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800 Business Park Drive, Suite D
Dixon, CA 95620

Annual Data Summary 2013–2014: Monitoring and Research on Ring-Necked Pheasant (*Phasianus colchicus*) in the Sacramento Valley and Sacramento-San Joaquin River Delta of California

FINAL DATA SUMMARY

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Prepared by: Peter S. Coates*, Ian A. Dwight, Jeffrey Kohl, Katie M. Andrle, and Michael L. Casazza

United States Geological Survey, Western Ecological Research Center, 800 Business Park Drive, Suite D, Dixon, California 95620

*Contact info: pcoates@usgs.gov, 530-669-5073

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*Contact info: pcoates@usgs.gov, 530-669-5073

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1.0 Abstract

The U.S. Geological Survey (USGS), Pheasants Forever, Mandeville Island duck club, and the California Department of Fish and Wildlife (CDFW) participated in a pilot study to monitor populations of ring-necked pheasant using radio-telemetry in the Sacramento Valley and the Sacramento-San Joaquin River Delta. Wild pheasant populations were monitored across four different study sites: Yolo Bypass Wildlife Area, Gray Lodge Wildlife Area, Roosevelt Ranch duck club, and Mandeville Island duck club. In 2013 and 2014, we radio- or GPS-marked 61 pheasant hens between the four study sites. Data collection focused primarily on investigating habitat selection, food availability, predator composition, and estimating population vital rates. We plan to carry out a comprehensive study of these and other populations in order to improve our understanding of pheasant population dynamics and identify factors that contribute to pheasant declines in California. The purpose of the study will be to provide agencies and private landowners with a framework for decision support tools to manage pheasant populations in the Central Valley. The data presented here represents a summary of a pilot study and should be

interpreted with caution as these findings are preliminary. Further data are required to draw conclusions regarding pheasant population dynamics in the Central Valley.

2.0 Background

The ring-necked pheasant (*Phasianus colchicus;* hereafter, pheasant) is one of California's most prized game birds, but hunters and harvest numbers have declined steadily since the mid-1970s based on annual game take surveys (CDFW 2014). Established pheasant populations are primarily of a stock originally introduced from China, and because of their economic and recreational value, wild pheasant populations in California have been maintained since the 1890s (Hart 1990). The Sacramento Valley refuges and wildlife areas typically produced some of the highest numbers of harvested pheasants in California, but average harvest in this area has decreased significantly since the late 1990s (CDFW 2014).

Anthropogenic land use alterations and evolving cropland management practices in the Central Valley, resulting in reduced wintering and nesting cover, may be contributing factors to pheasant decline within the study site. Many of the rice fields in the Sacramento Valley are disked or flooded during the winter (Hill and others., 1999), and the consistent increase in rice cultivation since the 1980s has come at the expense of fallowed fields and grain crops such as barley and winter wheat (USDA 2014a) that provide potential cover for pheasants . In the Delta, wetland habitat and cereal grain crop cultivation has also been reduced (USDA 2014a), which is thought to reduce the amount of potential nesting and brood rearing habitat in the region. Furthermore, mosquito abatement practices, predators, disease, weather, and farmed pheasant introductions may also be factors influencing pheasant population dynamics in the Central Valley. Demographic information on population vital rates (e.g., individual, nest, and brood

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survival) of pheasant populations is lacking in the Central Valley and such information would substantially benefit our understanding of factors that influence local population trends.

The U.S. Geological Survey (USGS), Pheasants Forever, and the California Department of Fish and Wildlife, as well as private landowners, collaborated on a pilot study to monitor pheasant populations in the Central Valley of California. The purpose of this study was 3-fold. First, we sought to develop effective field methodology that will be conducive to in-depth comprehensive population dynamics study. Second, we obtained preliminary estimation of population vital rates across different life phases as a baseline for an integrated population model. Third, we obtained high resolution movement data and identified factors that influence resource selection across different life phases. Lastly, we investigated potential limiting factors to pheasant populations, including information on the predator community, and how these factors influence demographic rates. Our primary objective was to provide an initial framework that clearly identifies factors contributing to pheasant decline in the Central Valley by monitoring seasonal movements, estimating vital rates, and measuring changes in habitat selection. This information will be used to develop decision support tools to help guide pheasant management practices by wildlife and land managers and other land stewards.

This annual data summary represents the first year of this pilot study. These findings are to be interpreted with caution and should be considered only as preliminary. The sample sizes are limited. Conclusive relationships regarding demographics and factors that influence vital rates can be estimated after a minimum of three years of data collection. These preliminary findings should be used only to monitor the progress of this study project.

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3.0 Study Area

The study area is located within the Central Valley, and includes the Sacramento Valley and Sacramento-San Joaquin River Delta regions of California. Three study sites, Gray Lodge Wildlife Area (GLWA), Yolo Bypass Wildlife Area (YBWA), and Roosevelt Ranch, are located in the Sacramento Valley region. The GLWA is located approximately 11 km southwest of Gridley, CA, and is just north of the Sutter Buttes. The YBWA is located between West Sacramento and Davis, CA, adjacent to the Sacramento deep-water shipping channel. The Roosevelt Ranch duck club is located near the town of Zamora and is 16 km north of Woodland, CA. Lastly, Mandeville Island duck club is located in the Sacramento-San Joaquin River Delta region and is approximately 24 km northwest of Stockton, CA.

The four study sites will provide both a sufficient sample size of pheasants for monitoring, as well as an adequate distribution of birds breeding in different parts of the Central Valley. Pheasant habitat at all study sites in the study area are typical of managed wetland-riparian and upland habitats surrounded by row crops, rice, and hayfields used by pheasants throughout Northern California. Major cover types within upland communities consist of white sweet clover *(Melilotus albus*), common sunflower (*Helianthus annuus*), gumweed (*Grindelia camporum*), cocklebur (*Xanthium strumarium*), curly dock (*Rumex crispus*), and pepperweed (*Lepidium latifolium*). Common herbaceous cover types in the wetland-riparian communities include tule (*Schoenoplectus acutus* var. *occidentalis*), cattail (*Typha latifolia*), smart weed (*Persicaria punctata*), watergrass (*Echinochloa crus-galli*), and sprangletop (*Leptochloa fascicularis*). In addition to wetlands and uplands, grassland communities contain primarily perennial grasses such as creeping wild rye (*Elymus triticoides*), and annual grasses such as Italian rye grass (*Festuca perennis*), and wild oat (*Avena fatua*). All study sites contain upland,

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grassland, and wetland-riparian communities, but species composition varies among sites based on local management. Agricultural practices are similar between sites, but crops harvested vary among sites. Surrounding agricultural practices include the cultivation of rice, wheat, alfalfa, tomatoes, sunflower, and corn. Mandeville Island duck club and Roosevelt Ranch are private hunting clubs that primarily manage for pheasant and waterfowl; Gray Lodge and Yolo Bypass Wildlife Areas are public wildlife refuges that manage for multiple game and migratory bird species.

4.0 Methods

4.1 Capturing and Handling Pheasant

We captured pheasants in the winter and early spring during November to March of 2013–2014. To avoid disturbing nesting hens, we concluded our trapping efforts when pheasants began to nest in late March and early April. We modified spotlighting techniques developed for greater sage-grouse (*Centrocercus urophasianus*) trapping (Wakkinen and others, 1992; Giesen and others, 1982) to capture adult pheasants at night using an ATV. We also attempted bait-trapping techniques during the winter. However, this method was considerably less effective than the spotlighting technique. Pheasants were captured at nocturnal roosting locations using spotlights and nets attached to 3-m extension handles. An ATV was used to locate roosting birds, and hens were preferentially targeted for capture when flushed. Captured hens were outfitted with battery powered necklace-style Very High Frequency (VHF) transmitters (<3% body mass, 1 – 1.8 kg, Schroeder and others, 1999; Advanced Telemetry Systems, Isanti, Minnesota) equipped with a mortality sensor. A subsample of pheasants were outfitted with a Global Positioning System (GPS), Platform Transmitter Terminal (PTT; <3% body mass, Northstar Science and Technology LLC, King George, VA) and a VHF transmitter. The purpose of the GPS transmitter was to

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collect locations remotely and transmit (using PTT) to a central database via satellites. The purpose of the VHF attachment to the GPS was to relocate the pheasant in the field and retrieve GPS devices that no longer transmitted. The weights of transmitters with collaring materials were well under the recommended values based on pheasant body mass to minimize post-release researcher-induced stress and mortality.

Captured pheasants were weighed and multiple morphometric measurements were taken including tarsus, culmen, and flattened wing cord. Blood was extracted from the brachial vein for disease analyses. Pheasants were classified as juvenile (pre-breeding) or adult (≥1 breeding year) based on the length or presence of a bursa of Fabricius, which is measured by inserting a metal probe into a small opening just above the cloaca (Linduska 1943). The bursa of Fabricius is only present in juvenile birds less than one year old. However, the accuracy of measuring the bursa decreases after January (Woodburn and others, 2009), so some pheasants were excluded from this measurement. We will not continue this measurement in upcoming years. Other methods to age pheasant include measuring the proximal primary (first primary), which is shorter in juvenile pheasants (Woodburn and others, 2009). Birds were processed within 30 minutes of capture and released at their capture location to minimize stress and disorientation.

4.2 Monitoring Pheasant Populations

4.2.1 Radio and GPS Telemetry

We conducted intensive on-the-ground monitoring of pheasant movements, survivorship, and reproduction following release of marked birds. We used a three-element Yagi antenna and portable receiver (Advanced Telemetry Systems Inc., Isanti, MN) to track radio-marked hens. We minimized relocation error by circling each bird at a radius of 10–20 m and then walked within 10 m of the bird's location. We then approximated the distance and recorded the azimuth

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from the observer's location (recorded using GPS) to estimate the location coordinates (Universal Transverse Mercator, UTM) of the pheasant. On the approach to obtaining the pheasant location, we sought to prevent the bird from flushing or running. However, occasionally birds flushed or ran, and in these instances we recorded the point of departure. Throughout nesting and brood-rearing, we attempted to locate hens at least twice per week. Relocation frequency was scaled down to one location per week after brood fate was recorded for each hen, and then reduced to one location per month during fall (September – November) to monitor seasonal movements and survival rates.

4.2.2 Utilization Distributions

We estimated utilization distributions (UDs; Kernohan and others, 2001), which interpolate animal space use across unknown areas based on the distribution and density of known location telemetry data (Worton 1989). These UDs provide useful tools for evaluating pheasant space use because they allow for estimation of the total area used by individual birds, while accounting for the imperfect monitoring effort that is common to radio-telemetry studies. To calculate UDs, we used a kernel density estimator with a likelihood based technique to estimate the most appropriate smoothing parameter (Horne and Garton 2006). Utilization distributions were calculated at the population level for spring through summer (March – August). We chose not to calculate utilization distributions for each individual because of limitations in relocations per individual during the spring period. We defined the regional core use area as the 50% contour (isopleth) from the UD and the home-range as the 95% contour.

4.3 Invertebrate Sampling

The spraying of mosquito larvacide and adulticide is conducted as a public safety measure to suppress the spread of West Nile Virus and varies in frequency among study sites depending on

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the amount of standing water. Pesticide use may reduce available arthropods for chicks and possibly result in lower brood survival in heavily sprayed areas. Therefore, we investigated the effect of the frequency of spraying on invertebrate diversity and abundance within pheasant habitat by deploying invertebrate pitfall traps during the summers of 2013 and 2014 at Mandeville Island, GLWA, and Roosevelt Ranch. Invertebrates collected from pitfall traps were classified to order, dried, and weighed. The processing of invertebrate samples is ongoing, and at least one more field season of sampling is needed for comparison across study sites.

4.4 Pheasant Crowing Counts

Pheasant (rooster) crowing counts were initiated at Mandeville Island and GLWA during 2013, and all four field sites were surveyed in 2014. Crowing counts are useful to estimate peaks in breeding activity and can be used as a relative annual index to monitor trends in breeding populations (Rice 2003). We are also evaluating the utility of using this survey data coupled with demographic data to more reliably estimate population growth rates using an integrated population model. These counts are typically conducted in the spring (March – May) as roosters establish territories (harems) prior to the nesting season. An observer conducted the counts on pre-established routes just before sunrise and drove for at least two km between sampling stations to minimize duplication of crow counts. Individual rooster crows were counted for two minutes at each station along the route, and visual detections of roosters or hens were recorded in the notes. Crow counts were averaged across all stations and days each season for every site, so one average was calculated per site. Survey stations were equally spaced, but the distance between stations varied between sites. Seven stations were established at Mandeville Island, YBWA and Roosevelt Ranch. GLWA had 15 stations, with eight stations on the west side and

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seven stations on the east side of the wildlife area. Surveys were conducted on days with minimal wind (<20 kph) and no precipitation to minimize detection interference from weather.

4.5 Estimating Adult Survival, Nest Survival, and Brood Survival

We employed the maximum likelihood estimation (MLE) approach to estimate cumulative survival probabilities for adults, nests and broods. We estimated model parameters for all analyses in program R (R Development Core Team, 2008) using package 'RMark' (Laake and Rexstad 2008).

We developed a monthly encounter history for adult pheasants using telemetry data that included the date of capture, last date known to be alive, and fate (confirmed mortality or censored). A censored bird is either still alive or its fate is unknown. We used these data to calculate cumulative annual survival probabilities.

We also estimated cumulative average nest survival probability over the 37-day egg laying and incubation phase. Nests were not verified visually until the nest was depredated or the eggs hatched to minimize nest abandonment. After hens were found in the same location on two consecutive observations, we assumed they were nesting. Each nest was then monitored ≥2 times per week until its fate was determined. A nest was considered successful if ≥1 chick hatched, ascertained by visual assessment of eggshell remains or observing ≥1 chick in the nest bowl. Nests were considered unsuccessful when the entire clutch failed to hatch. Failed nests were scored as depredated or abandoned. We developed an encounter history of individual nests based on the date each nest was found, last checked, and the fate determined.

Following the completion of a successful nest, we monitored brood-rearing pheasants once per week (every seven days) for 50 or more days. During our observations, we took extra precautionary approaches as to minimize disturbance to the brood, such as minimizing flushing

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or brood break-up. A brood was considered successful if at least one chick survived to 50 days post-hatch. During some surveys, we counted the number of surviving chicks in the brood. However, the accuracy of these counts is uncertain as it was often challenging to detect chicks in dense cover. To confirm unsuccessful broods and prevent false negative counts, an additional search for chicks was conducted in subsequent days or weeks. On some occasions, confirming brood failure was difficult because hens would run from the observer and flush without chicks. Hence, some hens were monitored for more than 50 days to confirm brood loss. We reported preliminary findings by estimating cumulative brood survival probabilities using the same methods as was used to determine nest survival. We will conduct a more intensive investigation of survival covariates with additional data from subsequent years of study. Our preliminary results include estimated survival probabilities for a 7-day interval and cumulative across the 50-day period.

4.6 Nest Site Vegetation

We closely followed USGS protocol for measuring nesting microhabitat in the field (USGS 2014). Following nest success or failure, we recorded understory cover at the nest bowl using a Jones coverboard (Jones 1968). The coverboard is placed at 0, 45, and 90 degree angles relative to the ground and is divided into 25 squares (1.25" x 1.25"). An observer counts the number of visible squares on the board from 2 m away, and the fraction of visible squares provides a measure of visual obstruction at that point. We also measured vegetation composition cover at seven subplots (20 × 50 cm) along three transects located ≤25 m of each nest using the Daubenmire method (Daubenmire 1959). Finally, we measured the height of vegetation within 0.5 m of all subplots for each cover type (e.g. grass, forb, shrub). Orientation of the first transect was randomly assigned and the remaining two transects were sequentially oriented at 120°

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intervals to the previous transect. Measurements were recorded at the nest bowl (0 m), and at 10 and 25 m distances from the nest along all three transect lines.

To examine nest-site microhabitat selection, defined as habitat use disproportionate to availability (Manly and others, 2002), we compared means and standard errors of the vegetation measurements at sites with nests to those at random locations. To characterize available sites, we generated random points throughout the study site and conducted the same microhabitat measurements at those locations. We evaluated evidence for multi-scale selection by generating two random points for each nest. One point was within 250 m of the nest (dependent random, DR) and the other point was within the boundaries of the study area (independent random, IR). The boundary of the study area was established using a minimum convex polygon generated from all telemetry locations. This design has two advantages: 1) inferences can be made about pheasant habitat selection at the individual level by comparing the used locations to dependent random locations, and 2) inferences can be made at the population level by comparing the used point to the independent random point. The preliminary results were reported as means (± Standard Error) of vegetation characteristics for nest sites and random points. This study is ongoing and preliminary results should be interpreted with caution. A robust modeling approach will be employed after obtaining appropriate sample sizes (≥3 years of data collection).

4.7 Brood–rearing Vegetation

We completed microhabitat surveys at each brood location every seven days. Surveys were conducted during the day at both used and random point locations. To accurately relocate a site where a brood was observed, the telemetry point was recorded by GPS, and a description of the area was recorded.

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We conducted the same habitat measurements for brood locations (USGS 2014) as was conducted at nests. However, visual obstruction was measured with a Jones coverboard at all subplots along the three 25-m transects. We conducted vegetation measurements for the first three brood locations for each hen to standardize data collection and minimize bias relative to location accuracy. Hens with older broods (>20 days) sometimes ran as the observer approached, making it difficult to obtain an accurate location to conduct a microhabitat surveys. To characterize habitat availability we carried out the same habitat measurements at DR and IR points.

4.8 Avian Predator Monitoring

We followed USGS predator survey protocol for common raven (*Corvus corax*; hereafter ravens) and raptor surveys (USGS 2014) conducted between mid-April and late-August 2014. We conducted visual surveys (using binoculars and unaided eyes) for each pheasant location (nest, brood, general) from a distance of approximately 50–100 m. Surveys were conducted over a 10-min period wherein all four directional quadrants around the survey point were scanned for an equal amount of time. For each avian predator detected, the time, bearing, and distance from the survey point when first detected (determined with a rangefinder) was recorded, and all birds were classified to species. The same survey technique was carried out at random points (DR and IR) as well.

5.0 Preliminary Results

5.1 Pheasant Space Use

During winter and spring (December – April) 2013–2014, we captured and marked 60 females with VHF (n = 58) or GPS (n = 2) transmitters (Table 1). In addition, one female was captured and outfitted with a VHF collar in November 2013 at GLWA, and three males were captured at

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Mandeville Island and outfitted with VHF (n=1) or GPS (n=2) transmitters. We monitored all 61 of the VHF and GPS-marked female pheasants via ground telemetry. However, the VHF transmitters failed following release of the birds with GPS units and, thus, ground telemetry using VHF equipment was limited for those two birds after July 2014. Overall, we collected 1,360 telemetry and 2,549 GPS relocations throughout the field season (Figure 2).

We calculated spring (March – May) and summer (June – August) utilization distributions for VHF-marked pheasants. Using VHF relocations during spring (n = 882) and summer (n =479; Figures 3 – 6), the core area of pheasant activity (50% UD) was 10, 50, 165, and 56 ha at Mandeville Island, GLWA, Roosevelt Ranch, and YBWA, respectively. The population level home range (95% UD) encompassed 99, 442, 732, and 325 ha, respectively, at these sites (Figures 7–10). During summer, pheasants showed minimal movement away from their nesting sites. Most hens stayed within a kilometer of their most recent nest attempt, and those with broods tended to move into neighboring areas with relatively more herbaceous flowering cover dominated by forbs. A few hens moved out of the study area borders during the field season at GLWA, Roosevelt, and YBWA. These hens moved much greater distances over the course of the season compared to hens that stayed within the study areas.

5.2 Crowing Counts

Average rooster crow counts per station at Mandeville Island were 71 in 2013 and 86 in 2014. The high for crow counts heard at a single station at Mandeville was 121 in April 2013 and 146 in April 2014. The average crow count per station at GLWA was 6 with a high of 16 in 2013 and an average of 10 with a high of 40 in 2014. Roosevelt Ranch had an average crow count of 26 with a high of 64 in 2014. YBWA averaged 16 crow counts per station and had a high of 43 in 2014.

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5.3 Pheasant Survival

Average monthly adult survival probability across all study areas was 90.6% (95% CI, 86.8 - 93.4%) and cumulative annual adult survival probability from the 2014 field season (March – August) was 30.5% (95% CI, 18.2 - 44.0%; Figure 11). We recovered 29 marked pheasant mortalities during the spring and summer seasons. Assumed causes of death included depredation by mammalian (n = 11), avian (n = 4), and unknown predators (n = 14). The majority of the remains were limited to pieces of bone and feathers, while only a few were recovered as an intact carcass. One radio transmitter was found near a coyote den.

The frequency of adult mortalities varied considerably between study areas depending on the total number of birds trapped and the length of time that collars were deployed at that site (Table 1). The average monthly adult survival probability for Mandeville Island was 86.0% (95% CI, 67.9 - 94.7%), and the cumulative adult survival probability was 16.3% (95% CI, 0.95 - 51.9%; Figure 12A). The average monthly adult survival probability for GLWA was 85.99% (95% CI, 75.86 - 92.30%), and the cumulative adult survival probability was 16.3% (95% CI, 3.6 - 38.2%; Figure 12B). The average monthly adult survival probability for Roosevelt Ranch was 93.2% (95% CI, 87.9 - 96.3%), and the cumulative adult survival probability was 43.2% (95% CI, 21.3 - 63.8%; Figure 12C). The average monthly adult survival probability for YBWA was 91.5% (95% CI, 81.2 – 93.4%), and the cumulative adult survival probability was 34.6% (95% CI, 8.2 - 64.6%; Figure 12D).

5.4 Nest Survival

We located 60 nests in 2014, of which 35 were successful and 25 failed (Figures 13–16). Multiple re-nesting attempts were observed. The cumulative average nest survival probability across all study sites for the 37-day egg laying and incubation phase was 51.3% (95% CI, 33.7%

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- 66.5%; Figure 17). Of the 25 failed nests, 11 were depredated (assumed to be avian or mammalian); three were plowed by farming equipment; two failed due to hen mortality; and nine were abandoned. We performed a separate nest survival analysis after removing the abandoned nests located at Roosevelt Ranch and YBWA. None of the nests located at GLWA and Mandeville Island were abandoned. Three nests were abandoned at Roosevelt Ranch after field crews attempted to install cameras at the nest. The remaining abandoned nests occurred after females were determined to be on a nest by field technicians and were found to not have returned during the subsequent visit.

We had a total of three successful and one failed nest attempt at Mandeville Island in 2014, and the cumulative nest survival probability was 53.7% (95% CI, 1.41 - 91.7%; Figure 18A). A total of 13 nests were located at GLWA, of which 9 were successful and 4 failed, and the cumulative survival probability was 54.1% (95% CI 19.6 - 79.5%; Figure 18B). At Roosevelt Ranch, 29 nests were located, of which 16 were successful and 13 failed. Cumulative average nest survival at Roosevelt Ranch was 58.5% (95% CI, 30.4 - 78.6%; Figure 18C) with abandoned nests (n = 7) removed, and was 36.5% (95% CI, 17.6 - 55.7%) with abandonment included. We also located 14 nests at YBWA in 2014, of which seven were successful and seven failed. When nests that failed due to abandonment at YBWA (n = 2) were included, the cumulative average nest survival probability dropped from 34.0% (95% CI, 7.6 - 64.0%; Figure 18D) to 23.6% (95% CI, 4.9 – 50.5%).

5.5 Nest Habitat Selection

Preliminary results suggest that average percent litter was greater at nest sites, particularly at the nest center, than at DR and IR locations; however, results were not significant at the 10 and 25 m spatial scales between used and IR points (Figure 19). Residual cover was significantly greater

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at nests compared to IR locations at all scales (Figure 19). Percent cover for perennial grasses was also greater at nest sites than at DR and IR locations; however, percent cover did not differ much among the 0, 10, and 25 m spatial scales (Figure 20). In addition, residual cover height and perennial grass height were greater at the nests compared to DR and IR locations (Figure 21). Conversely, percent cover of annual forbs and bare ground were lower at the nest center compared to IR random locations at all spatial scales (Figure 22). Perennial forb cover at nest sites was slightly lower than at IR points, but these results were not significant. Percent horizontal cover (0° and 45° angles) and vertical cover (90° angle) were significantly greater at used compared to both DR and IR locations (Figure 23).

Preliminary results also suggest that pheasants are choosing nest sites with a greater proportion of grasses (primarily perennial grasses) compared to forbs (Figure 24). In addition, combined forb (perennial and annual) cover is significantly lower at used and DR points compared to IR points, which suggests that hens are selecting other types of cover in lieu of available forb cover for nesting sites (Figure 24).

5.6 Brood Survival

We monitored 31 broods between the four field sites in 2014, of which 18 were successful (≥1 chick survived to 50 days post-hatch) and 13 failed (Table 2). The 7-day interval brood survival probability was 93.5% (95% CI, 89.1% - 96.2%), and the cumulative average survival probability for the 50-day brood rearing period across all study sites was 61.9% (95% CI, 43.7% - 75.7%; Figure 25). Many of the unsuccessful broods were not confirmed as failed until at least 50 days post-hatch because of the difficulty in observing chicks. Hens with broods tended to run away from the observer and leave their brood behind or would flush a short distance before returning to her chicks. Hence, we had to assume a brood was still present until no chicks were found for at

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least two weeks. We also had difficulty counting chicks until they were capable of flight and could be flushed, so chicks were rarely seen before 20 days of age. Occasionally, we were able to hear chicks calling after the hen had moved away or flushed.

Overall, brood success varied between sites but was relatively high compared to nest success. The cumulative average survival probability for the three broods tracked at Mandeville Island was 34.9% (95% CI, 1.4 - 77.5%; Figure 26A). We tracked nine broods at GLWA, of which five were successful, and the cumulative survival probability was 57.0% (95% CI, 22.3 - 81.2%; Figure 26B). Roosevelt Ranch had six successful broods, six failed broods, and the cumulative survival probability was 59.3% (95 CI, 31.3 - 79.2%; Figure 26C). Lastly, seven broods were tracked at YBWA, of which six were successful, and the cumulative survival probability was 85.7% (95% CI, 43.7 – 75.7%; Figure 26D).

Several pheasants at Roosevelt Ranch that nested in a large creeping wild rye field at the west end of the property subsequently moved into the adjacent fallowed rice fields when their nests hatched. The areas utilized by broods were characterized by perennial and annual forb cover, and these areas were usually near a canal or inundated wetland. Broods utilized areas within close proximity to their nests, and only a few broods traveled more than one km from the nest.

5.7 Brood-rearing Habitat Selection

Preliminary results indicate that brood-rearing pheasants used a significantly greater percent of horizontal and vertical vegetative cover at used compared to IR locations, which suggests that pheasants may rely on dense vegetative cover for concealment (Figure 27). Mean perennial and annual forb cover was also greatest at used locations compared to DR and IR points at all spatial scales, excluding annual forb cover at the 0 m scale (Figure 28). Areas with greater forb cover

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may offer more foraging opportunities for chicks and could provide cover for brood concealment. In contrast, perennial and annual grass cover was slightly lower at used points compared to DR and IR points, but these results were not significant (Figure 29). Although annual grass cover made up a large portion of the available grass cover, the small difference between the used and random points indicates that pheasants may not select annual grass cover over other available cover types.

Perennial and annual forb height was significantly greater at used locations compared to DR and IR locations; however, only annual grass height at brood locations were greater than at IR points across all scales (Figures 30 & 31). Hence, hens may be selecting taller horizontal cover when rearing broods, and areas with more forbs may provide more horizontal cover on average than areas dominated by grasses. However, most brood habitat surveys were done later in the season, meaning that taller forb cover could be an artifact of the potential for forbs to grow taller than grasses as the season progresses. In general, a greater proportion of forbs were observed at brood locations in comparison to the proportion of forbs observed at nest locations. Average percent residual cover and litter were greater at used points compared to both DR and IR locations; conversely, bare ground was avoided at brood locations (Figure 32).

5.8 Raven and Raptor Surveys

We conducted a total of 390 raptor and raven surveys during March – August 2014 across all four field sites. Raptors and/or ravens were detected in 369 of these surveys (94.6%), and we recorded 2369 raptor and 168 raven detections throughout the study period. Raptor species included Red-tailed hawk (*Buteo jamaicensis*; n = 207), Ferruginous hawk (*Buteo regalis*; n = 2), Turkey vulture (*Cathartes aura*; n = 1884), Northern harrier (*Circus cyaneus*; n = 48), Swainson's hawk (*Buteo swainsoni*; n = 96), White-tailed kite (*Elanus leucurus*; n = 11), and

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unidentified raptors (*n* = 114). Raptor species identified only once include the American kestrel (*Falco sparverius*), Golden eagle (*Aquila chrysaetos*), Bald eagle *(Haliaeetus leucocephalus*), Great horned owl (*Bubo virginianus*), Osprey (*Pandion haliaetus*), Red-shouldered hawk (*Buteo lineatus*), and peregrine falcon (*Falco peregrinus*). Other avian species detected included American crow (*Corvus brachyrhynchos*; *n* = 10), unidentified bird species (*n* = 263), and 21 surveys detected no birds.

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6.0 Acknowledgements

This research was part of a cooperative effort with USGS, Pheasants Forever, and the CDFW. We thank D. Connelly with Pheasants Forever and S. Gardner, M. Meshriy, B. Burkholder, L. Souza, J. Stoddard, A. Atkinson, and D. Van Baren with CDFW for their expertise and logistical support. We thank D. Munoz, B. Lowe, and K. Peterson for their time spent entering data and performing analyses. We thank Mandeville Island and Roosevelt Ranch for providing access onto their private lands. Finally, we are extremely grateful to M. Fearon, B. Lowe, and D. Munoz for their diligence collecting data in the field.

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8.0 Tables

Table 1. The number and sex of pheasants outfitted with VHF and GPS transmitters during the winter (December – February) and spring (March – April) 2013−2014 trapping seasons in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA. One hen was outfitted with a VHF transmitter in November 2013 at GLWA, and is not included in the totals for birds captured in the winter and spring.

		Winter		Spring	
		VHF	GPS	VHF	GPS
Mandeville	**F**	2	0	7	0
	M	0	0	1	2
GLWA	**F**	16	0	0	0
	M	0	0	0	0
Roosevelt	**F**	22	2	0	0
	M	0	0	0	0
YBWA	**F**	9	0	2	0
	M	0	0	0	0
Total	**F**	49	2	9	0
	M	0	0	1	2

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Table 2. The number of successful and failed broods by site during the 2014 field season in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA.

	Successful	Failed
Mandeville	1	2
GLWA	5	4
Roosevelt	6	6
YBWA	6	1
Total	18	13

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9.0 Maps and Figures

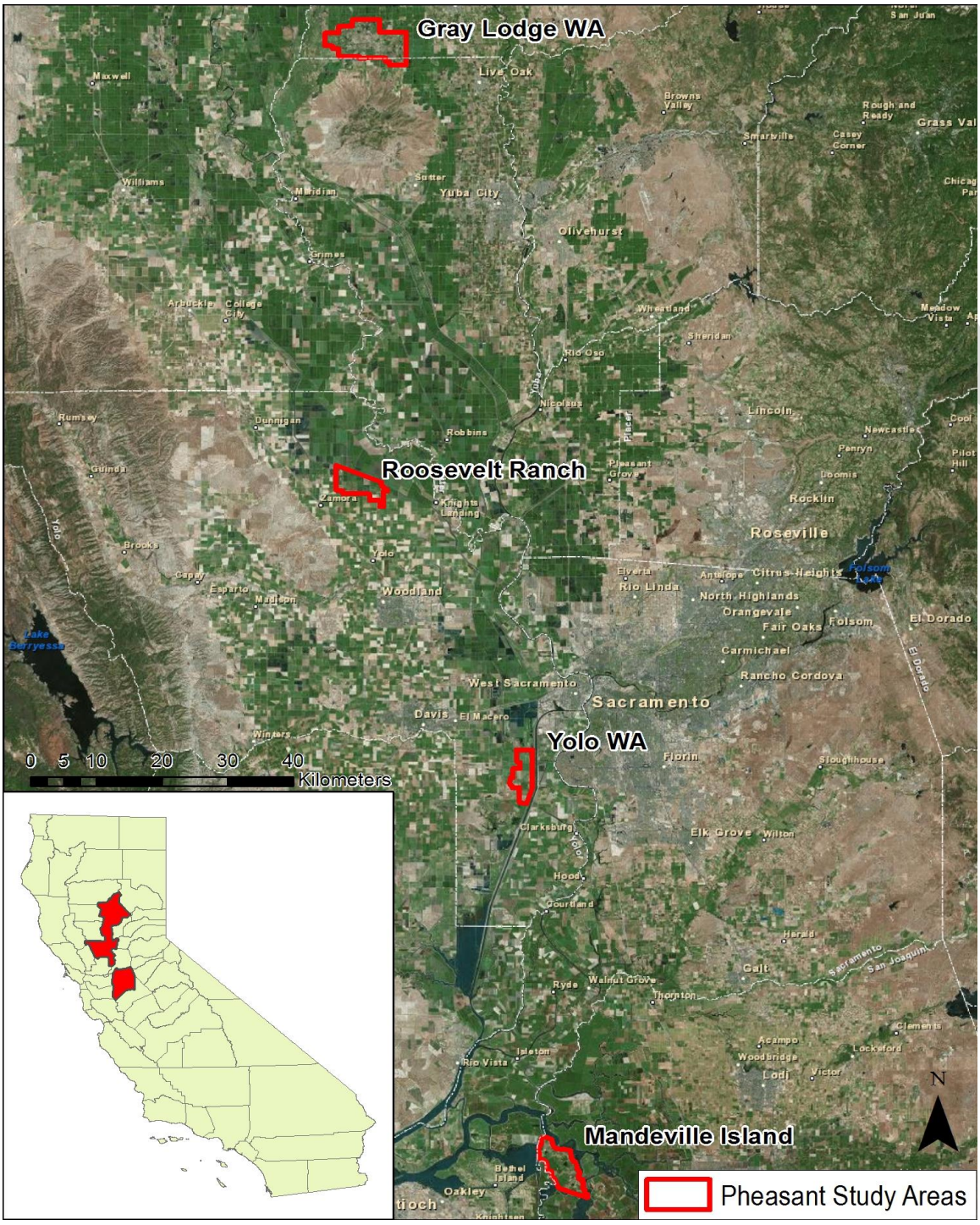

Figure 1. The pheasant study areas located in San Joaquin, Yolo, Sutter, and Butte counties in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA, 2013-2014.

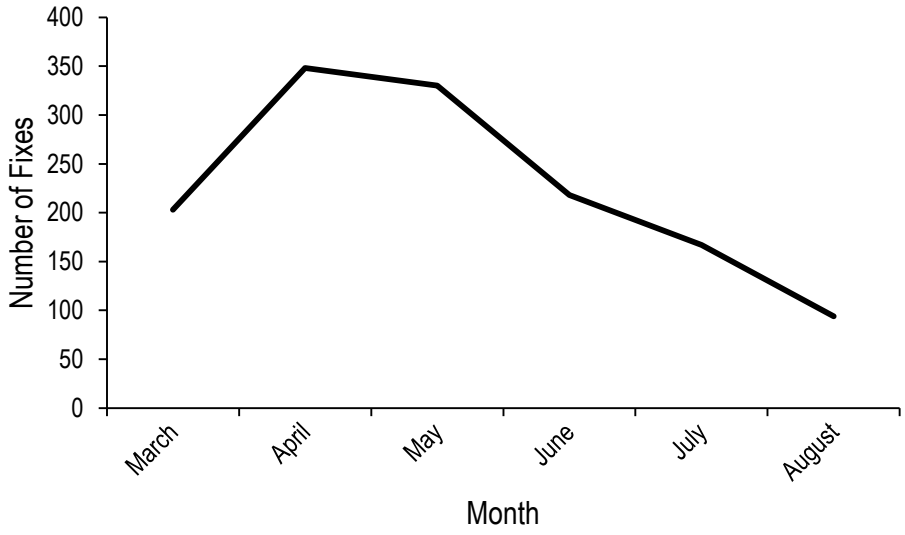

Figure 2. Number of VHF relocations by month (March – August) in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA, 2014.

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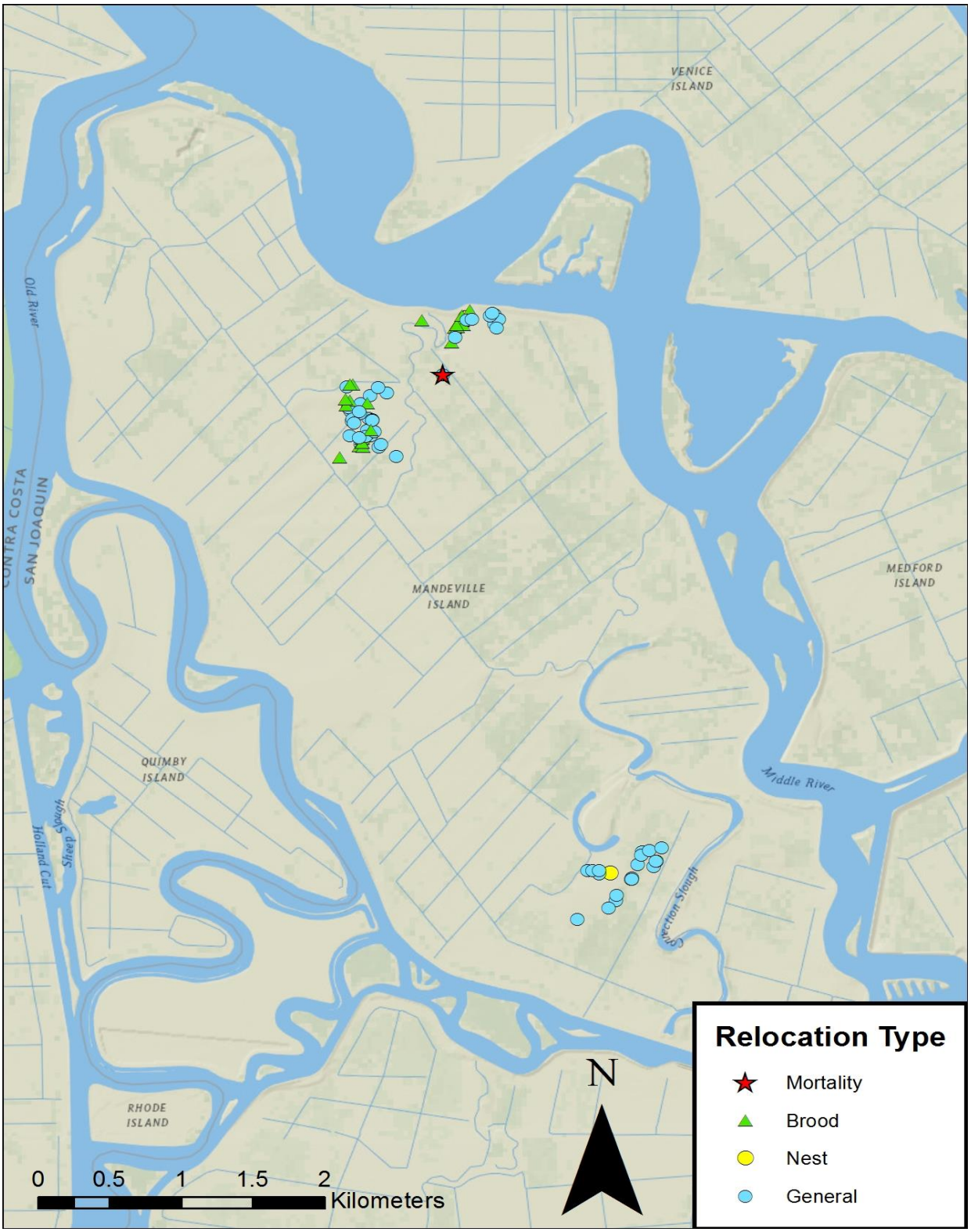

Figure 3. Nest, brood, and general telemetry relocations at Mandeville Island, 2014.

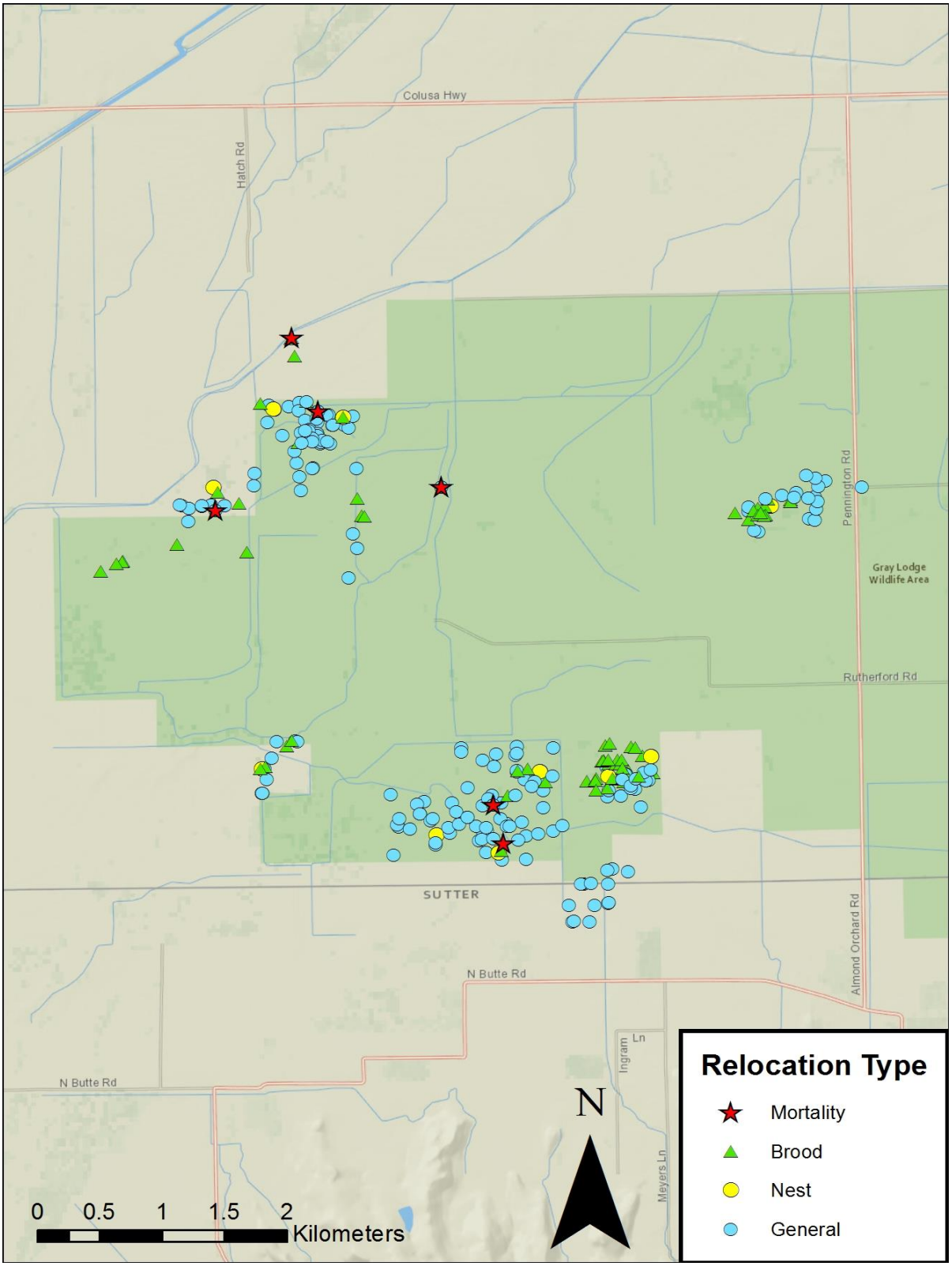

Figure 4. Nest, brood, and general telemetry relocations at GLWA, 2014.

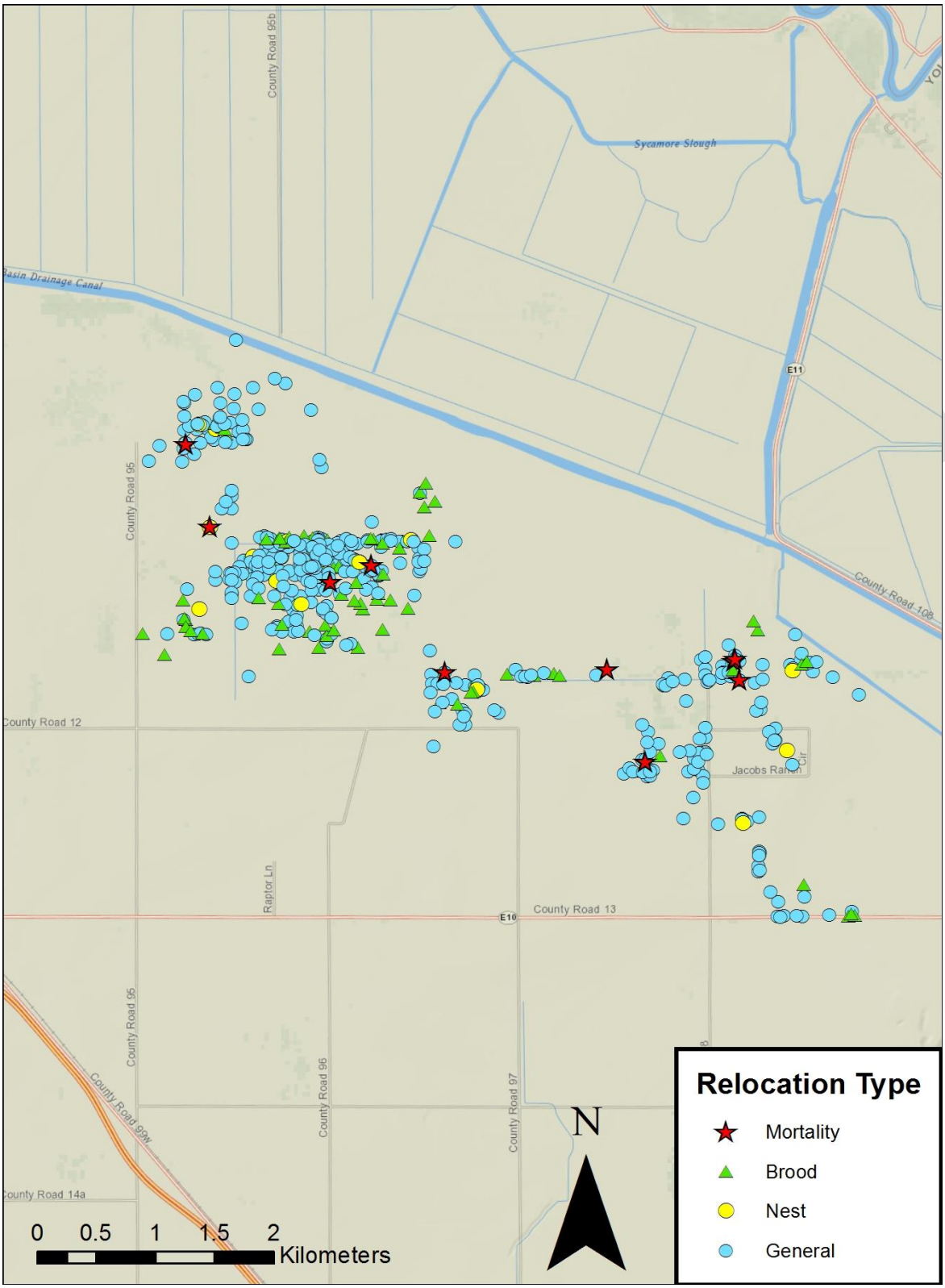

Figure 5. Nest, brood, and general telemetry relocations at Roosevelt Ranch, 2014.

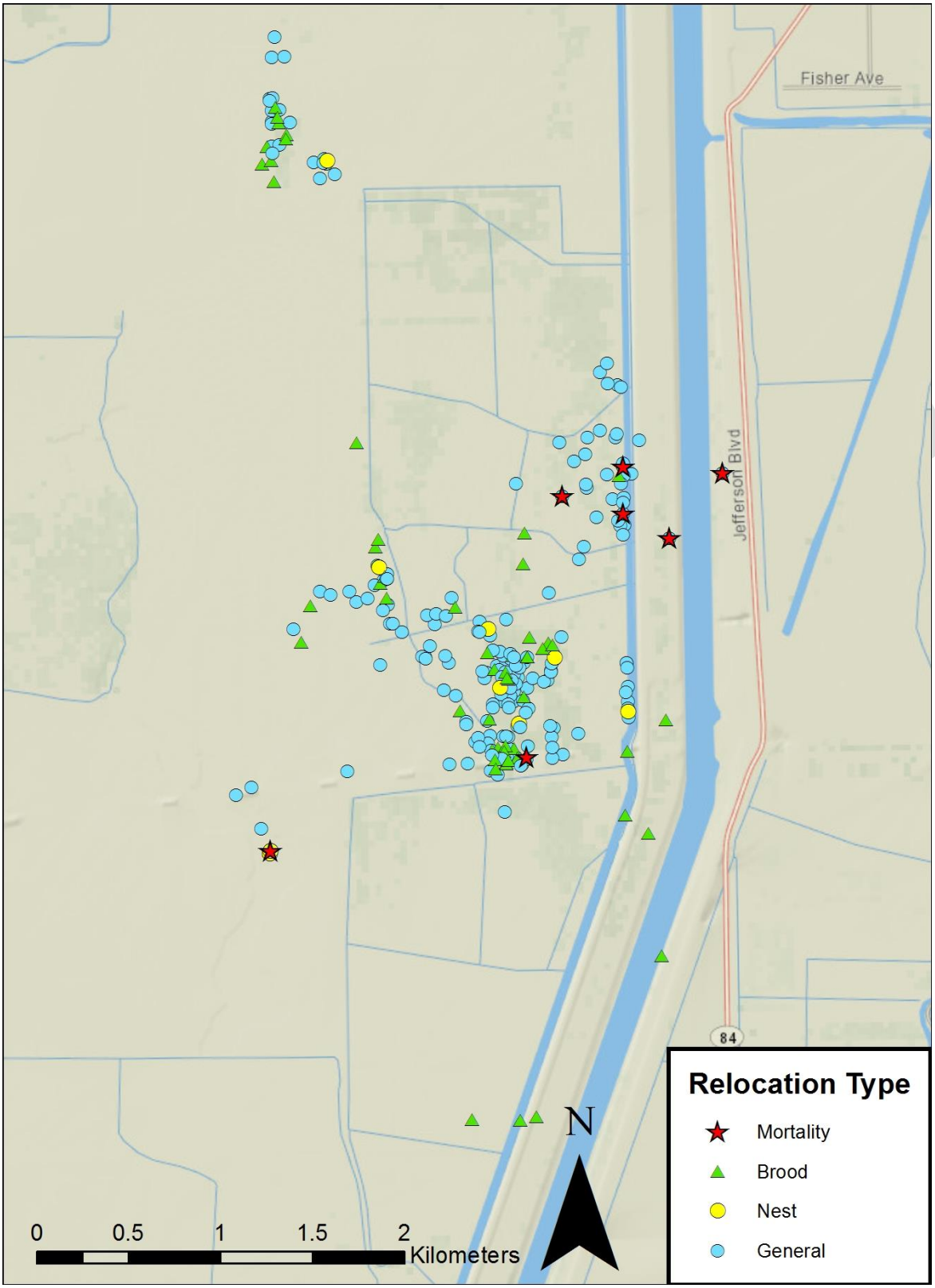

Figure 6. Nest, brood, and general telemetry relocations at YBWA, 2014.

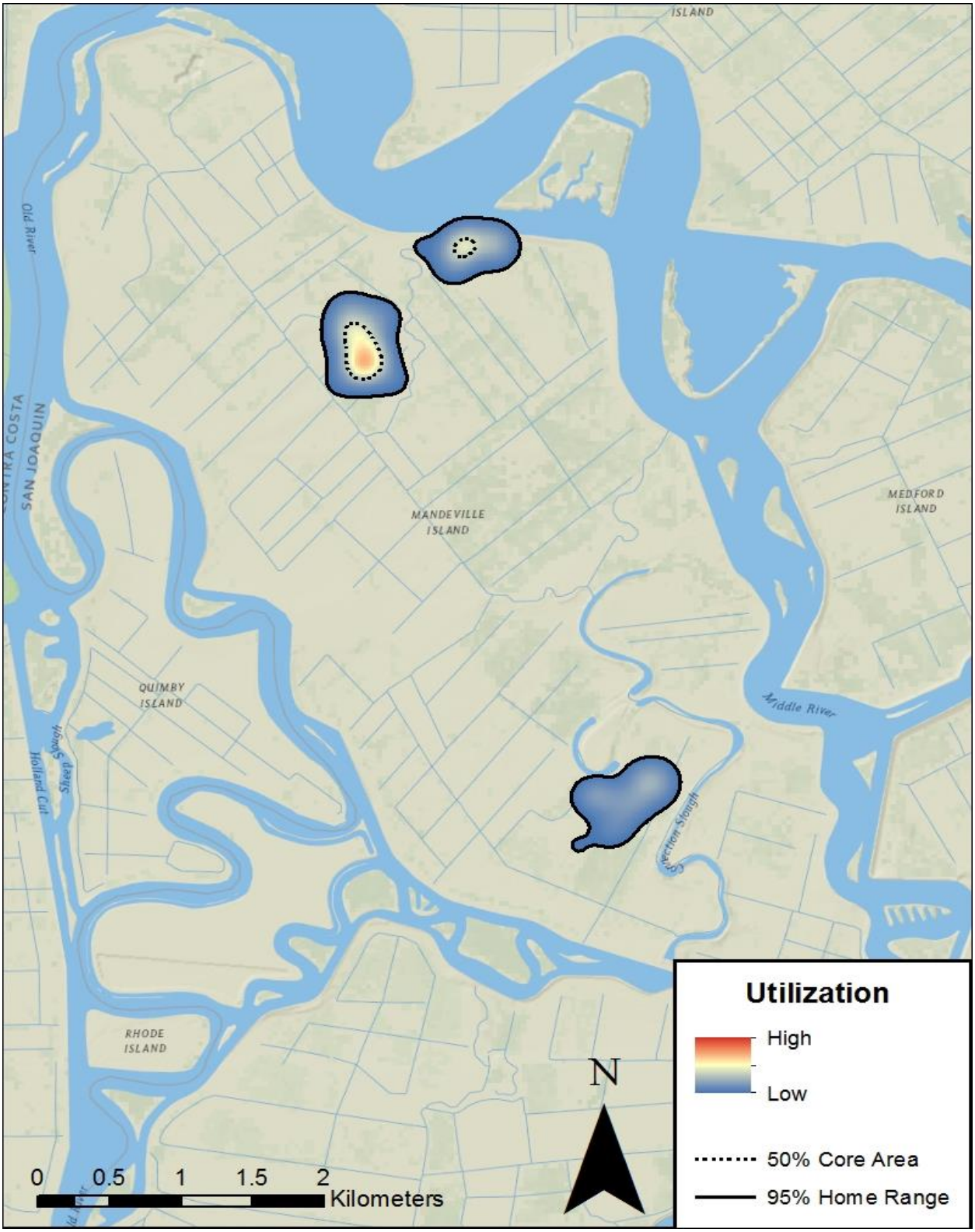

Figure 7. Utilization distribution of pheasant hens at Mandeville Island, during spring and summer (March – September) in 2014. (Utilization distribution was approximated by using kernel density estimators). This information is preliminary and subject to revision.

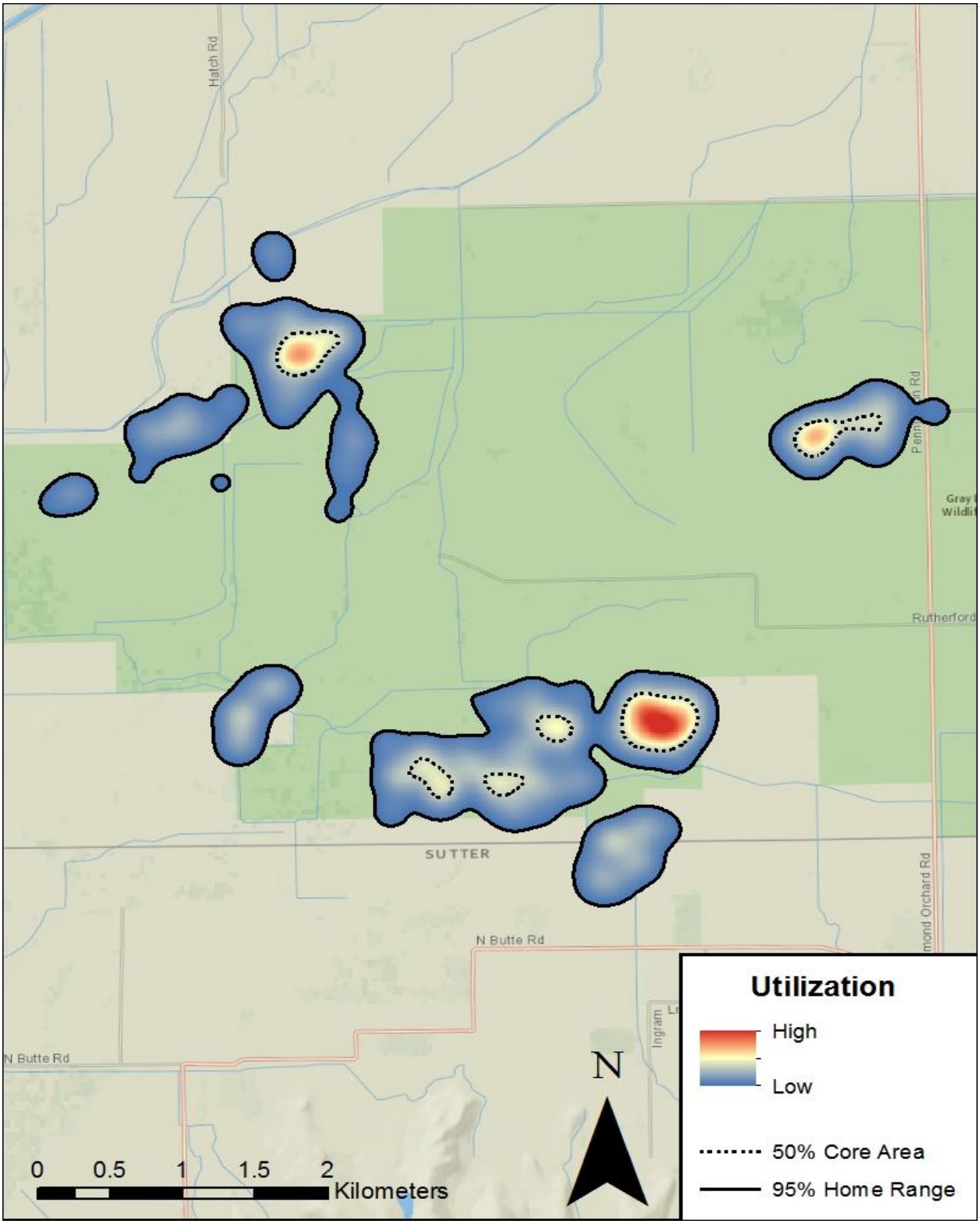

Figure 8. Utilization distribution of pheasants at GLWA, during spring and summer (March – September) in 2014. (Utilization distribution was approximated by using kernel density estimators). This information is preliminary and subject to revision.

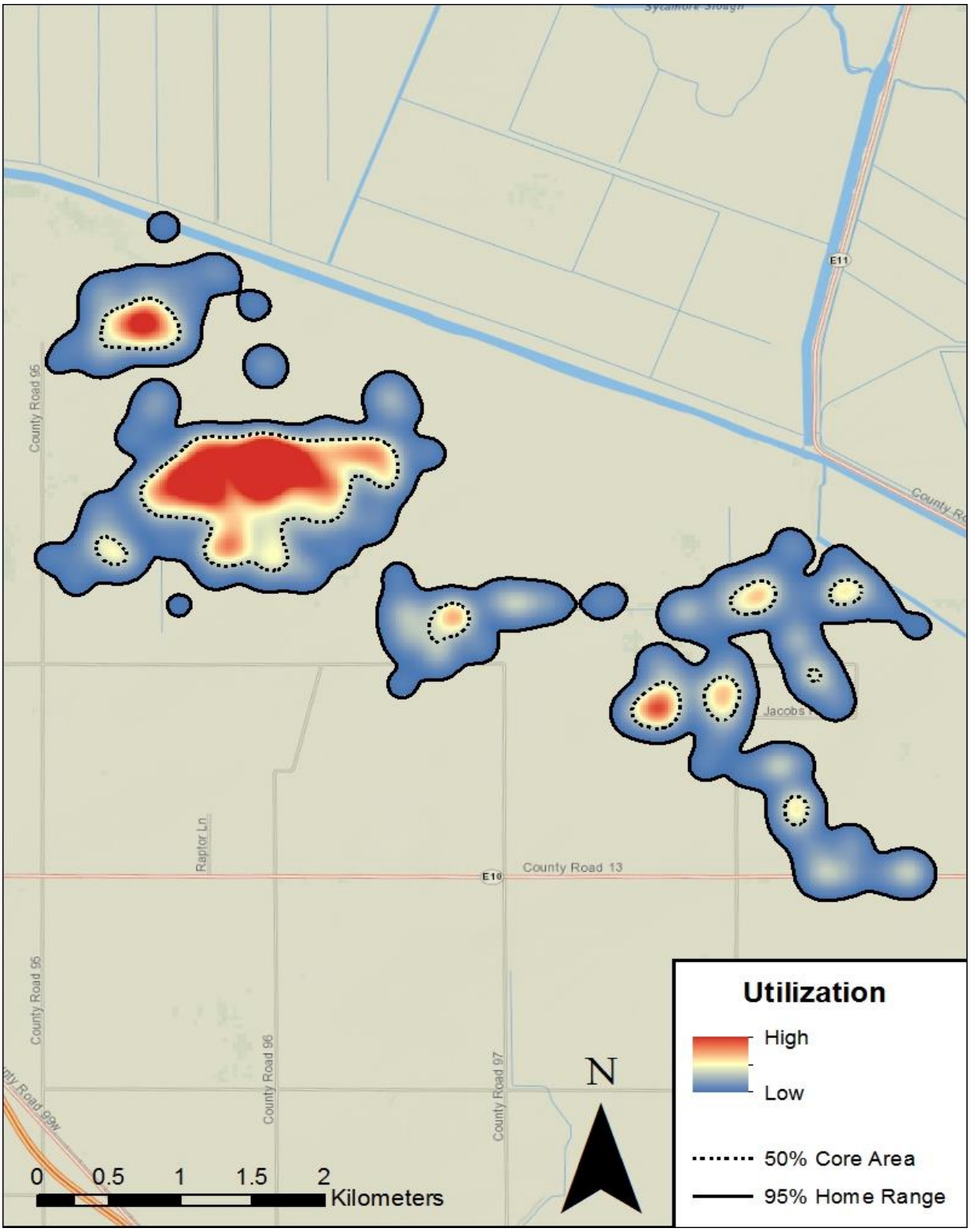

Figure 9. Utilization distribution of pheasants at Roosevelt Ranch, during spring and summer (March – September) in 2014. (Utilization distribution was approximated by using kernel density estimators). This information is preliminary and subject to revision.

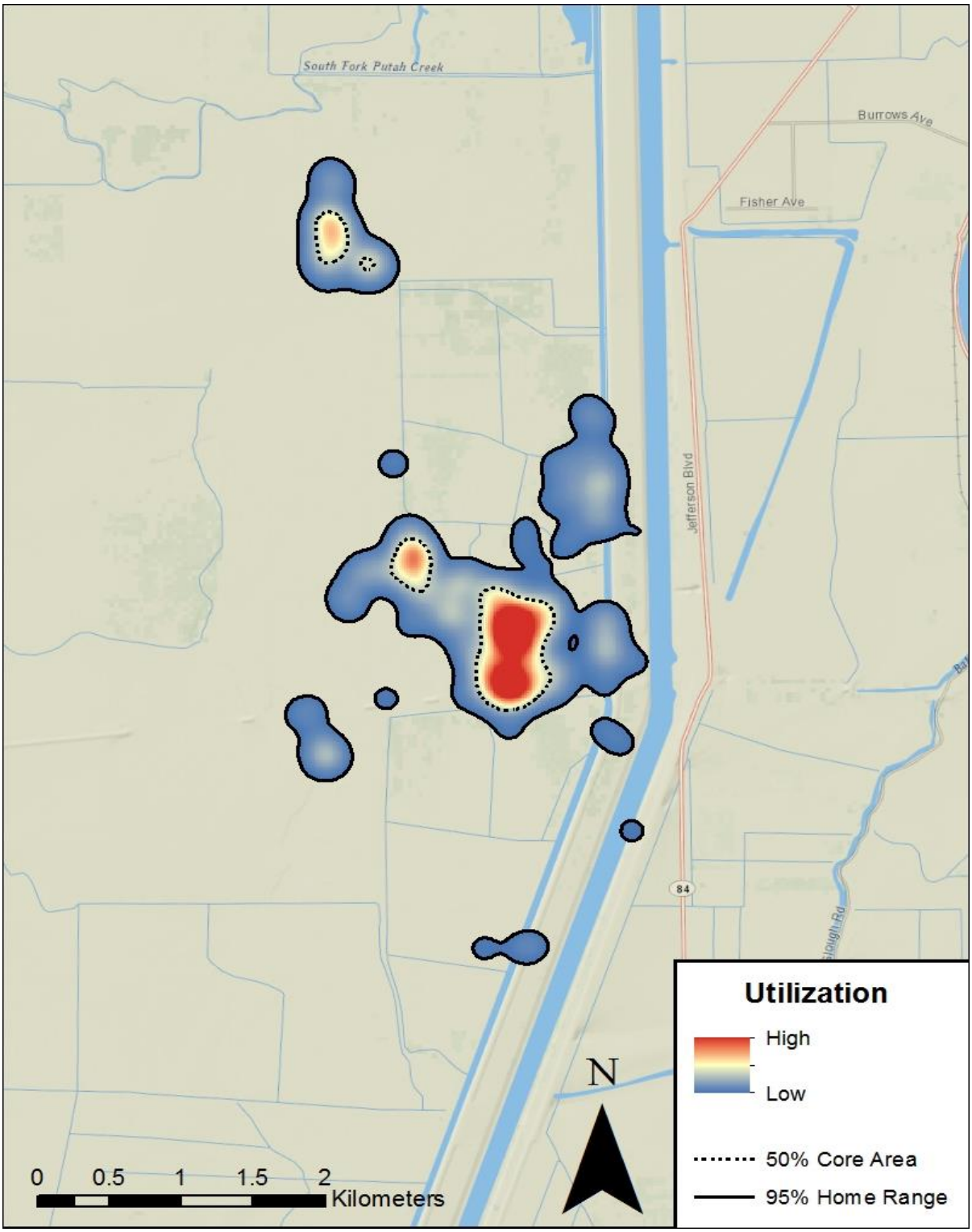

Figure 10. Utilization distribution of pheasants at YBWA, during spring and summer (March – September) in 2014. (Utilization distribution was approximated by using kernel density estimators). This information is preliminary and subject to revision.

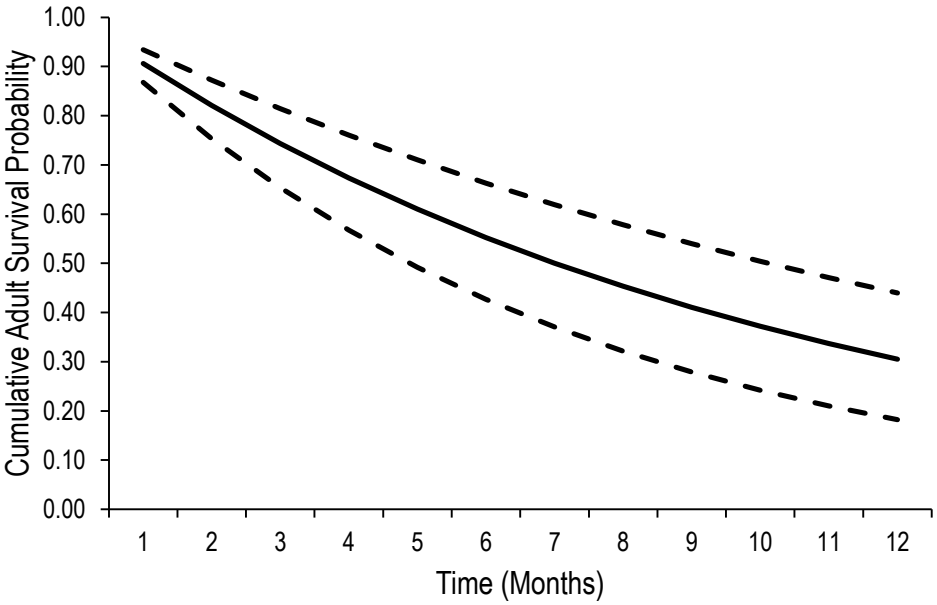

Figure 11. Cumulative average monthly adult survival probabilities for pheasant in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA during 2014. Solid line represents survival estimate while dashed lines represent 95% confidence intervals. This information is preliminary and subject to revision.

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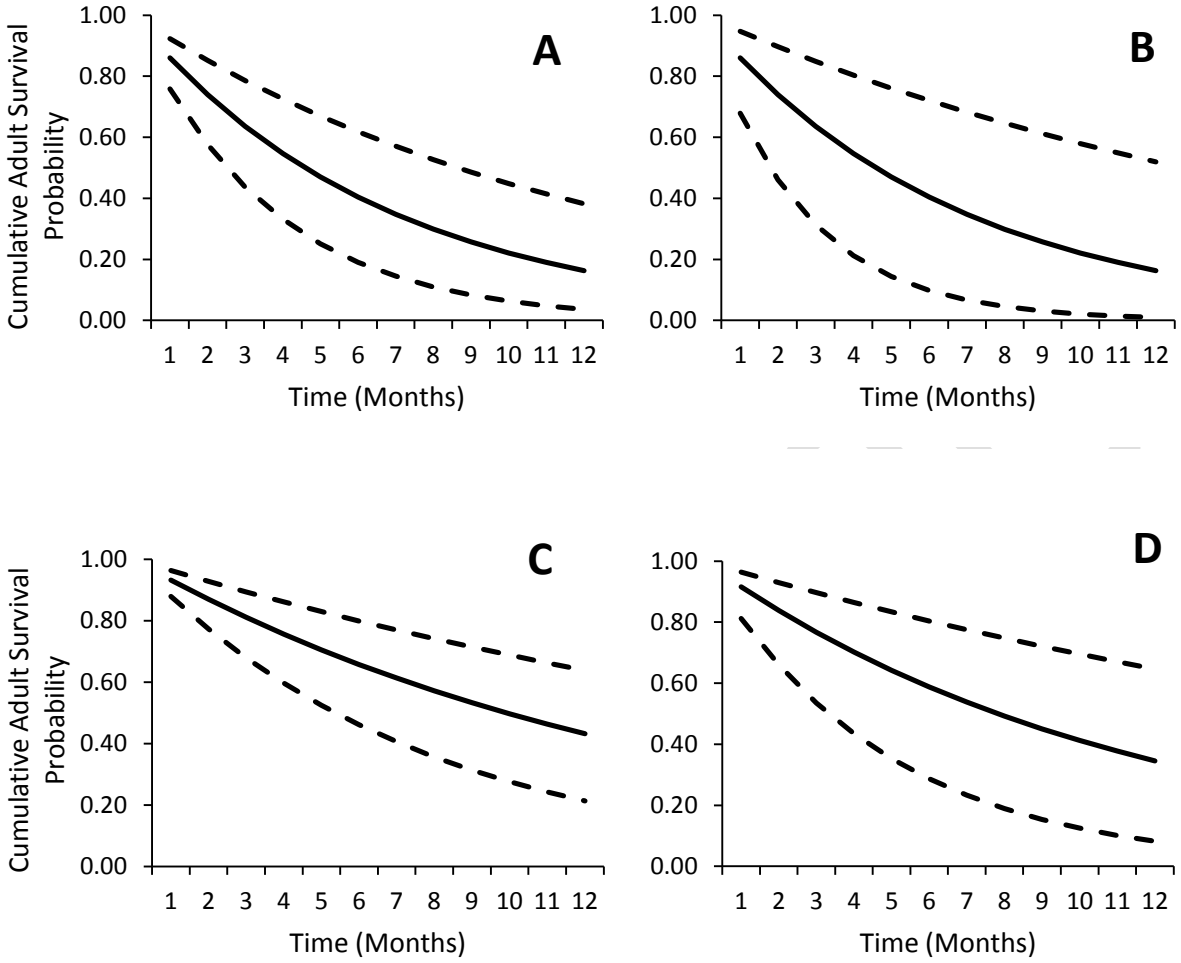

Figure 11. Cumulative average monthly adult survival probabilities for pheasant at each study area in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA, 2014: (A) GLWA; (B) Mandeville Island; (C) Roosevelt Ranch; (D) YBWA. Solid line represents survival estimate while dashed lines represent 95% confidence intervals. This information is preliminary and subject to revision.

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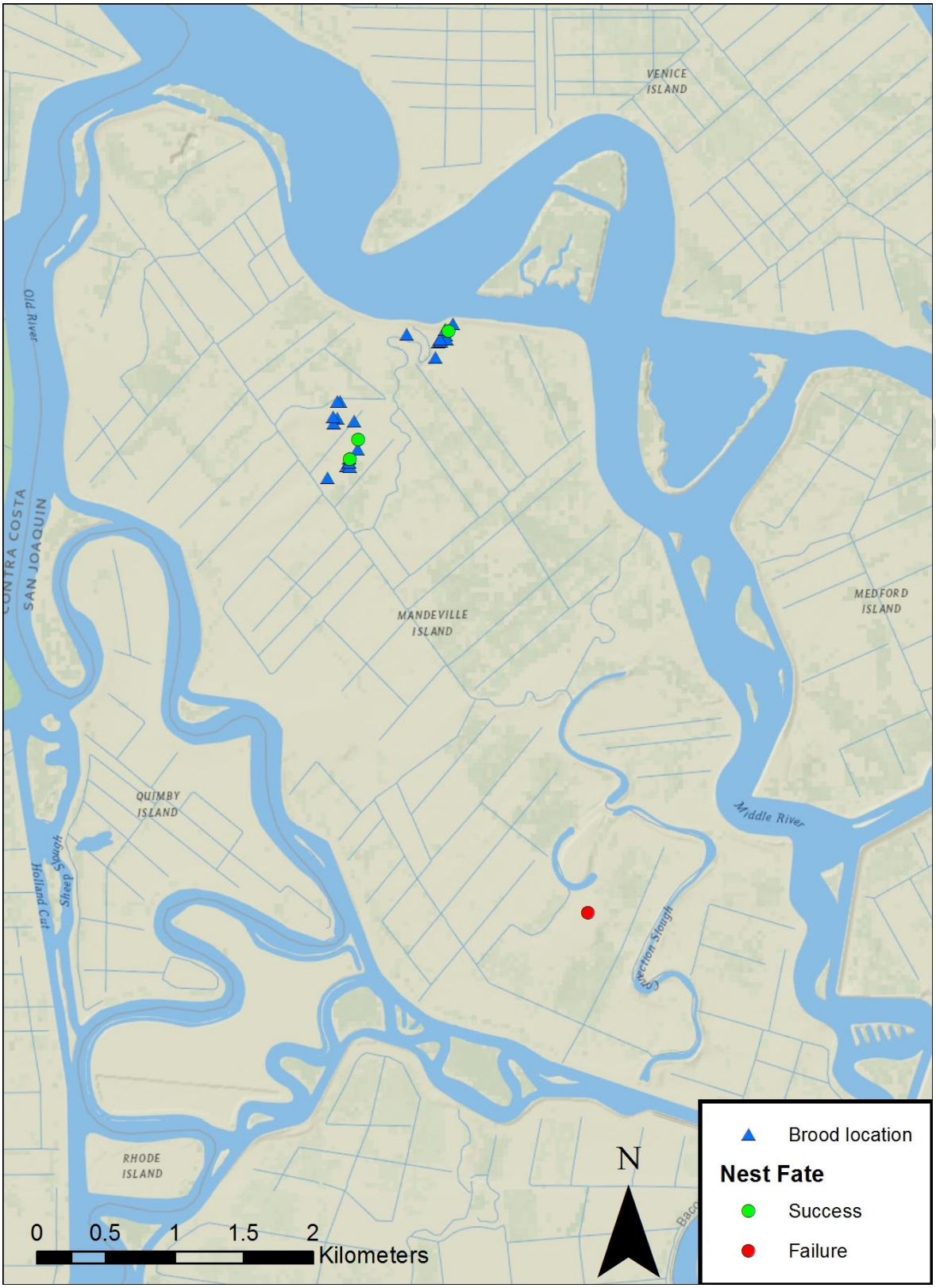

Figure 12. Successful (*n* = 3) and unsuccessful (*n* = 1) nests, and brood locations at Mandeville Island, 2014.

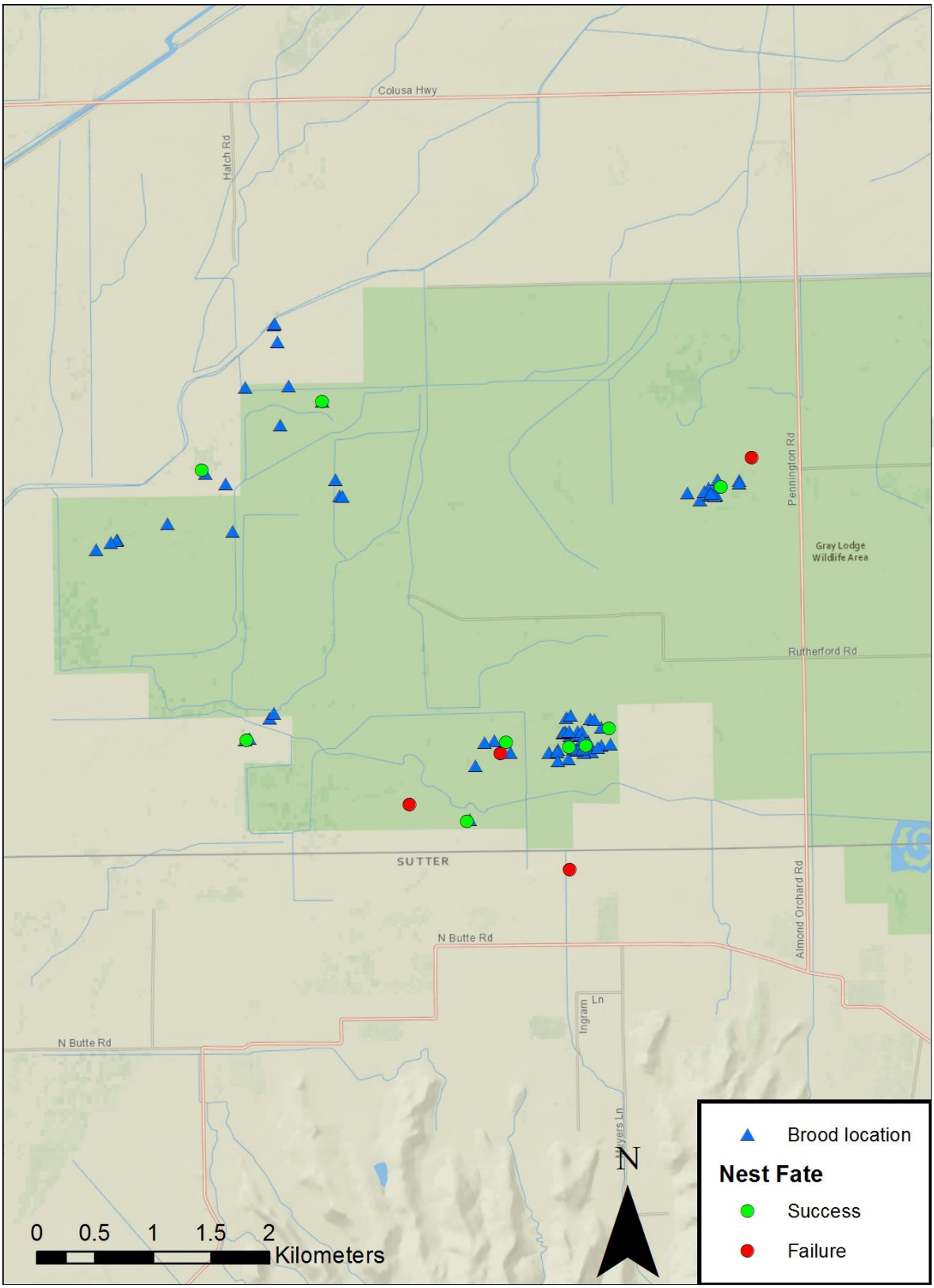

Figure 13. Successful (*n* = 9) and unsuccessful (*n* = 4) nests, and brood locations at GLWA, 2014.

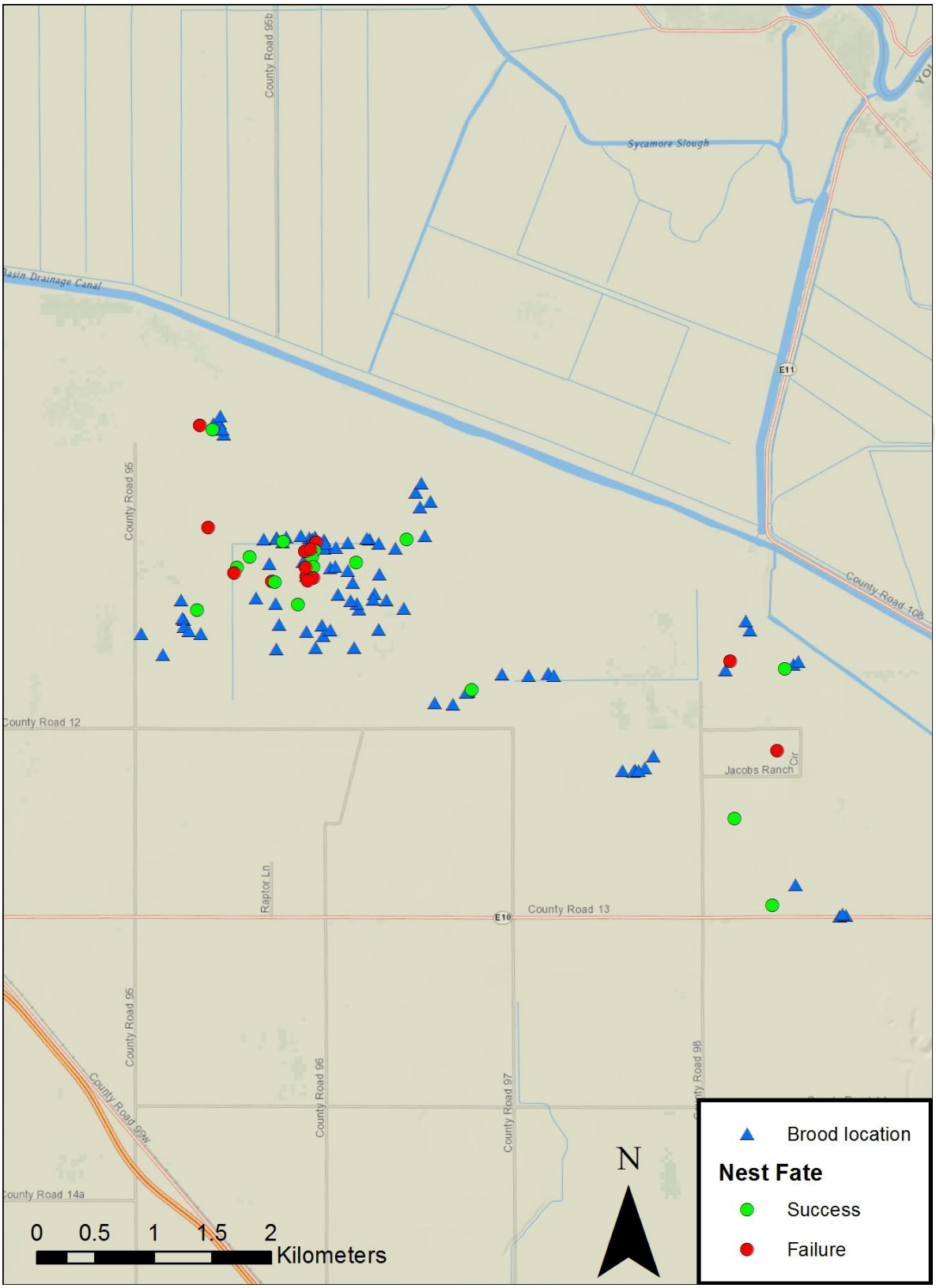

Figure 14. Successful (*n* = 16) and unsuccessful (*n* = 13) nests, and brood locations at Roosevelt Ranch, 2014.

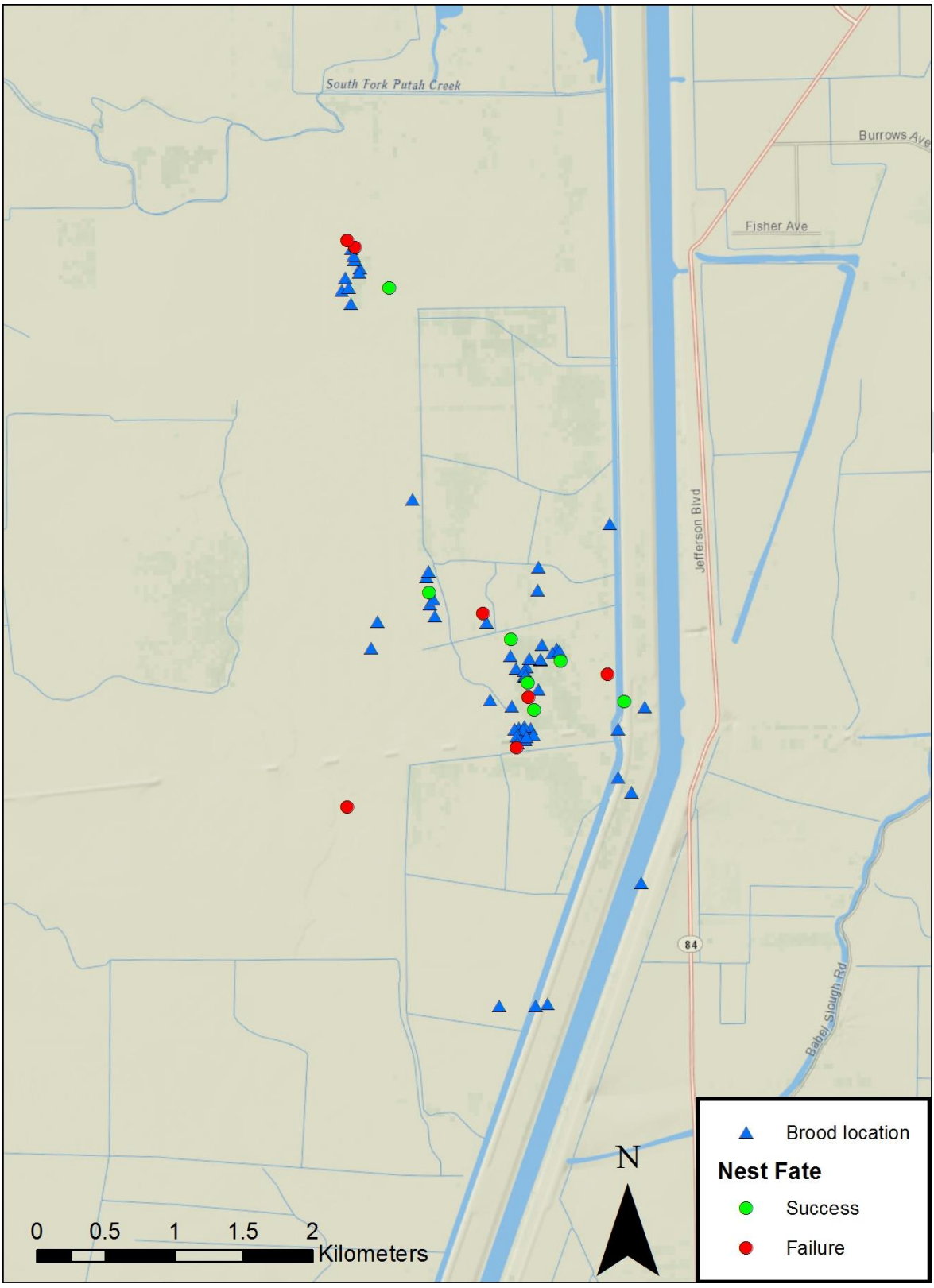

Figure 16. Successful (*n* = 7) and unsuccessful (*n* = 7) nests, and brood locations at YBWA, 2014.

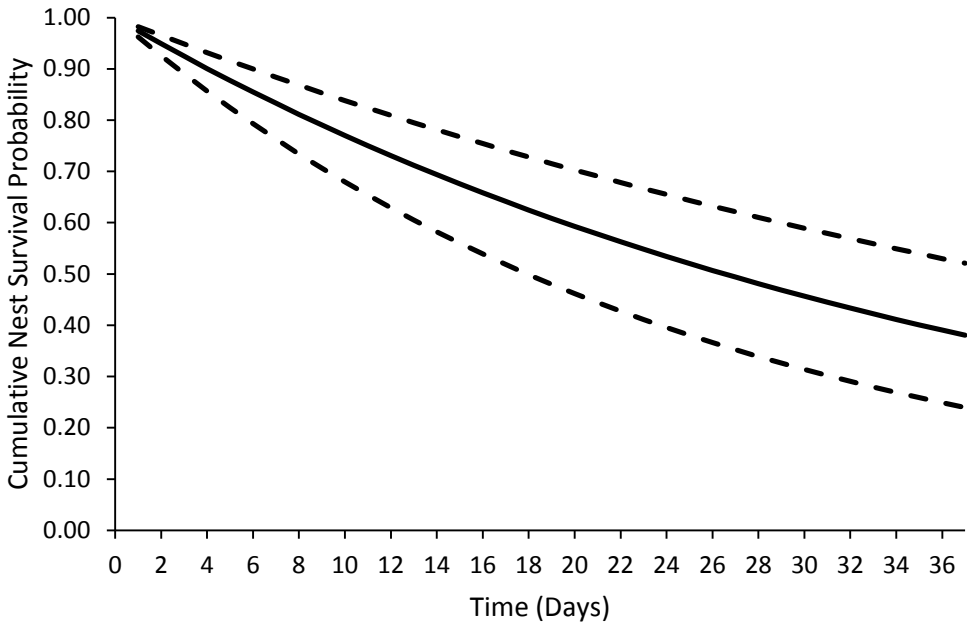

Figure 17. Cumulative average nest survival probabilities for pheasant over the 37-day laying and incubation period in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA, 2014. Solid line represents survival estimate while dashed lines represent 95% confidence intervals. This information is preliminary and subject to revision.

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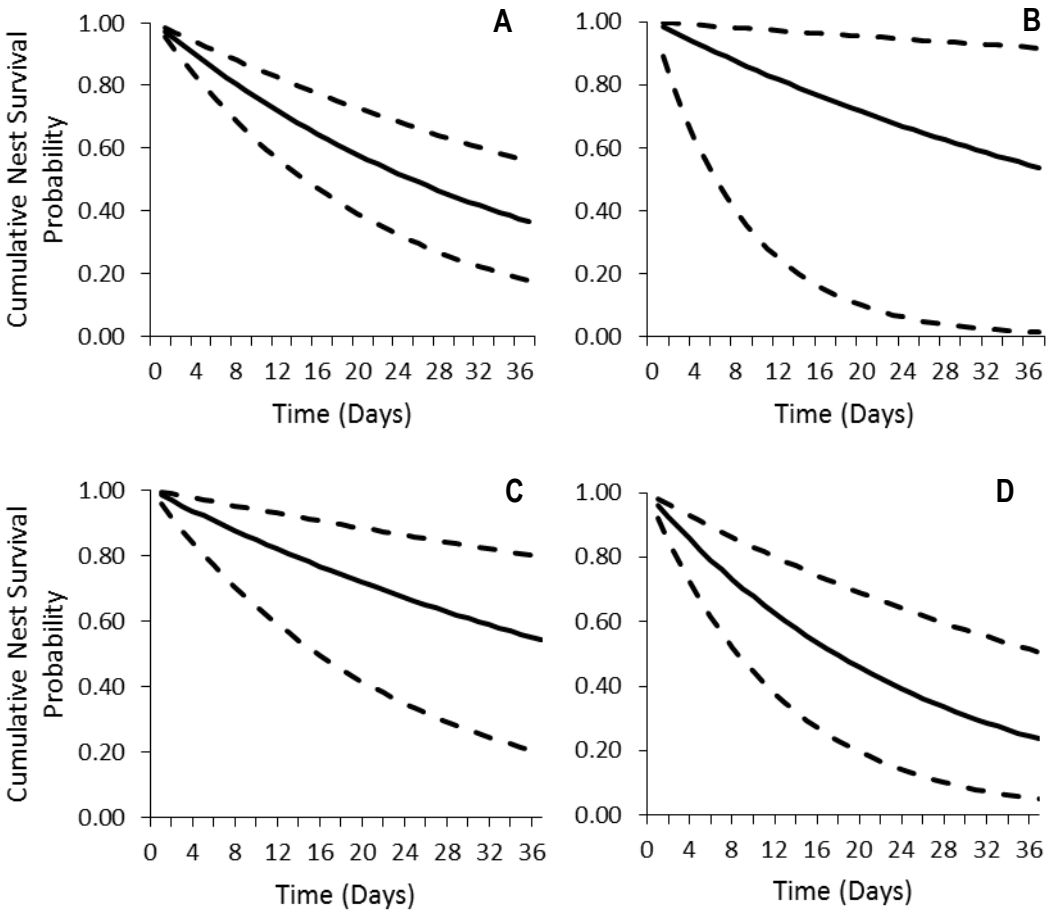

Figure 18. Cumulative average nest survival probabilities for pheasant over the 37-day laying and incubation period at each study site in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA, 2014: (A) GLWA; (B) Mandeville Island; (C) Roosevelt Ranch; (D) YBWA. Solid line represents survival estimate while dashed lines represent 95% confidence intervals. This information is preliminary and subject to revision.

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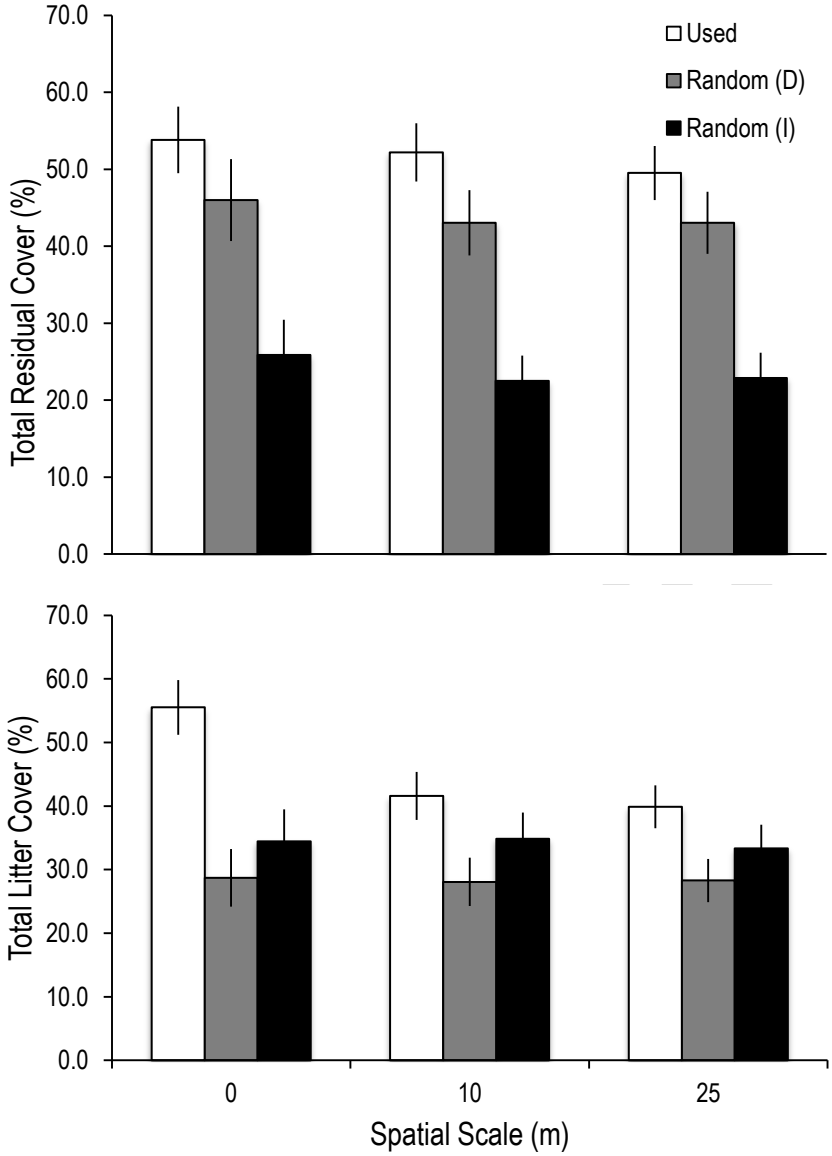

Figure 19. Average percent cover (lines represent standard errors) at 0, 10, and 25 m spatial scales from nest sites and random locations (dependent and independent) in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA, 2014. The spatial scale of 0 represents habitat at the center of each survey location. This information is preliminary and subject to revision.

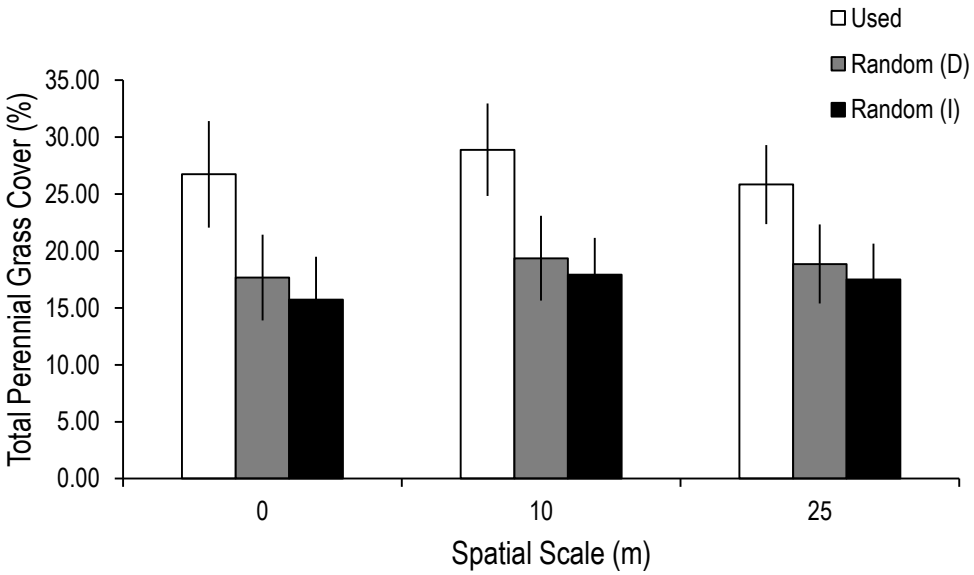

Figure 15. Average percent perennial grass cover at 0, 10, and 25 m spatial scales at nest sites and random locations (dependent and independent) in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA, 2014: The spatial scale of 0 represents habitat at the center of each survey location. This information is preliminary and subject to revision.

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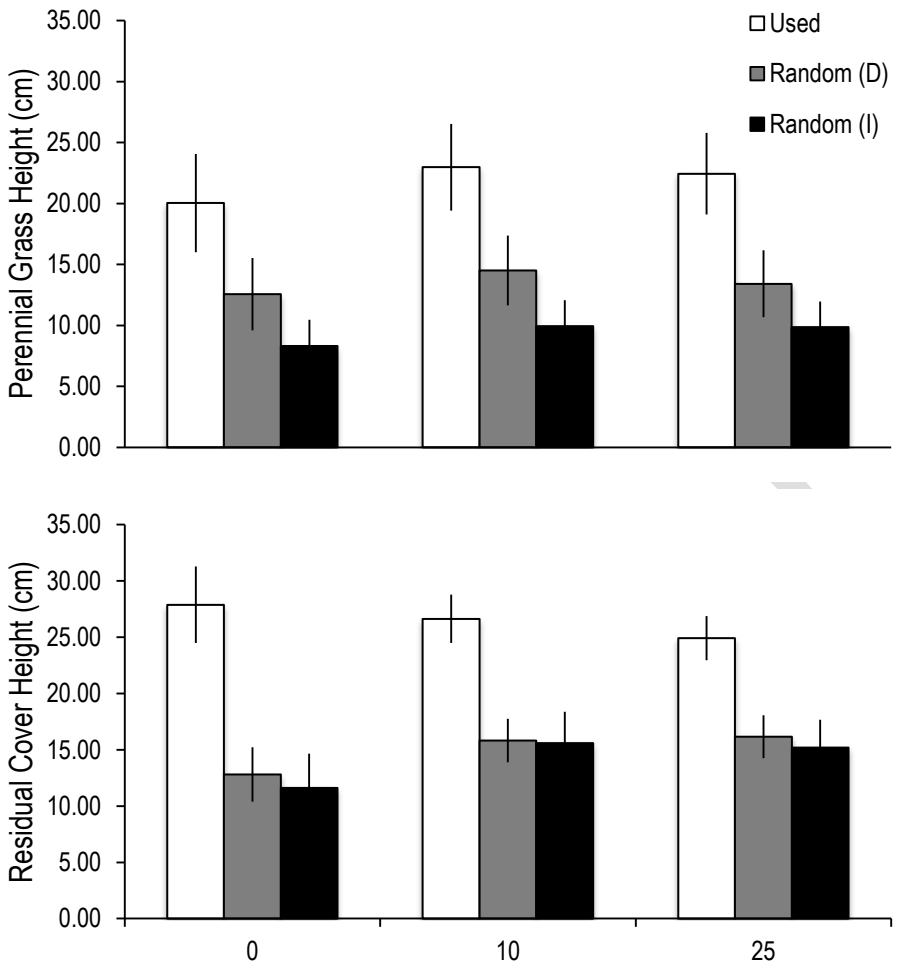

Figure 16. Mean values (lines represent standard errors) of cover height (cm) at 0, 10, and 25 m distances from nest sites and random locations in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA, 2014. This information is preliminary and subject to revision.

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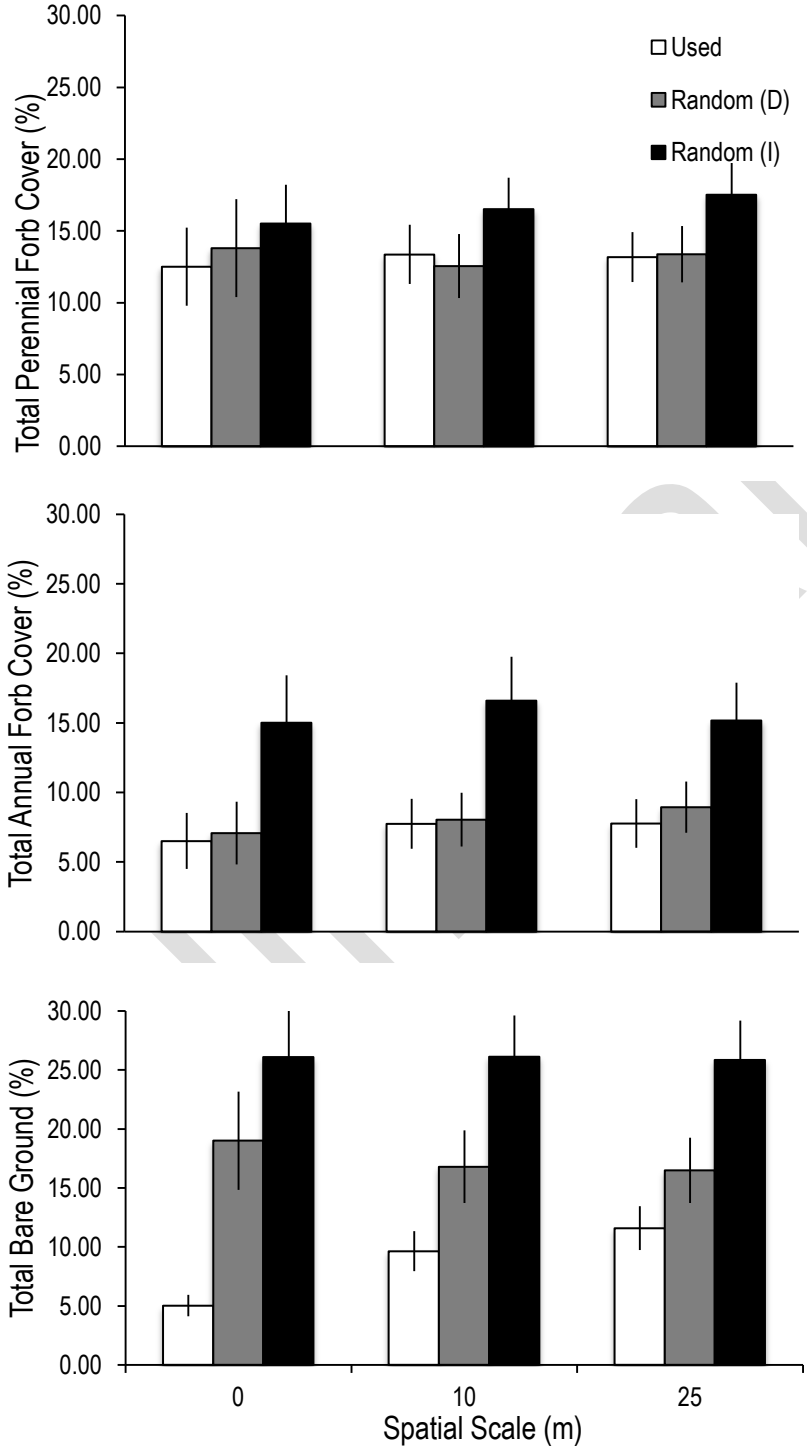

Figure 17. Average percent cover (lines represent standard errors) at 0, 10, and 25 m spatial scales from nest sites and random locations (dependent and independent) in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA, 2014. The spatial scale of 0 represents habitat at the center of each survey location. This information is preliminary and subject to revision.

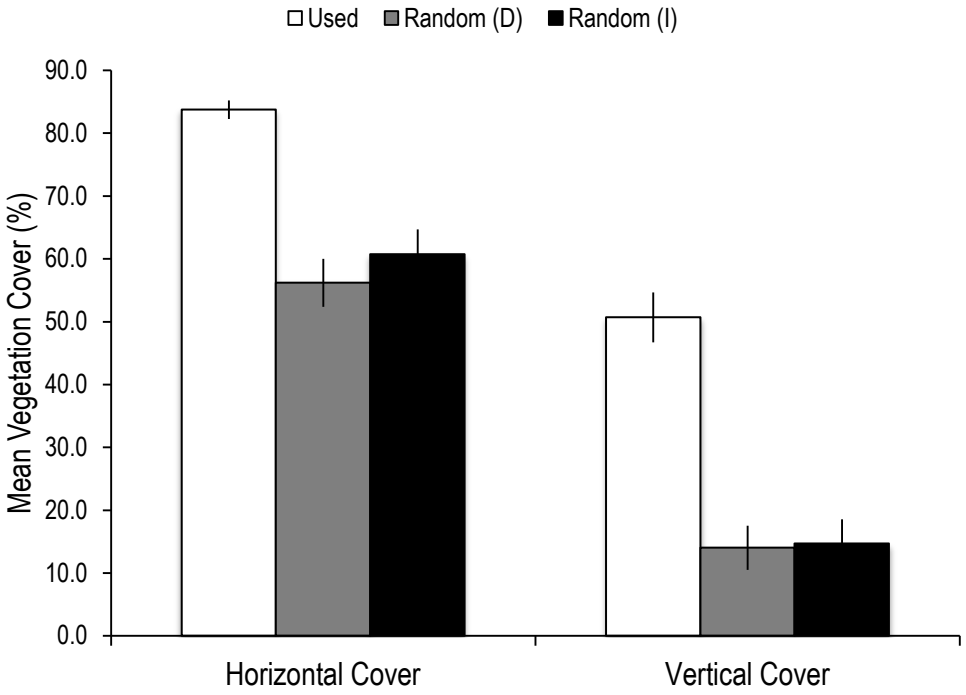

Figure 18. Mean values (lines represent standard errors) of percent cover at 0° and 45° angles (horizontal cover) and at 90° (vertical cover) for nest locations and at random locations (dependent and independent) averaged across all study sites in 2014. This information is preliminary and subject to revision.

Preliminary

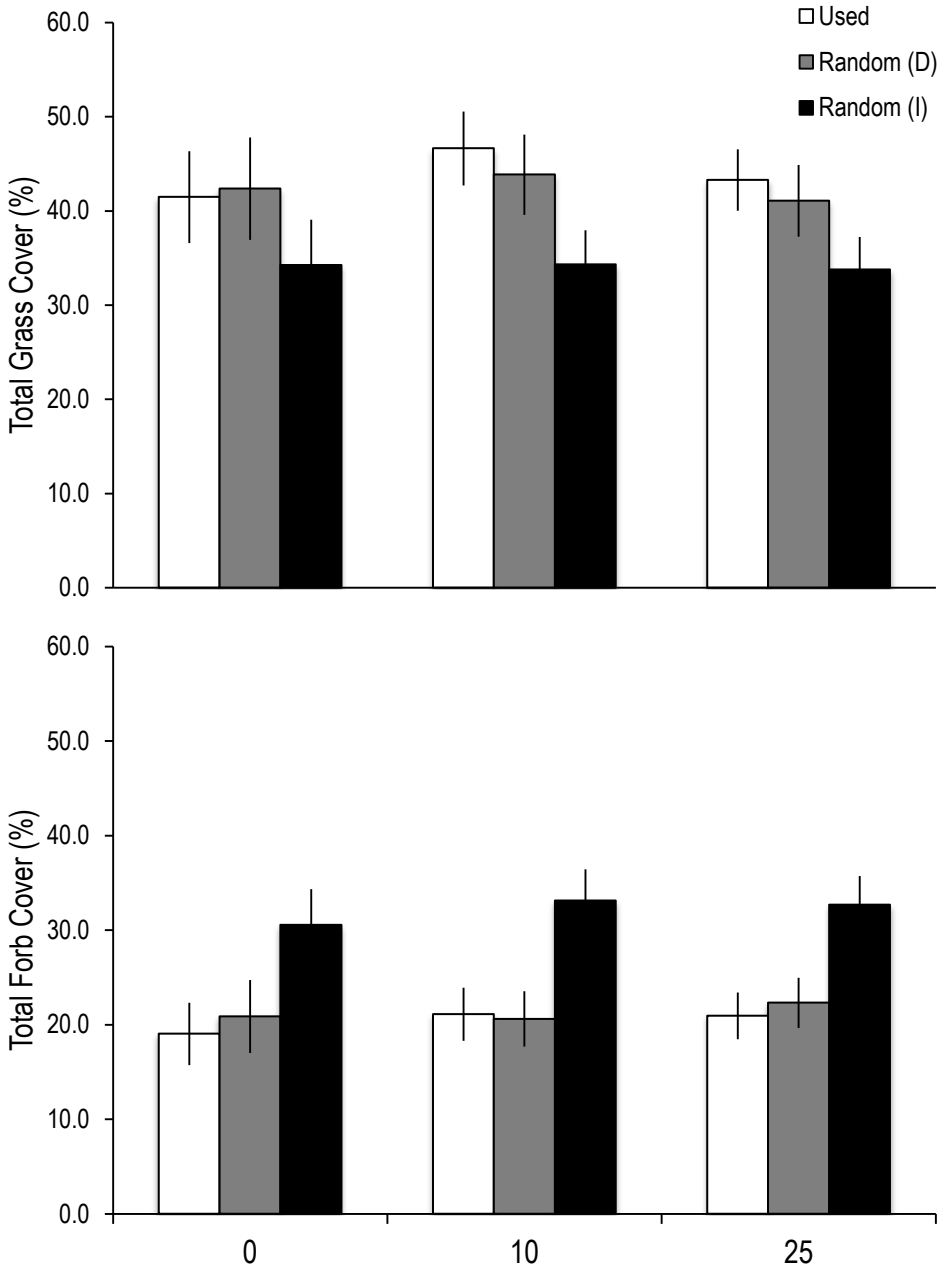

Figure 19. Mean values (lines represent standard errors) of percent cover for all grasses (perennial and annual combined) and all forbs (perennial and annual combined) at 0, 10, and 25 m from nest sites and random (dependent and independent) locations in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA, 2014. This information is preliminary and subject to revision.

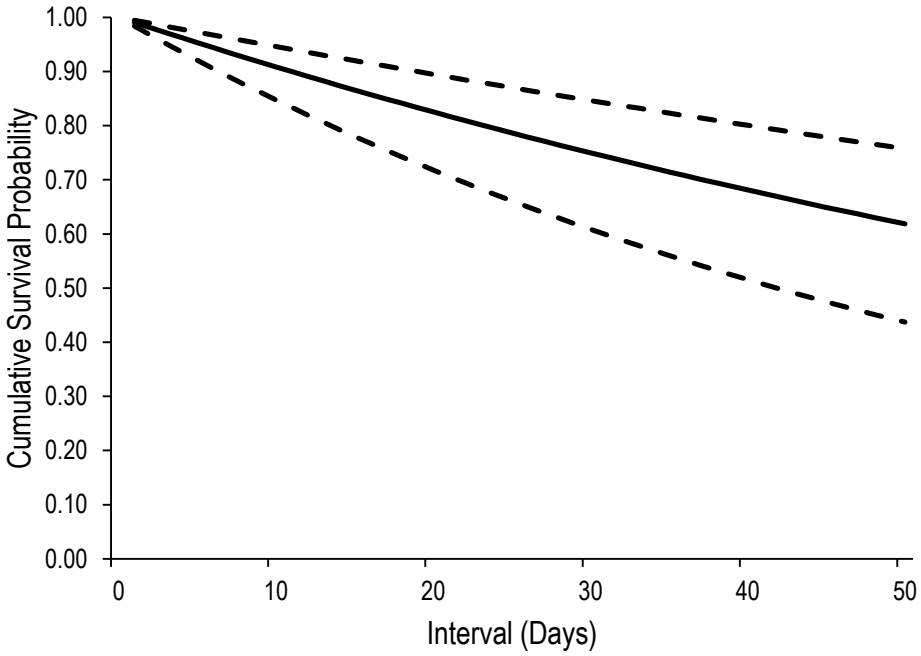

Figure 20. Cumulative average survival probability for the 50-day brood rearing phase across age of brood in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA, 2014. Dashed line represents 95% confidence interval. This information is preliminary and subject to revision.

Preliminary

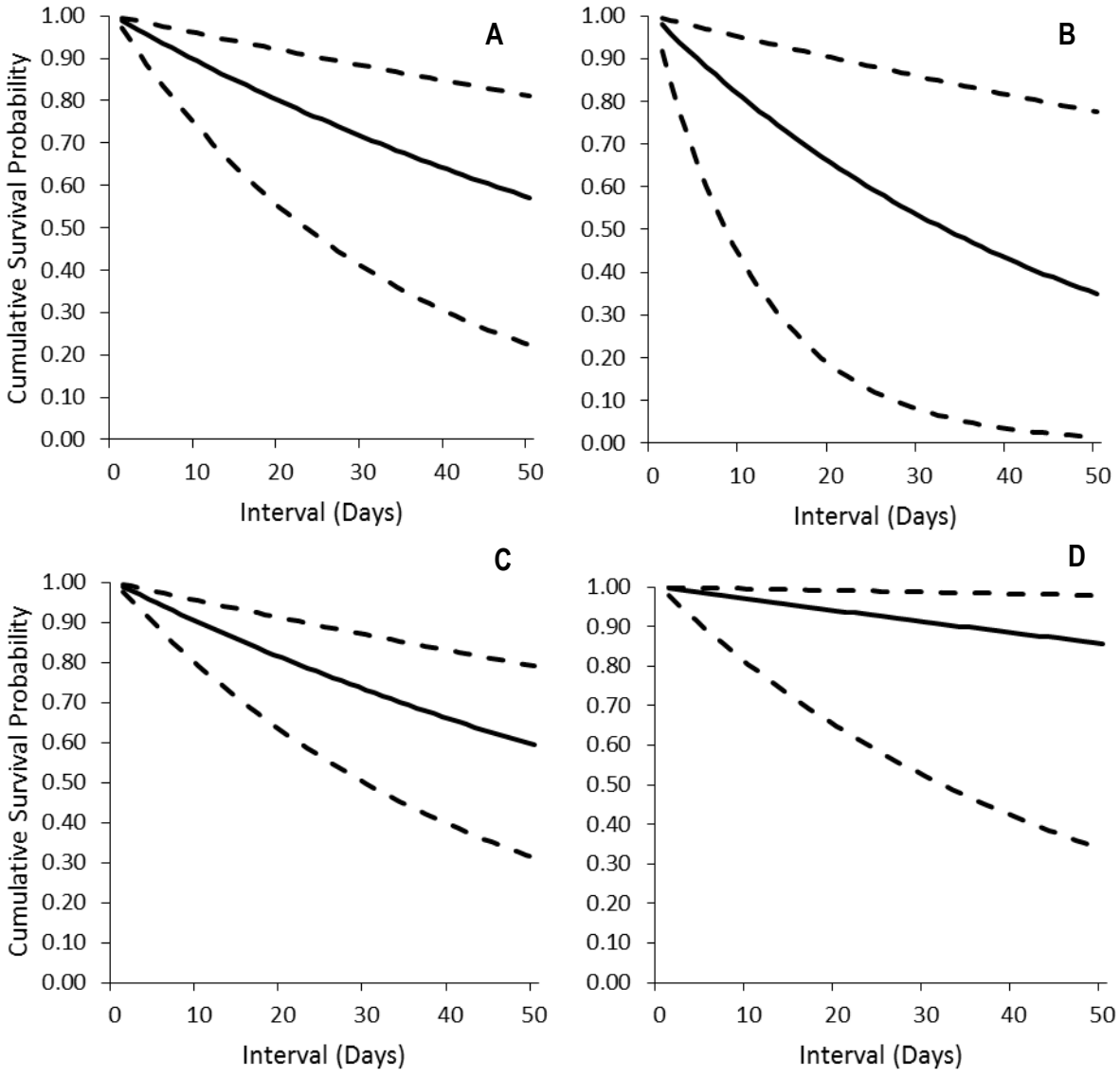

Figure 26. Cumulative average survival probability for the 50-day brood rearing phase across age of brood in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA, 2014: (A) GLWA; (B) Mandeville Island; (C) Roosevelt Ranch; (D) YBWA. Dashed line represents 95% confidence interval. This information is preliminary and subject to revision.

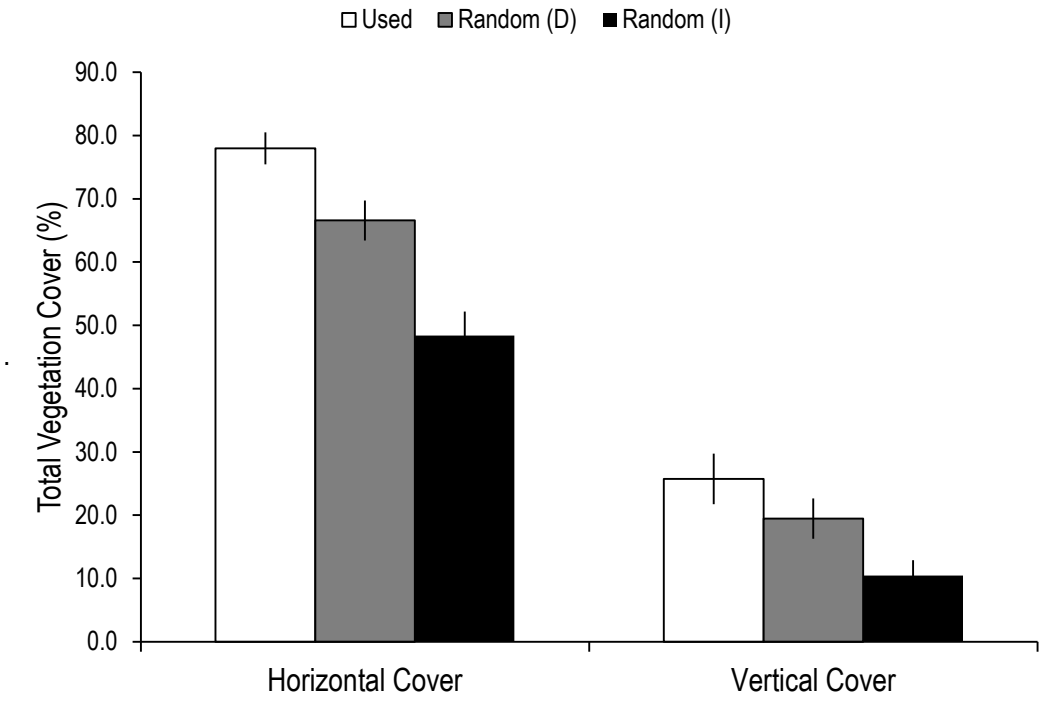

Figure 27. Mean values (lines represent standard errors) of percent cover at 0° and 45° angles (horizontal cover) and at 90° (vertical cover) for brood locations and at random locations (dependent and independent) averaged across all study sites in 2014. This information is preliminary and subject to revision.

Preliminary

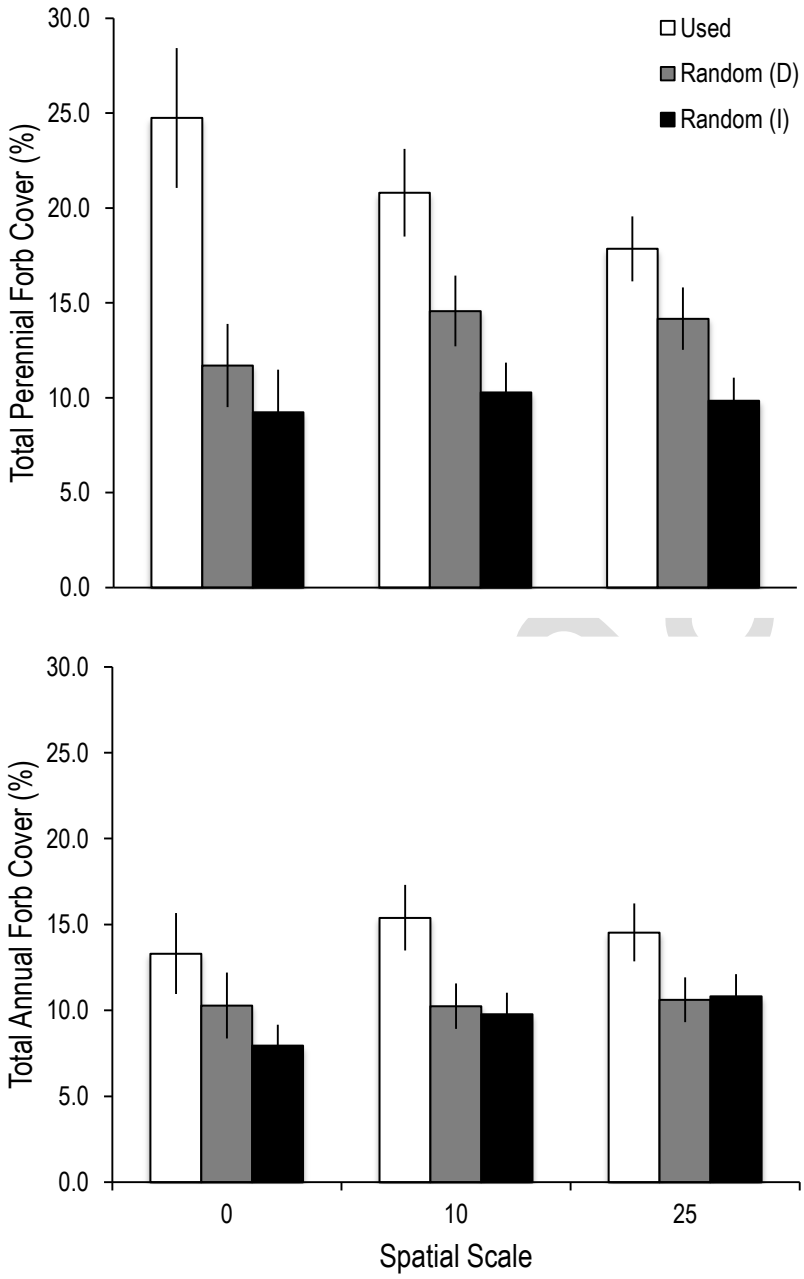

Figure 28. Average percent cover (lines represent standard errors) at 0, 10, and 25 m spatial scales from brood locations (used) and random locations (dependent and independent) in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA, 2014. The spatial scale of 0 represents habitat at the center of each survey location. This information is preliminary and subject to revision.

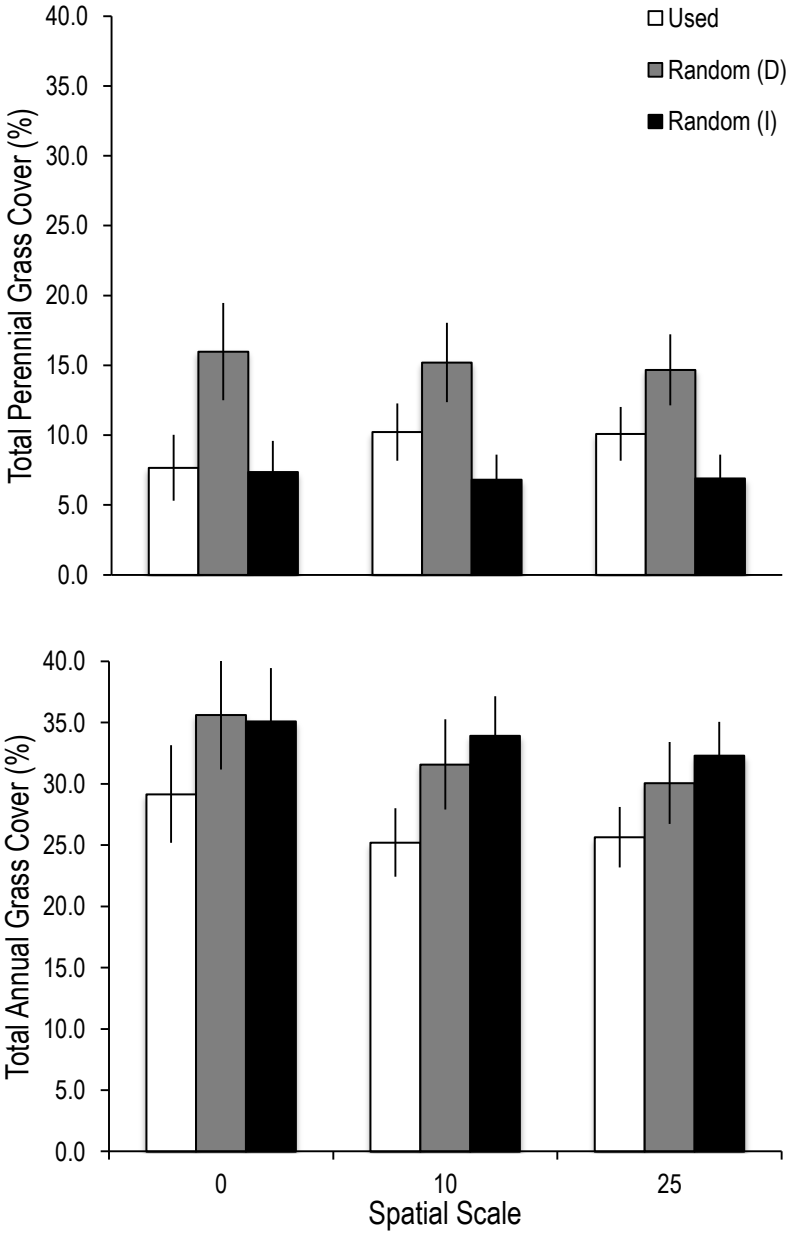

Figure 29. Average percent cover (lines represent standard errors) at 0, 10, and 25 m spatial scales from brood locations (used) and random locations (dependent and independent) in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA, 2014. The spatial scale of 0 represents habitat at the center of each survey location. This information is preliminary and subject to revision.

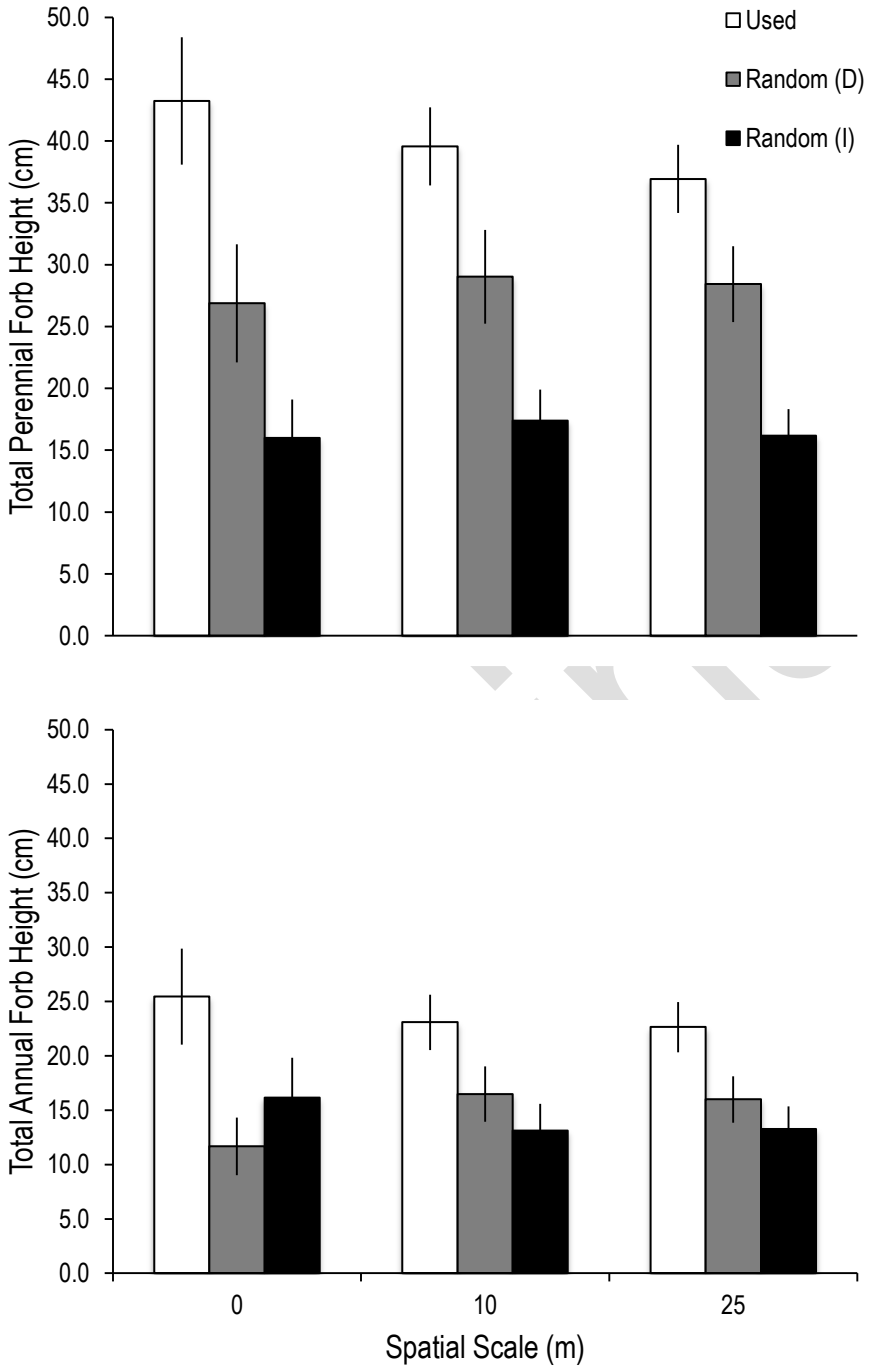

Figure 21. Average height (lines represent standard errors) at 0, 10, and 25 m spatial scales from brood locations (used) and random locations (dependent and independent) in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA, 2014. The spatial scale of 0 represents habitat at the center of each survey location. This information is preliminary and subject to revision.

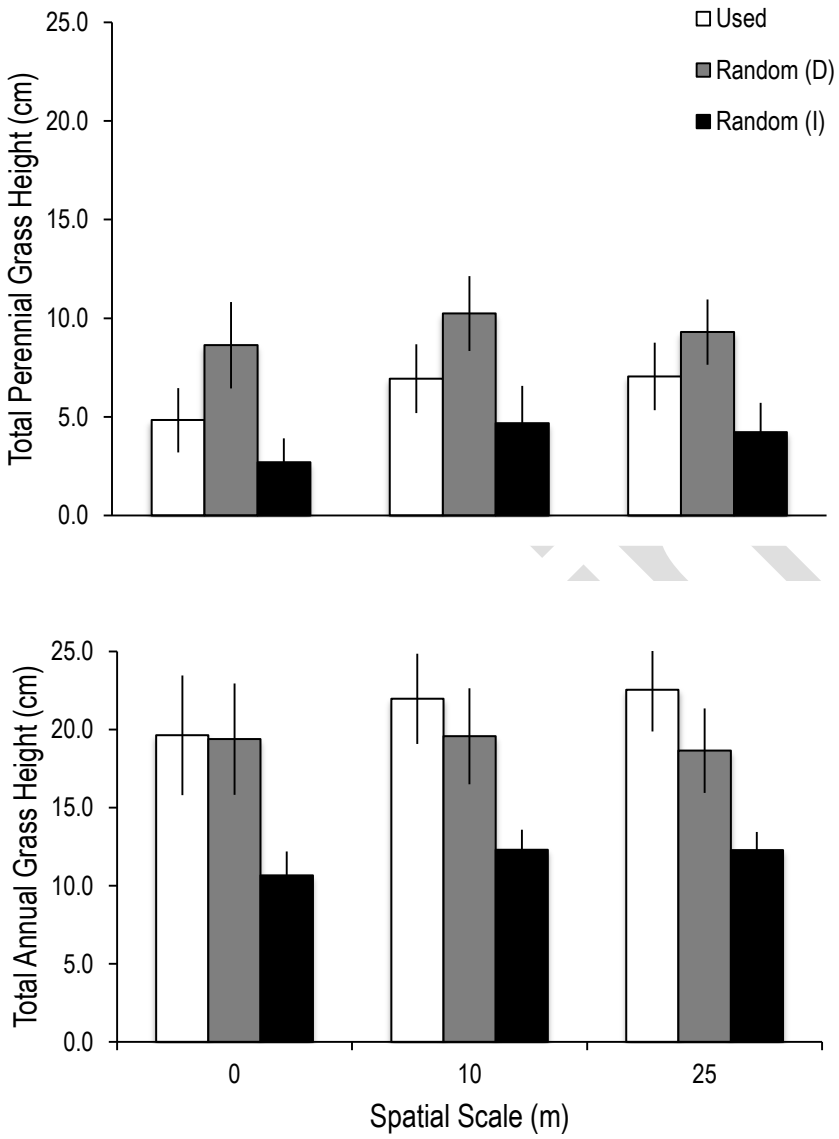

Figure 22. Average height (lines represent standard errors) at 0, 10, and 25 m spatial scales from brood locations (used) and random locations (dependent and independent) in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA, 2014. The spatial scale of 0 represents habitat at the center of each survey location. This information is preliminary and subject to revision.

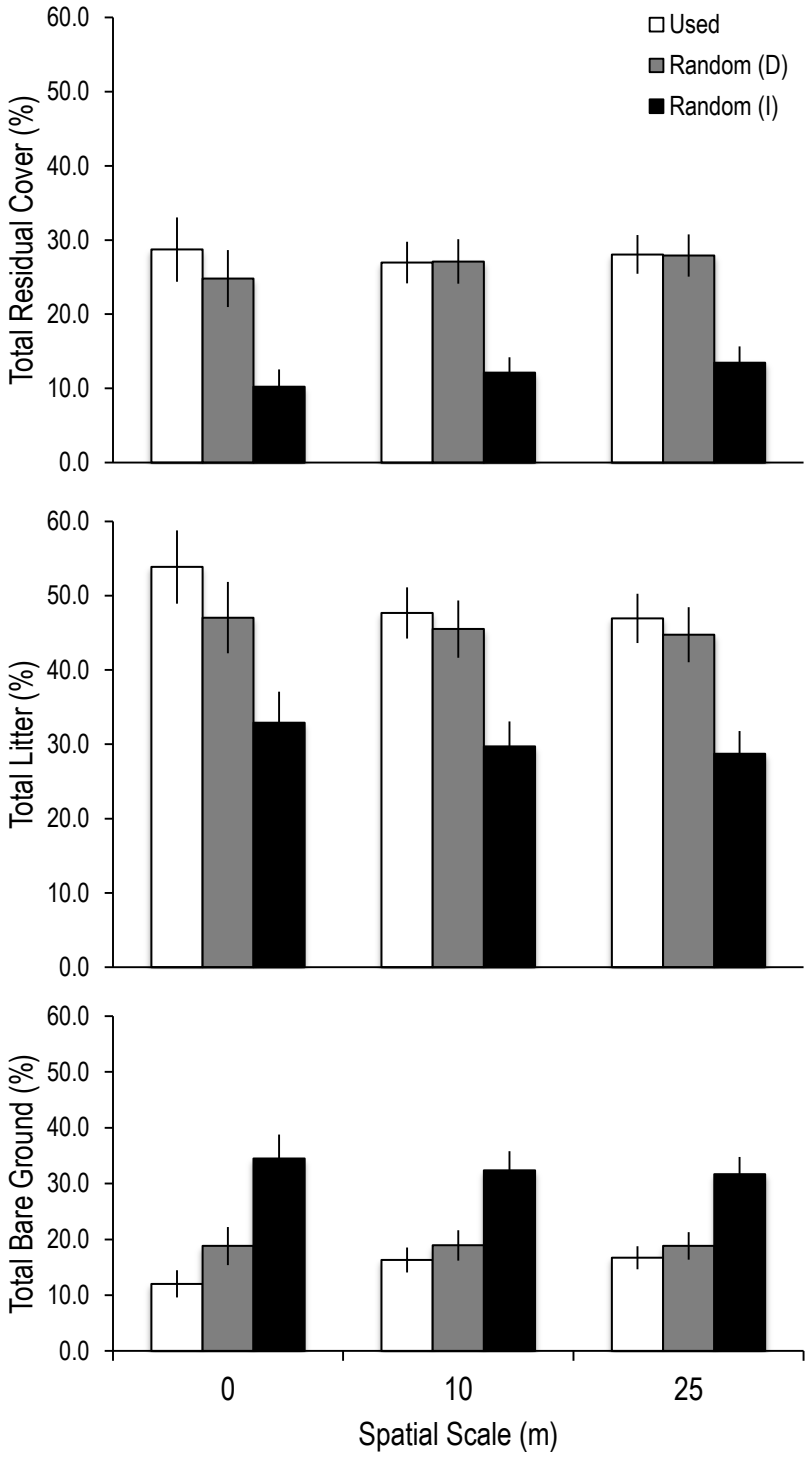

Figure 23. Percent cover (lines represent standard errors) at 0, 10, and 25 m spatial scales from brood locations (used) and random locations (dependent and independent) in the Sacramento Valley and the Sacramento-San Joaquin River Delta, CA, 2014. The spatial scale of 0 represents habitat at the center of each survey location. This information is preliminary and subject to revision.