0	1	0	1	0	1	1	0	1	1	1	1
25	1	1	1	0	0	1	0	1	1	1	1	1
26	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	1	0	0	0	0	0	0	0	1
28	0	0	0	0	0	0	0	0	0	0	0	0
29	1	1	0	1	0	1	1	1	1	1	1	1
30	0	0	0	0	0	1	1	0	1	1	1	0
31	1	1	1	1	1	1	1	1	1	1	1	1
32	0	0	0	0	0	0	0	0	0	1	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0

36	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	1	1
38	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	1	0	0	0	0	0	0
43	0	0	0	0	1	0	0	1	0	0	0	0
44	0	0	0	0	0	1	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	1	0	0	0	1	1	1	0
47	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0	1	1	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	1	1	0	0
53	0	0	0	0	0	0	0	0	1	0	0	0
54	0	0	0	0	0	0	0	0	0	0	0	1
55	0	1	0	1	0	1	0	0	0	1	0	0

Data description -

Camera Location - Sampling point ID for that unit. ESRI shapefile available.
Camera Latitude/Camera Longitude - Self-explanatory. Geographic projection NAD 1983. ESRI shapefile available.
Dates - Dates cameras were out. Includes dates the cameras were deployed and retrieved.
Day deployed / Day retrieved - indicates whether a DFS was detected the day the cameras were deployed and/or retrieved (not full sampling days).
Day 1, Day 2, etc. - Indicates whether a DFS was detected on that day. 1= DFS detected, 0 = DFS not detected, X = Camera malfunctioned, no data available.

Camera Location	Camera Latitude	Camera Longitude	Dates	Day Deployed	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day Retrieved
1A	38.452907	-76.065489	3/17-30/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1B	38.452268	-76.066551	3/17-30/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2A	38.451156	-76.033889	3/17-30/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2B	38.451736	-76.03461	3/17-30/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3A	38.448625	-76.056511	3/17-30/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3B	38.44949	-76.057738	3/17-30/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4A	38.44774	-76.043577	3/17-30/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4B	38.44983	-76.043351	3/17-30/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5A	38.44168	-76.067147	3/17-30/2016	0	1	0	0	0	0	0	0	0	0	0	0	0	0

5B	38.442987	-76.065434	3/17-30/2016	0	0	0	0	0	0	1	0	0	0	0	0	0	0
6A	38.441662	-76.0572	3/17-30/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6B	38.442423	-76.056055	3/17-30/2016	0	0	0	0	0	0	0	0	0	1	0	0	0	0
7A	38.443394	-76.048533	3/17-30/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7B	38.442384	-76.047963	3/17-30/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8A	38.433911	-76.05848	3/17-30/2016	0	0	0	0	0	0	0	0	1	0	0	0	0	0
8B	38.435758	-76.058545	3/17-30/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9A	38.435481	-76.050041	3/17-30/2016	0	1	0	0	0	0	0	0	0	0	0	0	0	0
9B	38.436006	-76.048304	3/17-30/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10A	38.435257	-76.037345	3/31-4/13/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10B	38.43486	-76.038713	3/31-4/13/2016	0	0	0	0	0	1	1	1	0	0	1	0	0	0
11A	38.436289	-76.028967	3/31-4/13/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11B	38.435327	-76.029351	3/31-4/13/2016	0	0	0	0	0	0	0	0	1	0	0	0	0	1
12A	38.434308	-76.020819	3/31-4/13/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12B	38.435105	-76.022744	3/31-4/13/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13A	38.430727	-76.042035	3/31-4/13/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13B	38.43022	-76.043878	3/31-4/13/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0

14A	38.431786	-76.027504	3/31-4/13/2016	0	0	0	0	0	0	0	0	0	0	0	0	1	0
14B	38.431536	-76.025744	3/31-4/13/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15A	38.427254	-76.051652	3/31-4/13/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15B	38.427258	-76.053195	3/31-4/13/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16A	38.427297	-76.033023	3/31-4/13/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16B	38.426503	-76.035903	3/31-4/13/2016	0	0	0	0	0	0	0	0	0	0	0	1	0	0
17A	38.428612	-76.017861	3/31-4/13/2016	0	0	0	0	0	0	0	0	1	0	1	0	0	0
17B	38.428012	-76.016149	3/31-4/13/2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18A	38.468274	-76.101879	3/6-3/20/2017	0	0	1	1	0	0	0	1	0	0	1	1	0	0
18B	38.467253	-76.103612	3/6-3/20/2017	0	0	0	0	0	0	0	0	1	0	0	0	0	0
19A	38.461305	-76.108733	3/6-3/20/2017	0	1	0	0	0	0	0	0	0	1	1	1	0	0
19B	38.461199	-76.107868	3/6-3/20/2017	0	0	0	0	0	0	0	0	0	0	0	1	0	1
20A	38.453306	-76.112194	3/6-3/20/2017	0	0	0	0	1	0	1	0	0	0	1	1	1	1
20B	38.453734	-76.113497	3/6-3/20/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21A	38.453693	-76.104629	3/6-3/20/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21B	38.45302	-76.103597	3/6-3/20/2017	0	0	0	0	0	0	0	0	0	1	1	1	0	0
22A	38.449675	-76.099251	3/6-3/20/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0

22B	38.450465	-76.098201	3/6-3/20/2017	X	X	X	X	X	X	X	X	X	X	X	X	X	X
33A	38.461208	-76.180408	3/6-3/20/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33B	38.461829	-76.179921	3/6-3/20/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34A	38.461833	-76.172038	3/6-3/20/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34B	38.461716	-76.171082	3/6-3/20/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35A	38.454861	-76.181608	3/6-3/20/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35B	38.454183	-76.181293	3/6-3/20/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36A	38.454729	-76.171729	3/6-3/20/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36B	38.455471	-76.171037	3/6-3/20/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37A	38.454067	-76.16241	3/6-3/20/2017	0	0	0	0	0	0	0	0	0	0	0	1	1	1
37B	38.454929	-76.162557	3/6-3/20/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23A	38.452126	-76.091374	3/21-4/3/2017	0	0	0	0	1	0	1	1	0	0	0	1	1	0
23B	38.453244	-76.091117	3/21-4/3/2017	0	0	0	0	0	0	0	0	0	0	1	1	1	0
24A	38.448618	-76.122344	3/21-4/3/2017	0	0	1	0	1	0	1	1	0	1	1	1	1	0
24B	38.448093	-76.121427	3/21-4/3/2017	0	0	0	0	0	0	0	1	0	0	0	0	0	0
25A	38.451801	-76.14067	3/21-4/3/2017	1	1	1	1	0	0	0	0	1	1	1	1	1	0
25B	38.452256	-76.141914	3/21-4/3/2017	0	0	1	0	0	0	1	0	0	1	0	1	1	0

26A	38.482353	-76.1177	3/21-4/3/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26B	38.482294	-76.11684	3/21-4/3/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27A	38.486951	-76.129634	3/21-4/3/2017	0	0	0	0	1	0	0	0	0	0	0	0	1	0
27B	38.485628	-76.130279	3/21-4/3/2017	0	0	0	0	1	0	0	0	0	0	0	0	1	0
28A	38.487704	-76.120023	3/21-4/3/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28B	38.48628	-76.120416	3/21-4/3/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29A	38.479543	-76.128674	3/21-4/3/2017	0	0	0	0	0	0	1	1	1	1	1	1	1	1
29B	38.480173	-76.128569	3/21-4/3/2017	0	1	1	0	1	0	1	1	1	1	1	1	0	1
30A	38.480344	-76.120123	3/21-4/3/2017	0	0	0	0	0	0	1	0	0	0	1	1	0	0
30B	38.479189	-76.120784	3/21-4/3/2017	0	0	0	0	0	0	1	1	0	1	1	1	0	0
31A	38.477323	-76.124646	3/21-4/3/2017	0	0	1	1	1	1	1	1	1	1	1	1	1	0
31B	38.4766	-76.1248	3/21-4/3/2017	0	1	1	0	1	1	1	1	1	0	1	0	1	1
32A	38.469372	-76.120072	3/21-4/3/2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32B	38.468432	-76.120695	3/21-4/3/2017	0	0	0	0	0	0	0	0	0	0	1	0	0	1
47A	38.462700	-76.261310	03/08-03/22/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47B	38.463790	-76.262150	03/08-03/22/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48A	38.460450	-76.258720	03/08-03/22/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0

48B	38.459110	-76.257690	03/08-03/22/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49A	38.456050	-76.251940	03/08-03/22/2018	0	0	0	0	0	0	0	0	0	1	0	0	0	0
49B	38.456320	-76.254230	03/08-03/22/2018	0	0	0	0	0	0	0	0	0	0	1	0	0	0
50A	38.451840	-76.247240	03/08-03/22/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50B	38.453120	-76.247440	03/08-03/22/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51A	38.449880	-76.242950	03/08-03/22/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51B	38.449000	-76.242660	03/08-03/22/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52A	38.433450	-76.227710	03/08-03/22/2018	0	0	0	0	0	0	0	0	0	1	1	0	0	0
52B	38.432540	-76.225240	03/08-03/22/2018	1	0	0	0	0	0	0	0	0	0	0	0	0	0
53A	38.421220	-76.238030	03/08-03/22/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53B	38.422240	-76.236890	03/08-03/22/2018	0	0	0	0	0	0	0	0	0	1	0	0	0	0
54A	38.418190	-76.234350	03/08-03/22/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54B	38.419270	-76.234020	03/08-03/22/2018	0	0	0	0	0	0	0	0	0	0	0	0	1	0
55A	38.412230	-76.230830	03/08-03/22/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55B	38.411300	-76.229660	03/08-03/22/2018	0	0	1	0	1	0	1	0	0	0	1	0	0	0
38A	38.500970	-76.238180	03/26-04/09/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38B	38.500130	-76.239120	03/26-04/09/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0

39A	38.497120	-76.236210	03/26-04/09/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39B	38.495950	-76.235010	03/26-04/09/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40A	38.493060	-76.237880	03/26-04/09/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40B	38.492560	-76.239150	03/26-04/09/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41A	38.489170	-76.236220	03/26-04/09/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41B	38.489110	-76.234620	03/26-04/09/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42A	38.482620	-76.236570	03/26-04/09/2018	0	0	0	0	0	0	1	0	0	0	0	0	0	0
42B	38.481270	-76.236030	03/26-04/09/2018	0	0	0	0	0	0	1	0	0	0	0	0	0	0
43A	38.479310	-76.238690	03/26-04/09/2018	0	0	0	0	0	1	0	0	0	0	0	0	0	0
43B	38.477960	-76.238680	03/26-04/09/2018	0	0	0	0	0	0	0	0	1	0	0	0	0	0
44A	38.475770	-76.243630	03/26-04/09/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44B	38.475180	-76.244560	03/26-04/09/2018	0	0	0	0	0	0	1	0	0	0	0	0	0	0
45A	38.478190	-76.272920	03/26-04/09/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45B	38.477940	-76.270520	03/26-04/09/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46A	38.466140	-76.266170	03/26-04/09/2018	0	0	0	0	0	1	0	0	0	1	1	1	0	1
46B	38.467770	-76.266270	03/26-04/09/2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0