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Tule Elk Monitoring and Management at Point Reyes National Seashore

2013-2014 Report

Natural Resource Report NPS/SFAN/NRR—2016/1317



ON THE COVER
Female tule elk in the fog, Point Reyes National Seashore.
Photograph courtesy of the National Park Service (Tim Bernot).

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Abstract

Native tule elk at Point Reyes National Seashore occur in three separate herds at Tomales Point, Drakes Beach, and in the Estero Road/Limantour area. During 2013 and 2014, the Tomales Point tule elk population declined from 356 to 286 total elk within the reserve. Although the decline may have been influenced by severe drought conditions, population dynamics in the reserve are complex and may also be affected by reproductive rates, mineral deficiencies, and disease. Meanwhile, elk herds at Drakes Beach and the Estero Road/Limantour areas increased from 2013 to 2014. Through visual observations and the deployment of GPS collars, park staff monitored the presence of tule elk on park ranches. In the Drakes Beach area, up to 76.8% of elk locations per year were recorded on park ranches, and GPS points of collared individuals occurred on park ranches between 26.9% and 82.3% per year. In the Estero Road area, where only male elk occur, up to 92.6% of elk locations per year were recorded on park ranches. Additional tule elk monitoring and management actions implemented by Point Reyes staff in 2013 and 2014 included attempted captures of male elk with antler entanglements, a water development project in the Drakes Beach area, hazing of elk from park ranches, Johne's disease monitoring, elk fence maintenance at Tomales Point, cattle fence repair and removal in the Drakes Beach area, shed antler collection, and investigation of notable mortalities. The tule elk docent program at Tomales Point was active again in 2013 and 2014, reaching over 5,000 visitors annually. Tule education and outreach at the park also included class field trips from local universities and public presentations at park headquarters.

Introduction

The tule elk (*Cervus elaphus nannodes*) is one of two subspecies of elk native to California. Its numbers were severely reduced in the mid-1800s, primarily due to uncontrolled market hunting and displacement by cattle. By some accounts, fewer than 30 animals remained in a single herd near Bakersfield in the mid-1870s. A conservation-minded cattle rancher named Henry Miller preserved this last isolated group discovered on his ranch in 1874. Until this discovery, tule elk were thought to be extinct. All of the estimated 4,000 or more tule elk present in 25 herds across California were derived from this small remnant herd.

Tule elk are endemic to California. Roosevelt elk (*C. elaphus roosevelti*), also native to California, are found on forested slopes in the Pacific Northwest and in several other western states. Rocky Mountain elk (*C. elaphus nelsoni*) are a non-native transplant to the state and are found in the northeast corner of California. Point Reyes National Seashore (PORE) is the only national park unit with tule elk.

Tule elk once inhabited the grasslands of the Point Reyes peninsula and the Olema Valley, as well as other grasslands within Marin County. They were the dominant grazers on these lands until their local extirpation in the 1850s. Following state protection (SB 722, 1971) and federal legislation directing the federal government to make suitable lands available for "the preservation and grazing of tule elk" (PL 94-389, 1976), the California Department of Fish and Game, in cooperation with the U.S. Fish and Wildlife Service and the National Park Service (NPS), reintroduced tule elk to the park at Tomales Point. In 1978, 10 animals (8 females and 2 males) were transplanted from an existing reintroduced herd in the San Luis National Wildlife Refuge near Los Banos to a 2,600 acre fenced enclosure on Tomales Point. The site of this release had a long history of cattle ranching, known as Pierce Point Ranch, which was designated as wilderness in 1976 (PL 94-544 and PL 94-567).

Following the recommendations of a scientific advisory panel convened by the park (McCullough et al. 1993) and the release of a Tule Elk Management Plan and Environmental Assessment (National Park Service 1998), an additional free-ranging herd of tule elk was established at Point Reyes National Seashore. In 1999, 28 animals taken from the Tomales Point preserve were released in the wilderness area south of Limantour Beach (Figure 1). A few of the elk soon dispersed from the Limantour area, and by the fall of 2001, a small herd (one bull and four cows) had established itself near Drakes Beach, including in areas permitted for dairy and beef ranching.

Today, as detailed within this report, the Drakes Beach elk occur from the edges of Drakes Estero and southwest towards the Point Reyes Headlands, the Limantour elk range from the wilderness areas near the 1999 release site and northwest to adjacent ranch lands, and the Tomales Point elk remain within the reserve, contained by an elk fence that straddles the peninsula (Figures 1 and 2). Elk are not known to move between the three herds.

Each year Point Reyes National Seashore wildlife staff dedicates significant amounts of time and effort to the monitoring and management of native tule elk (*Cervus elaphus nannodes*) within the park. Since 2000, the park has produced an annual census report of the elk within the Tomales Point



Figure 1. General locations of tule elk herds at Point Reyes National Seashore.

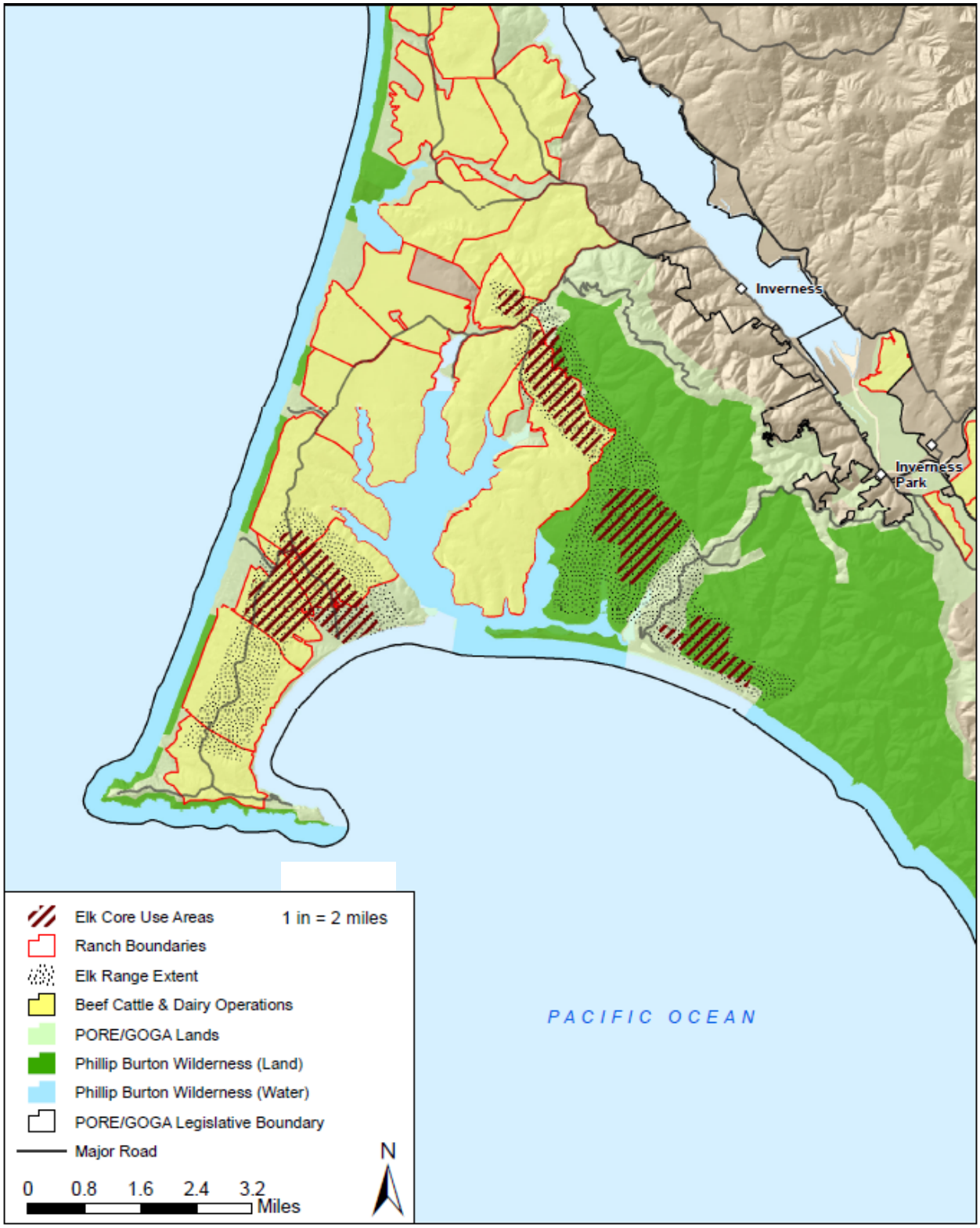


Figure 2. Core use areas of free-ranging elk herds at Point Reyes National Seashore.

Reserve. This report is the first to expand annual elk reporting to all tule elk herds in the park and extends beyond the latest census numbers by including sections on monitoring and management of elk on park ranch lands, antler collections, disease surveillance, fencing, notable mortalities, and education and outreach efforts. The time span for this report is October 2012 through to October 2014. We also report here census data collected in late 2014 and early 2015.

Population Data

Tomales Point

Elk in the Tomales Point elk reserve are censused yearly by a team of 4-6 National Park Service staff and trained volunteers on horses, boat, and foot (Figure 1). The reserve is divided into three sectors with a census team assigned to each sector, allowing for a complete census of the peninsula in a single day. With little vegetative cover on the peninsula, the elk are easily located for census. Elk observed outside, if detected, of the reserve boundary are also counted (Figure 1 and Figure 2). Elk that escape the Tomales Point Reserve, typically males, never stray far from the elk fence, herd together, and are easily detected. At least two counts are conducted in November – December of each year. A third count may occur, especially if the results of the first two counts are not consistent.

During census surveys, observers record count data using notebooks and topographical maps. Observers approach groups and individual elk as closely as possible without displacing them and use binoculars to count and classify animals. Sightings of black-tailed deer, coyotes, bobcats, and other wildlife of special interest are noted, as are any elk carcasses. All observed elk are counted and classified into 5 groups: (1) cows - adult females, (2) calves - young of the year of either sex, (3) spikes - adult males with unbranched antlers, (4) raghorns - adult males with branched antlers having 2 to 4 tines, and (5) prime bulls - adult males with branched antlers having 5 or more tines. Locations of elk are noted on field maps during the census, and at the end of the census, observers review elk locations, especially at sector boundaries, in order to consider whether or not any elk may have been double-counted.

The final minimum population estimate is compiled from the highest daily sum of animals per classification. For example, in the event that the high count of adult cows occurs on a different day than the high count of branched antler males, data from both dates may be used in order to obtain the most accurate annual population estimate. In previous years, the minimum population estimate was taken from the highest total daily sum count regardless of classification count differences between surveys, resulting in a potentially less accurate population estimate.

2013 Census

In 2013, the censuses were conducted on December 4 and December 11. The weather for both censuses was clear with good visibility and no precipitation or fog. For both counts, a pair of horseback riders was assigned to each of the south and middle sectors, and the north sector was surveyed by one person on foot who was dropped off by boat.

The highest total elk count occurred on December 4 with 356 elk observed. The next count on December 11 was slightly lower, recording 348 elk. Complete results from both censuses are included in Appendix A. Due to differences in the data collected between the two counts, the final minimum population estimate for 2013 was pooled from data collected on both surveys. The final population determination conservatively presumed that some spike males integrated within the larger herds were misidentified as cow elk on the first census. Staff determined that the final herd composition for Tomales Point in 2013 was 188 cows, 46 calves, 11 spike males, and 111 branched antler males (356 total elk). The December 11 count recorded 23 elk carcasses, which is more than two times higher than the previous high count of 10 elk carcasses recorded in 2012.

Other wildlife species observed during the December 4 census included a total of 26 black-tailed deer and 3 coyotes. On December 11, a total of 33 black-tailed deer and 3 coyotes were noted. Bobcats were not observed on either survey.

2014 Census

The census dates in 2014 were November 13 and December 18. Weather conditions on November 13 were variable following an overnight rainstorm. Morning mist and fog lifted, allowing for sun and good visibility, but there was intermittent rain during the census as well. Two pairs of observers on horseback surveyed the south and middle sectors and a single observer covered the north sector on foot. The weather was clear on December 18. The north and middle sectors were both covered by single observers on foot, while a pair on horseback took the south.

The highest total elk count occurred on December 18 with a total of 286 elk. Ten fewer elk were counted on the previous November 13 survey. Complete results from both censuses are included in Appendix A. There were slight differences between the cow and calf counts between the two surveys, even though the combined total of the two groups was nearly equal (190 vs 191). Observers reported that it was easier to distinguish cows from calves on the December 18 survey because fewer of the groups were bedded down. The final herd composition for Tomales Point in 2014 was estimated to be 168 cows, 23 calves, 10 spike males, and 85 branched antler males.

Other wildlife species observed during the November 13 census included a total of 15 black-tailed deer and 4 coyotes. On December 18, a total of 5 black-tailed deer and 0 coyotes were noted.

Population Trends

Following a high count of 540 total elk in 2012, the estimated minimum elk population at Tomales Point dropped to 356 elk in 2013 and then to 286 elk in 2014 (Figure 3). The 2012 count of 540 elk was the highest count since 2007, and included 101 calves, the highest calf count since 2006. The 2014 elk count was the lowest since 1995. While the decline from 2012 to 2014 was quite substantial, other fluctuations in the population have been observed over time, most notably from

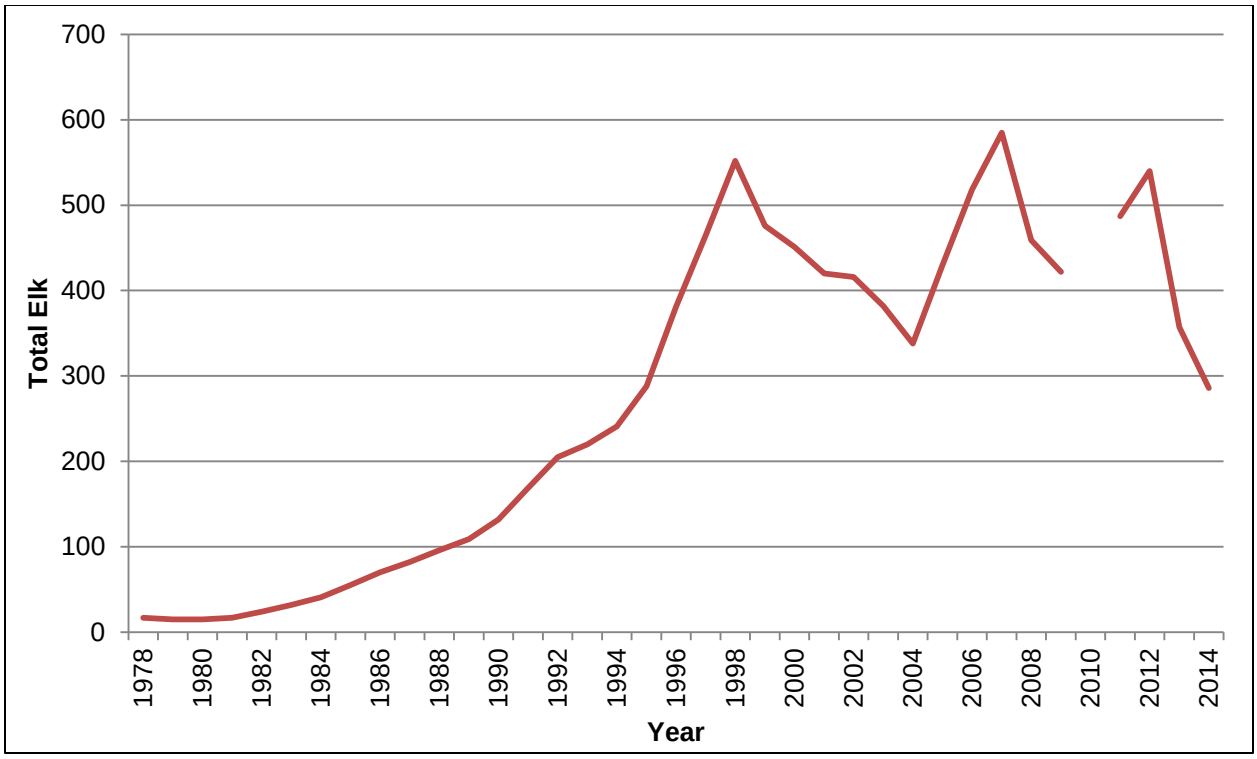


Figure 3. Total elk at Tomales Point since establishment of the herd in 1978. No census occurred in 2010.

2007 to 2009. The population decline from 1998 to 2004 can be largely attributed to the removal of animals from the reserve to establish free-ranging elk within the park in 1998 and implementation of an experimental contraception program within the reserve during this time period (Figure 3, Table1).

Adult female elk that carried radio-collars from past research projects were notably absent during the 2013 and 2014 census observations, suggesting that older animals may have been a significant component of the mortalities lost during this time. In addition, although calf production in 2012 was very high, of which an estimated 50% would have been new males, the spike male numbers for 2013 and 2014 do not demonstrate significant recruitment of younger animals into the population (Table 1). Although we have no direct measure of survivorship, the spike male numbers suggest that many of the 2012 calves did not survive their first year.

The population decline at Tomales Point was intensified by low calf production in 2013 and 2014. We observed 46 calves in 2013, which less than half of what we documented in 2012 at 101 calves. The 2014 count of 23 calves was by far the lowest calf count since 1998 (Table 1). With the recruitment rate so much lower than the mortality rate in 2013 and 2014, the elk population decline was more pronounced during this time period.

The population decline may be attributed to a combination of factors. This time period represented unprecedented drought conditions, reportedly the worst drought in California's recorded history. All but one of the remaining viable stock ponds in the elk reserve were completely dry or nearly empty at the time of both censuses. Based on later survey work, water was likely still available to the elk in the

Table 1. Tomales Point elk herd composition since 1999. No census occurred in 2010.

Year	Total Elk	Cows	Calves	Spike	Branch Antler	Total Bull	Calf:Cow	Bull:Cow	% Growth
1998	552	234	65	73	45	135	0.28	1.08	18.7
1999	476	210	92	n/a	n/a	174	0.44	0.83	-13.8
2000	451	260	61	17	113	130	0.23	0.50	-5.3
2001	423	254	50	22	94	116	0.20	0.46	-6.9
2002	416	241	30	18	127	145	0.12	0.60	-1.0
2003	386	241	50	4	87	91	0.21	0.38	-8.2
2004	338	217	40	10	66	81	0.18	0.37	-11.5
2005	430	246	79	20	85	105	0.32	0.43	27.2
2006	518	276	114	45	83	128	0.41	0.46	20.5
2007	585	332	97	35	121	156	0.29	0.47	12.9
2008	459	270	85	17	87	104	0.31	0.39	-21.5
2009	441	247	45	13	117	93	0.18	0.53	-8.1
2011	487	309	38	27	113	140	0.12	0.45	15.4
2012	540	291	101	19	24	105	0.35	0.51	10.9
2013	356	188	46	11	18	93	0.24	0.65	-33.9
2014	286	168	23	10	19	85	0.14	0.57	-19.9

seeps and springs that are scattered across the peninsula (https://www.nps.gov/pore/learn/nature/tule_elk_tomales_point_faq.htm). Elk mortality may have also been influenced by both forage quantity and quality during the drought. In regards to forage quality, one significant issue may have been the bioavailability of copper (Cu) and selenium, essential trace elements that are naturally deficient on the Point Reyes peninsula (Gogan et al. 1989, NPS unpublished data). Field sampling by Gogan et al. (1989) at Tomales Point demonstrated that Cu was seasonally least available in two common plants during October, the end of California's dry season. With Cu and other essential elements less available to the elk during drier periods, it may have been that the prolonged dry periods during the drought resulted in fatal deficiencies for the animals (Grace and Wilson 2002, Handeland et al. 2008, Cobb 2010).

In addition, Cu deficiency can result in reduced calving rates (Gogan 1986), which may partially explain the low calf counts in 2013 and 2014. Evidence for Cu deficiency at Tomales Point during the recent drought is supported by observations of at least two males with deformed antlers in August 2014 (Figure 4), a condition consistent with previously described Cu deficiencies at Tomales Point (Gogan et. al 1988).

Fidelity to herd home ranges also may have played a role in regulating the population during the drought. Previous radio-collar studies of elk movements and associations at Tomales Point have demonstrated that Tomales Point elk typically remain consistently within limited home ranges (Howell et al. 2002, Cobb 2010), and thus may not have attempted to migrate to other areas with better conditions. We observed no noticeable shifts in elk group locations across the reserve, and the



Figure 4. Young male elk at Tomales Point observed with deformed antlers in August 2014.

percentage of animals in the southern portion of Tomales Point, was consistent with non-drought years at about 30%. Our observations did not suggest any movements towards the elk fence in attempts to leave the reserve in search of water sources or higher quality feed.

Despite a substantial decline in the population, there was no evidence that a mortality event was underway until the 2013 census demonstrated a population decline. We observed and received only a handful of reports of elk mortalities from visitors and park staff in 2013 and 2014. This may also suggest that elk mortality occurred throughout this two year period, rather than at concentrated times. One might expect that more carcasses would have been reported or discovered, but scavenging in the reserve has been observed to be very rapid, and animals tend to obscure themselves when dying by hiding in heavy cover or ravines. Unfortunately, none of the mortalities recorded during our censuses were suitable for necropsy. Without the ability to necropsy any deceased elk, we were unable to determine the exact cause of death for any elk at Tomales Point in 2013 and 2014. We do not know the extent to which disease, particularly Johne's disease, or other factors may have contributed to the elk decline at Tomales Point. However, it appears likely, as would be expected, that environmental stressors associated with the drought conditions in 2013 and 2014 may have affected the tule elk population, particularly young and older animals. Widespread impacts on many species of wildlife were documented across California during this drought (http://www.latimes.com/local/california/la-me-drought-animals-20141228-story.html).

Drakes Beach Area

Census of the Drakes Beach herd takes less effort and has a higher level of certainty than the other two herds in the park because of proximity to roads, lack of cover, herd cohesion of both bachelor and harem groups and general range limitation. In addition, this herd is regularly monitored on a weekly basis and therefore census counts here have inherently more confidence than census of the other two herds which are monitored less frequently.

2013 Census

We counted elk in the Drakes Beach herd on December 3, 2013. A total of 76 elk was observed. The herd was composed of 42 cows, 13 calves, 5 spike males, 6 raghorn males, and 10 prime bulls (Table 2). This increase of 10 animals over the 2012 census of 66 elk represented a local single year growth rate for this herd of 15% (Table 2).

2014 Census

We counted elk in the Drakes Beach herd on December 8, 2014. A total of 92 elk was observed. The herd was composed of 45 cows, 17 calves, 7 spike males, 6 raghorn males, and 17 prime bulls (Table 2).This count was an increase of 16 animals over the 2013 census of 76 elk, a local single year growth rate for this herd of 21% (Table 2).

Calf mortality rates are unknown, but it is likely that a number of young calves in both 2013 and 2014 did not survive to the date of census. The first spotted (neonate) calves were observed on March 15, 2013 and February 19, 2014, with the last neonate observed September 13, 2013 and October 22, 2014. This range of neonate observed dates is far greater than observed at Tomales Point (timing of

Table 2. Drakes Beach area elk herd composition since 1999.

Year	Total Elk	Cows	Calves	Spike	Branch Antler	Total Bull	Calf:Cow	Bull:Cow	% Growth
1999	1	1	0	0	0	0	0.00	0.00	n/a
2000	3	2	1	0	0	0	0.50	0.00	200.0
2001	5	4	0	0	1	1	0.00	0.25	66.7
2002	6	3	2	0	1	1	0.67	0.33	20.0
2003	8	5	2	0	1	1	0.40	0.20	33.3
2004	10	5	2	n/a	n/a	3	0.40	0.60	25.0
2005	15	6	5	n/a	n/a	4	0.83	0.67	50.0
2006	20	9	5	n/a	n/a	6	0.56	0.67	33.3
2007	22	9	5	n/a	n/a	8	0.56	0.89	10.0
2008	32	15	4	3	10	13	0.27	0.87	45.5
2009	38	14	8	4	12	16	0.57	1.14	18.8
2010	50	18	15	2	15	17	0.83	0.94	31.6
2011	54	26	12	6	10	16	0.46	0.62	8.00
2012	66	34	13	5	14	19	0.38	0.56	22.2
2013	76	42	13	5	16	21	0.31	0.50	15.2
2014	92	45	17	7	23	30	0.38	0.67	21.1

rutting behaviors at Drakes Beach, and therefore mating, is also widely protracted in comparison to Tomales Point). This protracted length of the calving season makes detection of calf mortalities difficult. Overall, the high rates of herd growth in 2013 and 2014 suggest very high annual survival of elk adults and juveniles, as also evidenced by the few mortalities observed in each of these years.

Limantour

Of the three herds in the park, the Limantour herd is the most difficult to census. This herd ranges across three primary core areas (Figure 2). The elk occur near road corridors at times, but the primary use areas are in undeveloped wilderness that must be travelled on foot or by horseback. At this time, census surveys are performed on foot in the roadless wilderness areas. The primary bachelor herd is regularly monitored for most of the year within the adjacent pastoral zone, but the herd is at times spread across the wilderness from the boundary in the north and beyond Coast Camp in the south (Figure 5).

Group cohesion in the Limantour herd seems to be less pronounced than in the Drakes Beach herd, therefore females, calves and spikes are not always found in a single group, but may range widely in small groups or singly. The bachelor herd and sub-groups have also been observed on the southwest slope of Mount Vision all the way up to Mount Vision Road and across Sir Francis Drake Boulevard to the west on D. Rogers and M ranch. During the rut season (July-September), the males will partially integrate with the herd in the wilderness area and become difficult to locate, most becoming solo in the forested upper areas of the Glenbrook drainage (Figure 5). Census attempts are performed typically after the rut when the males again congregate in the pastoral zone and can be counted in groups in a readily accessible area.

2013 Census

Multiple census attempts were made in late 2013, most of which turned up smaller numbers than anticipated, possibly because the elk were less cohesive and ranging to more obscure locations. The highest count was on January 7, 2014, when 71 animals were observed. This minimum population was composed of 38 cows, 8 calves, 5 spike males, 2 raghorn males, and 18 prime bulls (Table 3).

2014 Census

The low total number of 71 elk in 2013, compared to 94 the previous year, reflected the difficulty in locating some animals, as confirmed in our 2014 counts. Multiple census attempts were again made in 2014. The highest count on December 30, 2014 recorded 120 total elk. The elk population was composed of 69 cows, 15 calves, 4 spike males, 9 raghorn males, and 23 prime bulls (Table 3).

An increase in the cow count from 38 in 2013 to 69 in 2014 and an increase of males from 25 to 36 cannot be explained by calf production since only 8 calves were detected in 2013.We suspect that despite repeated efforts in 2013, many elk eluded our counts due to the ranging behaviors of the herd during the unusually dry winter months. In 2013, indications of elk presence (tracks and scat) were found as far south as Sculptured Beach along Coast Trail, much farther south than previously detected. Muddy Hollow Creek was completely dry during the census, and other water sources were also diminished, which may have led to animals searching wider areas for water or higher quality feed. In addition, tule elk may have been utilizing the more forested (and difficult to survey) areas of



Figure 5. Map of Limantour area and Estero Road area locations where tule elk occur.

Table 3. Limantour area elk herd composition since 1999.

Year	Total Elk	Cows	Calves	Spike	Branch Antler	Total Bull	Calf:Cow	Bull:Cow
1999	27	16	9	0	2	2	0.56	0.13
2000	25	14	4	5	2	7	0.29	0.50
2001	21	12	3	2	4	6	0.25	0.50
2002	22	13	2	1	6	7	0.15	0.54
2003	28	14	6	1	7	8	0.43	0.57
2004	30	14	5	3	8	11	0.36	0.79
2005	34	15	7	4	8	12	0.47	0.80
2006	41	20	6	3	12	15	0.30	0.75
2007	41	21	3	6	11	17	0.14	0.81
2008	50	21	10	4	15	19	0.48	0.90
2009	55	32	8	2	13	15	0.25	0.47
2010	54	26	8	2	18	20	0.31	0.77
2011	60	32	9	7	12	19	0.28	0.59
2012	94	53	14	5	22	27	0.26	0.51
2013	71	38	8	5	20	25	0.21	0.66
2014	120	69	15	4	32	36	0.22	0.52

their range, where, compared to open range habitats, forage persists for longer without direct sun exposure and benefits from fog drip off of the trees. Due to the decreased reliability in the census data for the Limantour herd compared to Tomales Point and Drakes Beach, we have not attempted to estimate population growth rate for the Limantour herd (Table 3)

Monitoring of Elk on Park Ranches

PORE manages more than 28,000 acres of federal National Park Service lands with the Seashore and the northern district of the Golden Gate National Recreation Area for beef and dairy cattle grazing through special use lease permits. The park has monitored tule elk on and adjacent to ranches within the park since September 2010 to better understand the potential impacts of elk to ranch operations. Park staff surveys areas along or near Drakes Beach Road and Estero Road in order to document numbers, locations, and behavior of tule elk in these areas. Because the elk flush easily, complete counts are not always possible. In many instances, at Drakes Beach especially, the location of the main herd is noted without getting a complete count of the elk. Most observations occur in the morning; however, additional surveys occur in order to verify movement patterns of the elk and to check for unintended bias in the data resulting from a concentration of observations earlier in the day. Surveys occur one to two days per week, however, blocks of time are missing from the dataset due to staff availability. More than one survey can occur on a single day. Elk locations are noted by assigning observed elk to the nearest of many pre-assigned points on the landscape. When elk were

in transit during a survey, the location of where the elk were first observed was recorded rather than the final location seen. Surveys were often cancelled due to fog and poor visibility.

In October 2012, recognizing that direct visual observations did not include elk locations on nights and weekends, the park worked with a contractor to capture four elk from the Drakes Beach herd and fit them with satellite GPS collars (Figure 6). The GPS collars selected for this project (Advanced Telemetry Systems GS110E/E2 Iridium GPS Collar) collected location data every three hours with an estimated battery life of up to three years. Collars were programmed to collect a position at 2am, 5am, 8am, 11am, 2pm, 5pm, 8pm, and 11pm. The GPS location data collected by each collar was sent to a satellite system approximately every three days and then transmitted to the park by email.

Four animals (two males and two females) were targeted for capture whose movements would more or less represent movements of the elk herd. The elk near Drakes Beach segregate themselves into two groups for much of the year – the main herd comprised of the cows, calves, and a few males and a separate herd of bachelor males. Two cows were captured from the main herd and two males from the bachelor herd.

The elk were captured and collared from October 19 through to October 24, 2012 using tranquilizer darts following protocols approved by the National Park Service Institutional Animal Care and Use Committee. Vital signs were monitored for the entire time that each animal was down, including



Figure 6. Raghorn male elk with newly applied satellite GPS collar.

temperature, pulse, respiration, and capillary refill time (CRT). Basic measurements were taken on each animal such as total length, estimated weight, and girth. We took blood samples and administered prophylactic injections of MuSe (selenium), penicillin, and clostridial vaccine. Once the GPS collar was properly fitted and each animal was given a unique identifying ear tag, a reversal drug was injected to counter effects of the immobilization drugs and the elk were monitored until they recovered and went along their way. The captures were successful with no injuries to the elk or to the capture team.

The first female that was captured had a metal tag (#A298) in her right ear. She was one of the animals captured at Tomales Point in December 1998 and subsequently released near Limantour Beach in June 1999 when the free range herd was initially established. She moved over to the Horseshoe Pond drainage (Figure 7) in October 2001, joining a small group of elk that had already moved to that area.

Drakes Beach Area

Visual Observation Data

In preparing the NPS field observation data for summary, we identified elk groups as a cow group if the group was at least 10 individuals comprised predominantly of adult females. Elk often occurred in the same location throughout the day. When summarizing the data, if more than one survey session occurred in a day, we did not include a repeat location for a group of animals unless the sessions occurred more than 4 hours apart.

Wildlife staff completed a total of 158 surveys of the Drakes Beach herd between November 2012 and October 2013. A total of 449 unique elk locations were recorded during 158 surveys on 117 days. Table 4 summarizes elk locations by ranch lease permit between November 2012 and October 2013, but note that the data in this table do not give weight to the number of elk observed per location. During this time period, elk were observed almost exclusively to the southeast of Sir Francis Drake Boulevard, as far east as the ridge above Drakes Estero, and as far west as the border between C Ranch and B Ranch (Figure 7). Elk were not observed on A Ranch or B Ranch, although they had been known to visit those ranches in prior years and may have ranged there unobserved.

Table 4. Elk locations collected by field observations in the Drakes Beach area by ranch lease, November 2012 - October 2014. Number of elk per location not taken into account.

	Percent of Total Observations (All Elk)		Percent of Total Observations (Cow Group)	
Year	Nov 2012 – Oct 2013 (n = 449)	Nov 2013 – Oct 2014 (n = 607)	Nov 2012 – Oct 2013 (n = 154)	Nov 2013 – Oct 2014 (n = 210)
Non-permit	23.2	33.6	40.9	71.4
B Ranch (Mendoza)	0.0	2.3	0.0	0
C Ranch (Spaletta)	13.6	13.3	25.9	13.8
West D Ranch (Spaletta)	12.5	9.2	10.4	5.7
E Ranch (Nunes)	7.6	12.7	0.0	0
East D Ranch (Nunes)	43.2	28.8	22.7	9.0

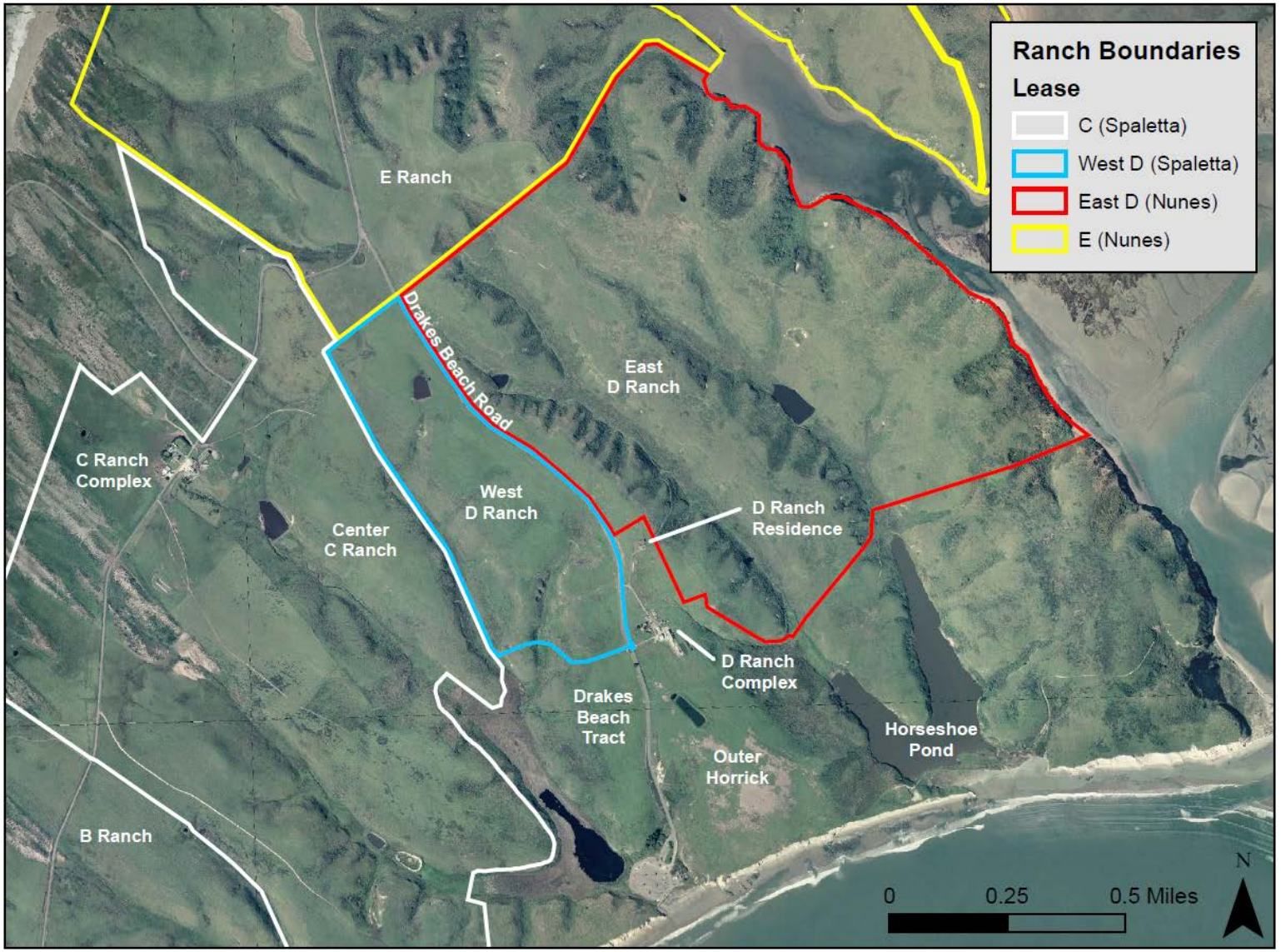


Figure 7. Map of Drakes Beach Road area where tule elk occur.

Wildlife staff completed a total of 207 surveys of the Drakes Beach herd between November 2013 and October 2014. A total of 607 unique elk locations were recorded during 207 surveys on 161 days. Table 4 also summarizes elk locations by ranch lease permit between November 2013 and October 2014. During this time period, the elk were predominantly observed within the same home range as the prior year as described above. Elk were not observed on A Ranch; but a group of up to 14 bulls were observed on B Ranch during November and early December 2013 near the C Ranch boundary.

GPS Collar Data

Three of the four elk captured and fitted with GPS collars during October 2012 successfully transmitted data for the entire time period between November 2012 and October 2013. One of the males (White Bull 031711) lost his collar in mid-January 2013 after only collecting data for three months. During the second year of the collar deployment, in early December 2013, the second male (Red Bull 031710) also lost his collar. With both collars, the collar fabric tore cleanly through, likely by getting snagged on something sharp in the field. The collar for White Cow 031713 remained on the animal but failed to continue transmitting data in April 2014. The GPS collar on Red Cow 031739 was the only collar that collected and transmitted data for more than two years.

At times, the collars collected location data outside of the programmed three hour schedule beginning at 2am. For example, when animals were bedded down for extended periods, an erroneous mortality signal was generated causing the collars to collect location data every half-hour until the animal started to move again and the problem corrected itself. For reporting and summary purposes, we established a consistent data set between the collars by excluding all GPS data collected outside of our programmed time intervals of 2am, 5am, 8am, 11am, 2pm, 5pm, 8pm, and 11pm.

Table 5 summarizes the amount of available data per animal that is presented in this report between November 2012 and October 2014. Because White Bull 031711 lost his collar after only 75 days, the data collected by this collar is not summarized any further in the report. In addition, because Red Bull 031710 lost his collar early during the second year of deployment, data from this collar is only summarizes for the first year. Variations in the total number of data points collected per animal during the same time periods can be explained by temporary collar malfunctions in which data were not collected as scheduled.

Table 5. GPS collared elk identification information and available data.

				Nov 2012 – Oct 2013		Nov 2013 – Oct 2014	
Collar ID	**Age/Sex**	**Ear Tag**	**AKA**	**#Days**	**# Locations**	**#Days**	**# Locations**
031713	Adult Female	34 White Square / Left A298 Right	White Cow	364	2830	171	1302
031739	Adult Female	23 Red Round / Right	Red Cow	365	2861	365	2829
031710	Raghorn Male	19 Red Round / Left	Red Bull	365	2878	37	291
031711	Raghorn Male	47 White Square / Left	White Bull	75	594	No Data	No Data

Table 6 summarizes collar locations by ranch lease permit between November 2012 and October 2014, and between November 2013 and October 2014, respectively.

Table 6. Percent of GPS collared elk locations in the Drakes Beach area by ranch lease, November 2012 - October 2014.

	Cow 031713		Cow 031739		Bull 031710
Year	Nov 2012 – Oct 2013 (n = 2830)	Nov 2013 – Oct 2014 (n = 1302)	Nov 2012 – Oct 2013 (n = 2861)	Nov 2013 – Oct 2014 (n = 2829)	Nov 2012 – Oct 2013 (n = 2878)
Non-permit	48.6	73.1	49.3	69.6	17.7
C Ranch (Spaletta)	25.3	12.2	25.5	14.9	11.6
West D Ranch (Spaletta)	6.1	2.0	6.4	3.7	3.3
E Ranch (Nunes)	0.1	0	0.1	0	9.6
East D Ranch (Nunes)	19.8	12.7	18.6	11.8	57.8

In order to clarify the degree to which the collared cows represent the movements of a cow group or the main herd, we noted in our observational records every time that a collared elk was observed. Because the collars are not always easy to see (e.g. the animals are bedded down or seen from a distance), we also cross-referenced the observational data with the GPS data to confirm when the GPS data was consistent with recorded elk locations. Cow groups were at times noted more than once during a survey, usually when the elk was broken into smaller but significant groups, as can happen during calving or the rut. These factors were taken into account when cross-referencing and summarizing the data.

The results of our effort to determine the degree to which the collared cows represent the movements of a cow group or the main herd are as follows:

- White Cow – 031713. Out of 221 field surveys where a cow group was observed and the collar was still functional (Nov12 – Apr14), White Cow was confirmed as associated with a cow group on 165 (75%) surveys.
- Red Cow – 031739. Out of 326 field surveys where a cow group was observed (Nov12 – Oct14), Red Cow was confirmed as associated with a cow group on 264 (81%) surveys.

While both cows are good representations of the movements of a cow group or the main herd, Red Cow was particularly so. She was associated with a cow group on 96% of our observations during the first year in which she was collared. White Cow had a tendency to split off from the main herd with a smaller group of cows and spend time to the east around Horseshoe Pond, particularly during the calving season (see Appendix B, June 2013). White Cow is an elder animal, having arrived in the Drakes Beach area in 2001 after being captured at Tomales Point in 1998 and moved to Limantour. White Cow was often in the company of two cows with old radio collars, one of which we know was captured and collared as a yearling near Drakes Beach in 2005.

Patterns of Movement

The main herd concentrated its activity on C Ranch, D Ranch west, D Ranch east, and areas not permitted for grazing immediately to the north of Drakes Beach and around Horseshoe Pond (Figure 7, Appendix B). The elk did not use their range uniformly, however, but displayed an affinity for particular areas, most notably center C Ranch, lower west D, east D pastures close to Drakes Beach Road, Outer Horrick, Drakes Beach Tract, and around the D Ranch residence (Figure 7, Appendix B). The latter three areas are areas currently not permitted for dairy or beef grazing. Besides a spatial pattern with the main herd, a temporal pattern was also observed in how they utilize the landscape. Generally speaking, the following temporal observations were made of the main herd in the two years from November 2012 to October 2014 (Appendix B):

- In both years, from November to January, the main herd split it's time between center C, east D pastures, Outer Horrick, and the Drakes Beach Tract. Notable variations in the elk's use of these areas were that the main herd did not occur on C Ranch at all in January 2013 and that the main herd was used Outer Horrick almost exclusively in November 2013.
- In both years, between February and May, the main herd moved almost entirely off of center C, concentrated at east D pastures, D Ranch residence, Outer Horrick, and the Drakes Beach Tract, and gradually began spending more time east towards and beyond Horseshoe Pond and on lower west D.
- While still using these above areas, the main herd began coming back to center C in June and were using it heavily in July and August. The herd would move closer to the C Ranch barns in the middle of the night (Figure 8). Use of C Ranch was far more common in 2013 than 2014. For example, between June and August 2013, 33.3% of the GPS points from Red Cow 031739 occurred on C Ranch compared to 9.1% from June to August of 2014.
- In September of both years, the main herd concentrated on center C and moved closer to the border with B Ranch than usual, particularly in 2013. Use of C Ranch was more significant in 2013 than 2014. For example, in September 2013, 85.6% of the GPS points from Red Cow 031739 occurred on C Ranch compared to 47.6% in September 2014.
- By October of both years, the main herd continued use of center C but moved back to east D pastures, D Ranch residence, Outer Horrick, and the Drakes Beach Tract.

For the most part, the main herd was rather cohesive, representing the majority of females and juveniles present in the Drakes Beach area. There were, however, anomalies to this pattern during the two years reported here. For example, there was a group of cows that split off from the main herd in April and May 2013. This sub-group's numbers fluctuated between 10 and 20 cows plus some calves and the occasional bull or young spike male. It is not uncommon for there to be breaks in the elk herd composition during the spring calving season.

Most of the older bull males remained separate from the main herd at Drakes Beach during the course of the year, often forming a cohesive bachelor group of 10-20 individuals. Bull males were more often associated with the main herd during the rut in July, August, and September and the other males were more likely to be dispersed in several small groups rather than forming one bachelor

group during this time. Visual observations most often documented the bachelor group on E Ranch near the intersection of Sir Francis Drake Boulevard and Drakes Beach Road and on East D Ranch along the first ridge to the northeast of Drakes Beach Road. A regular routine for the males was to cross Drakes Beach Road at around sunset, spend the night on C Ranch, cross back over Drakes Beach Road at sunrise, and spend the day to the east of Drakes Beach Road (Figure 9).

The spatial preferences for the tule elk in the Drakes Beach area can be visually presented by mapping the GPS data for an entire year for each of the collared animals. By grouping the number of GPS points by area, a map can be created that demonstrates areas of high, medium and low elk use. Figures 10-13 present the GPS collar data with the density of GPS points in an area represented by a color ramp from green (low density) to red (high density).

Estero Road Area

Visual Observation Data

A total of 88 elk surveys occurred from November 2012 through October 2013 in the Estero Road area, covering the D. Rogers Ranch on the northwest side of Sir Francis Drake Boulevard to the edges of Home Ranch to the southeast (Figure 5). Elk were observed on 75 of these surveys allowing us to document 147 elk location records.

From November 2013 through to October 2014 a total of 102 elk surveys occurred in the Estero Road area. Elk were observed on 99 of these surveys and 188 elk locations were recorded.

During this two year period, only male elk were observed in the Estero Road area; the larger herds of cows and juvenile elk remained on the Glenbrook peninsula and further to the southeast within designated wilderness. On occasion, however, the operators of Home Ranch reported small groups of elk, including cows and juveniles, crossing over to Drakes Head within the Home Ranch boundary near the Estero Trail in the late summer and early fall. The elk did not remain for long on any occasion.

In both years, a small group of male elk crossed over Sir Francis Drake Boulevard to the D. Rogers ranch in the early winter. Elk were first observed using this area for a short time in January and February 2012, but at that time the elk rarely spent the day at D. Rogers and were known to cross over to the ranch at sunset and return to the southeast side of Sir Francis Drake at sunrise. In contrast to 2012, a small group of male elk was consistently present on D. Rogers and occasionally crossed to M Ranch as well during the timeframe of this report. The elk left the area in early to mid-June just before the rut.

Elk within the Estero Road area are at their lowest numbers from approximately mid-June to October. During this time, male elk move further to the southeast and into the wilderness area to join up with the cow/calf groups for the rut. In fact, no elk were observed by park staff on ranches adjacent to the wilderness between June 26, 2013 and September 6, 2013. The following year, during the 2014 rut, some male elk remained on Home Ranch in low numbers.

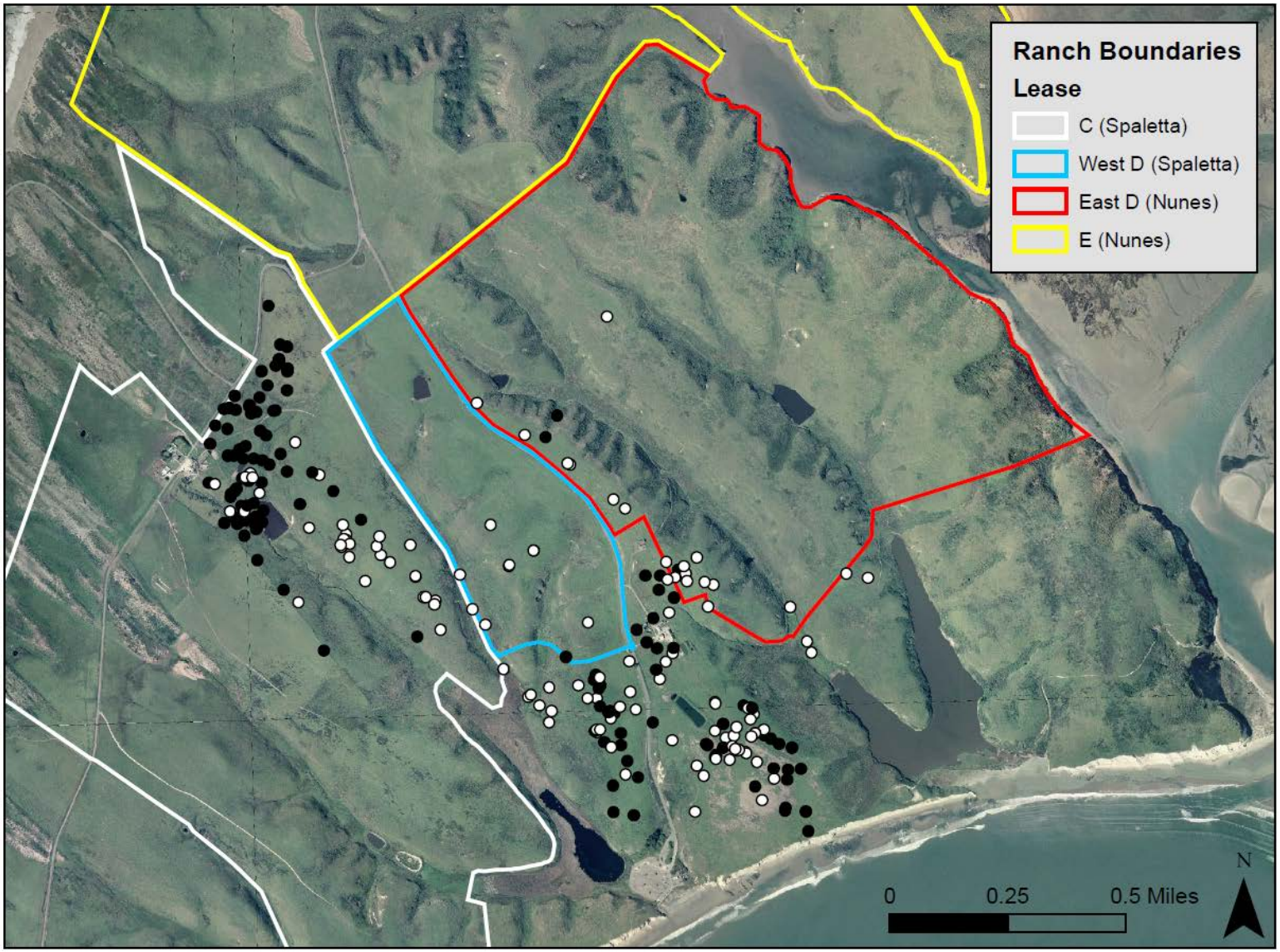


Figure 8. Night (black dots) and day (white dots) locations of cow elk 031739 during August 2013. Note the concentration of night activity near the C Ranch complex.

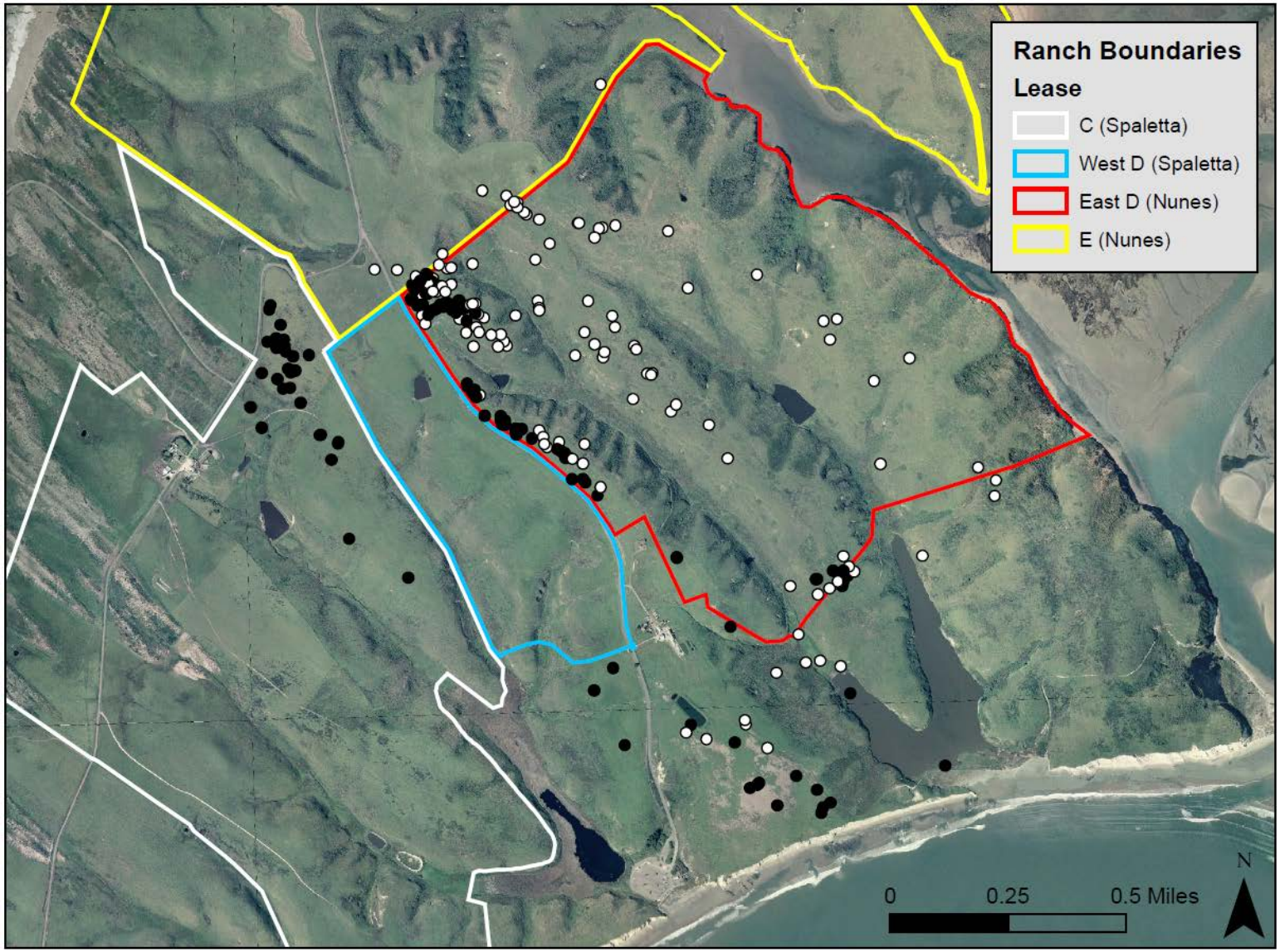


Figure 9. Night (black dots) and day (white dots) locations of male elk 031710 during January 2013. Note the concentration of night activity above the C Ranch complex.

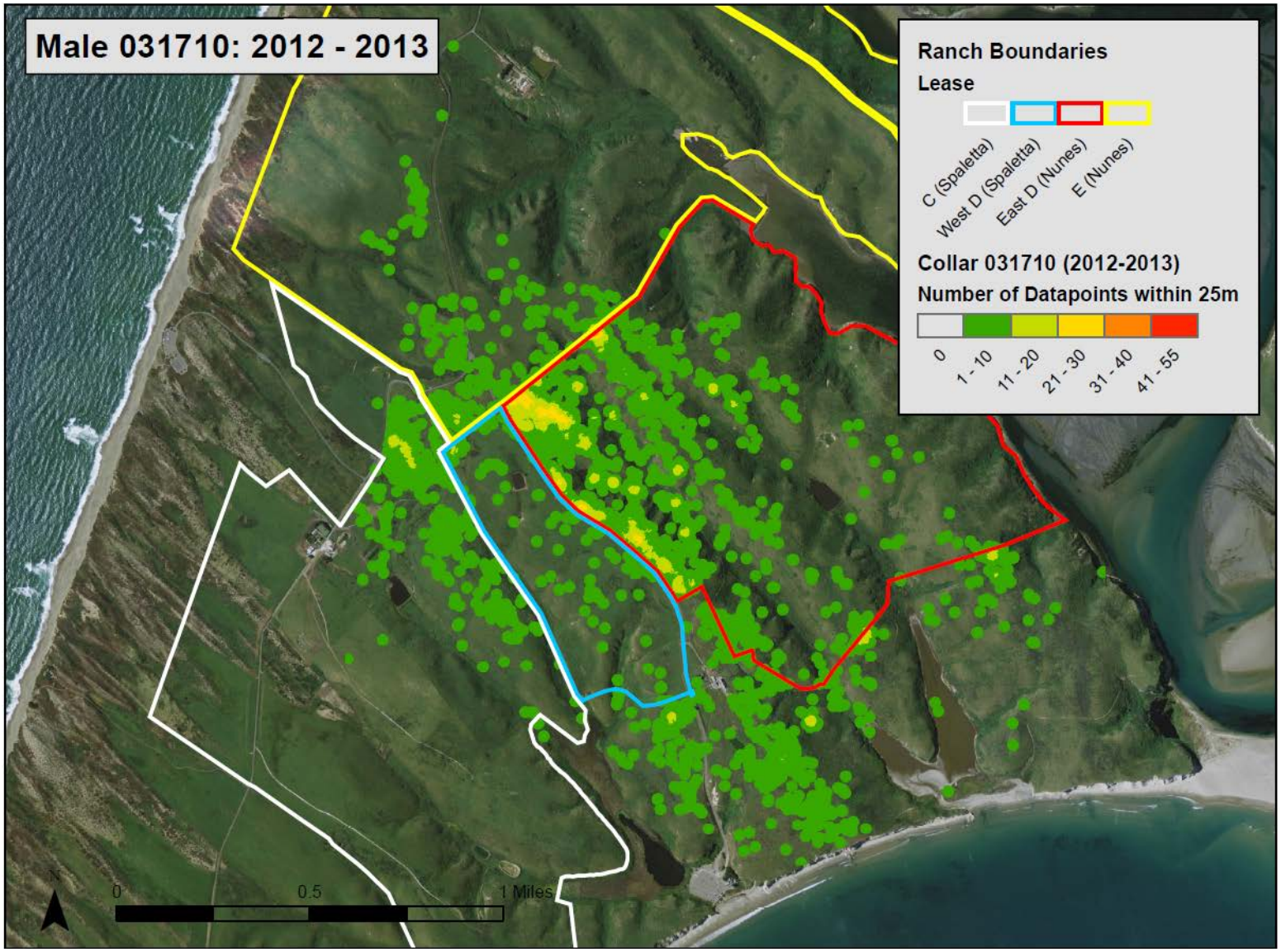


Figure 10. Spatial preferences of male elk 031710 from November 2012 to October 2013. Color ramp represents number of location points within 25 meters of each other, thus depicting areas of low, medium, and high use.

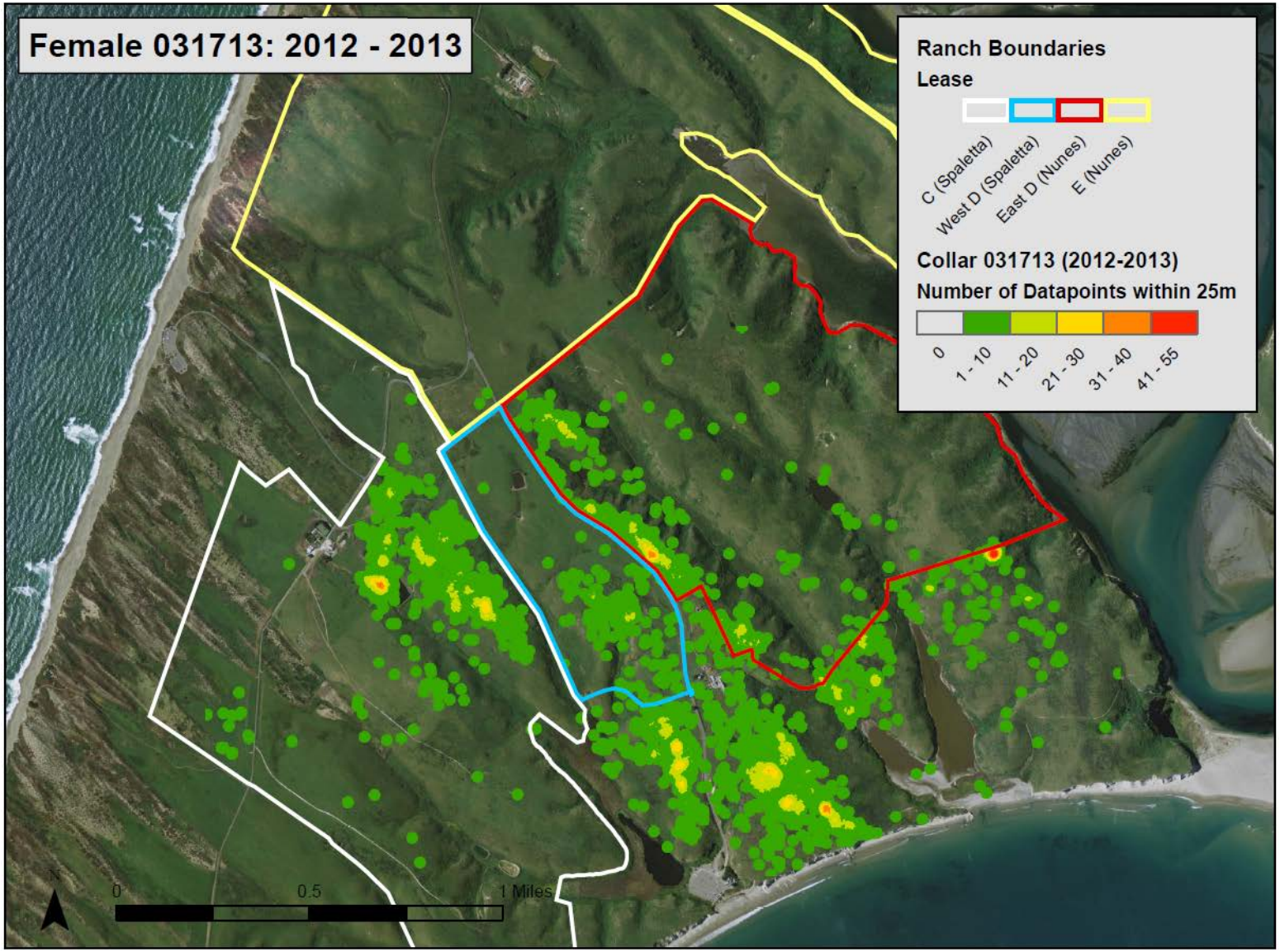


Figure 11. Spatial preferences of female elk 031713 from November 2012 to October 2013. Color ramp represents number of location points within 25 meters of each other, thus depicting areas of low, medium, and high use.

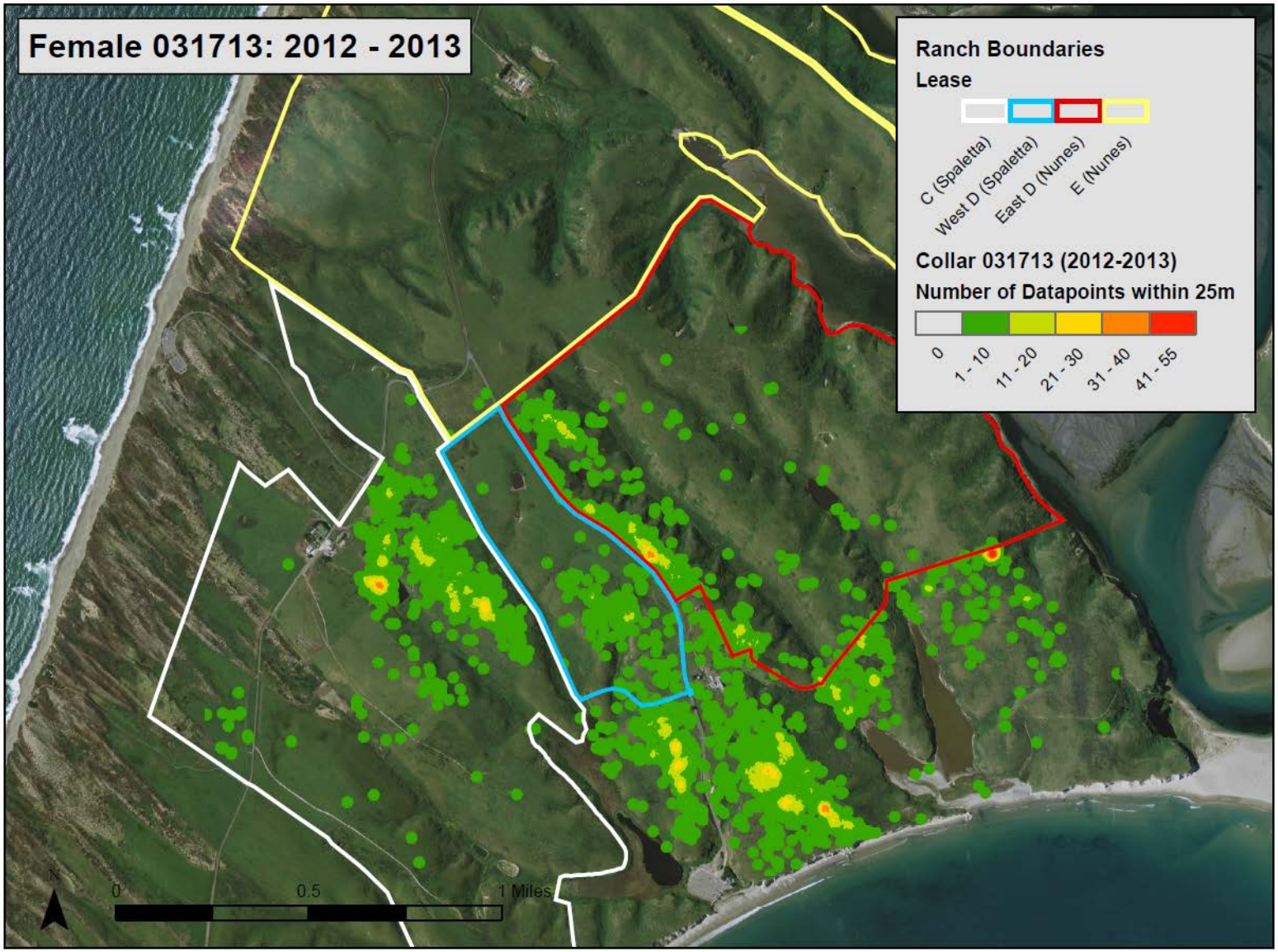


Figure 12. Spatial preferences of female elk 031739 from November 2012 to October 2013. Color ramp represents number of location points within 25 meters of each other, thus depicting areas of low, medium, and high use.

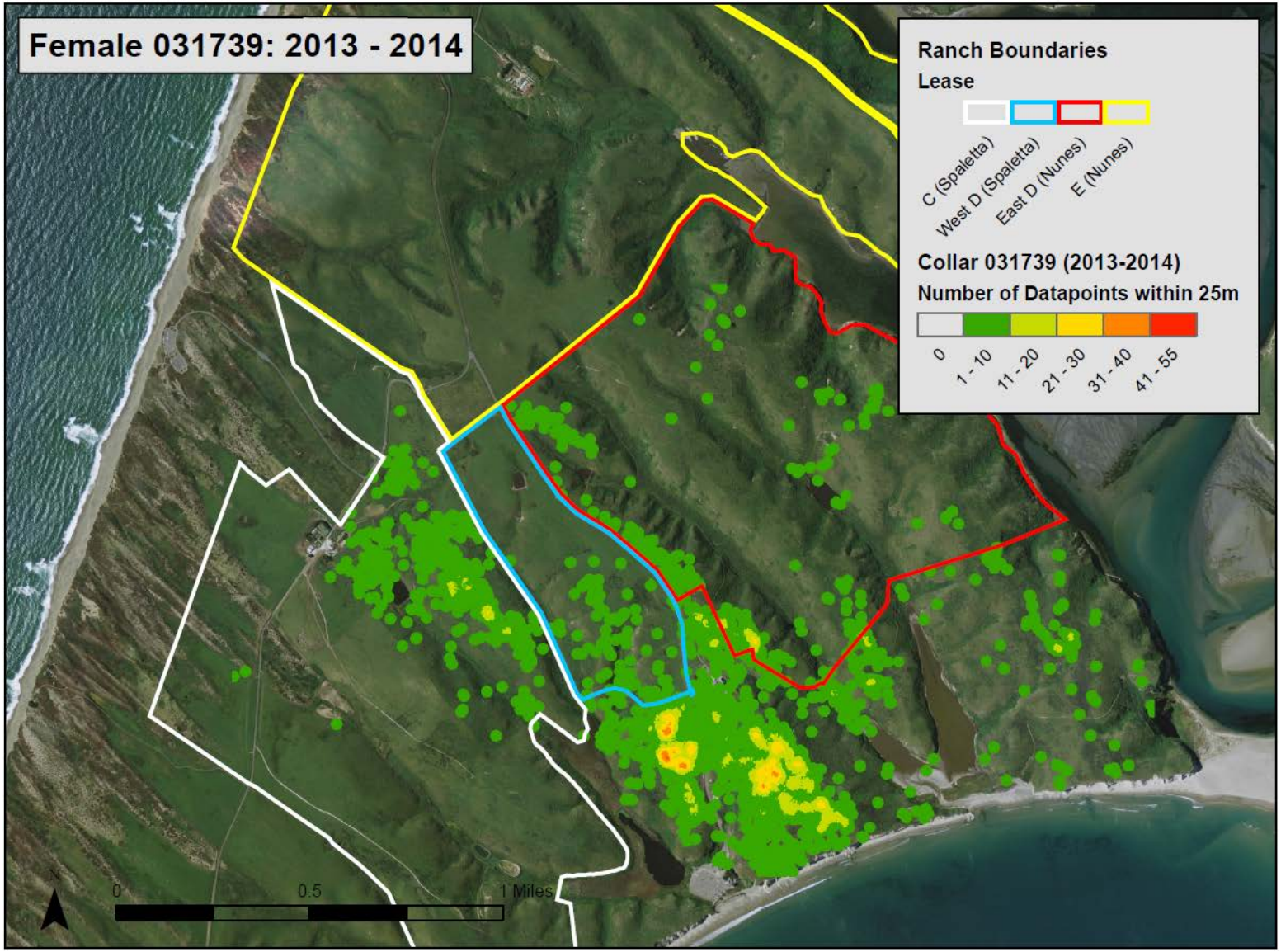


Figure 13. Spatial preferences of female elk 031739 from November 2013 to October 2014. Color ramp represents number of location points within 25 meters of each other, thus depicting areas of low, medium, and high use.

Tables 7 and 8 summarize the elk locations and count data for the Estero Road area by ranch lease permit between November 2012 and October 2014. We should note that without GPS collared elk in the Estero Road area, our elk location data is biased towards weekdays and daylight hours. Although the general results presented in the tables would likely not change significantly with collared elk, we would have a better understanding of how specific areas are used by elk on the ranches at night versus the day. For example, we know that the elk are known to use the bull pastures behind the Home Ranch compound during the night but move up to the adjacent ridges during the day.

Table 7. Percent of observed elk locations in the Estero Road area by ranch lease, November 2012 - October 2014.

	Nov 2012 – Oct 2013 (n = 147)	Nov 2013 – Oct 2014 (n = 188)
Year	**Number of Occurrences (All Elk)**	**Percent of Total Observations (All Elk)**
Non-permit	8.2	7.4
Home Ranch (Luchessi)	61.2	57.4
M Ranch (Grossi)	0.0	1.1
N Ranch (McDonald)	0.7	6.4
D. Rogers (Evans)	29.9	27.6

Table 8. Numbers of male elk in the Estero Road area by ranch lease, November 2012 - October 2014.

	Nov 2012 – Oct 2013 (n = 147)		Nov 2013 – Oct 2014 (n = 188)	
Year	**Average Number Elk per Ranch per Survey**	**Maximum Number Elk per Ranch per Survey**	**Average Number Elk per Ranch per Survey**	**Maximum Number Elk per Ranch per Survey**
All Areas	13	29	13	33
Non-permit	7	12	7	14
Home Ranch (Luchessi)	14	29	11	28
M Ranch (Grossi)	0	0	4	5
N Ranch (McDonald)	2	2	7	14
D. Rogers (Evans)	5	8	6	8

Antler Entanglements

In May 2013, one of the younger raghorn males in the Drakes Beach herd was observed with a rope and buoy entangled in its antlers (Figure 14). The animal was closely monitored but there was no sign that the rope and buoy would fall on their own. With the assistance of local field biologists from the California Department of Fish and Wildlife, we made two attempts to capture the animal and remove the buoy in July and August 2013. Despite multiple attempts, we were not able to get close enough to the animal to get a clean shot with a dart gun. We subsequently decided to wait until the antler drop, and the animal was eventually observed to have shed the antler with no additional injury.

In October 2014, a prime bull in the Drakes Beach area was observed to have barbed wire entangled in his antlers (Figure 15). The animal was closely monitored for possible injury and further entanglement with his limbs or with other intact or inordinate fencing. The wire eventually fell off on its own with no intervention or further complication after 10 days.



Figure 14. Raghorn male elk with buoy entanglement.



Figure 15. Prime male elk with wire entanglement.

D Ranch Water Project

Our elk observations in the Drakes Beach area have documented a seasonal shift in how the main herd uses the area. The main herd shifts from frequent use of natural areas around the old D Ranch compound and near Horseshoe Pond to use of the C Ranch pastures near a large stock pond close to the ranch complex (see Appendix B, January – June 2013 versus July – October 2013). The C Ranch operators have expressed concern regarding forage and water consumption by the elk during a critical time of year for the ranch. The drying of seasonal ponds in the preferred non-permit areas near D ranch may have been driving elk from unpermitted areas to the available stock pond at C Ranch during the dry season. During the summer, we observed that several ponds near D Ranch go mostly dry, the former sewage pond is largely avoided by the elk perhaps due to water quality conditions (significant blooms of blue-green algae), and there appears to be a lack of available forage in the area due to weed infestations.

In August 2013, we implemented an experimental project at D Ranch to encourage the main elk herd to spend less time on C Ranch and more time in areas not permitted for cattle grazing. The project added water to two of the D Ranch ponds in the Outer Horrick area to keep them from going dry and added water to an existing spring in hopes of expanding the availability of forage around the spring

later into the dry season. The selected ponds and spring were chosen based on field observations of elk use at these sites.

Two 5,000 gallon holding tanks were placed next to the hay barn at D Ranch and connected to the Drakes Beach water system using PVC pipe. Additional PVC pipe was laid down to bring the water from the holding tanks to the ponds and spring (Figure 16). Over 3500 feet piping was laid down to bring the water from the water supply behind the D Ranch residence, to the holding tanks, and then out to the ponds and spring. The water pipes were not trenched in any area and were simply placed on the surface of the ground/vegetation. A slight gradient between the tanks and ponds allowed water flow to occur by gravity, precluding the use of any pumping equipment. Because the ponds are known to be frequented by California red-legged frogs, listed as federally threatened under the Endangered Species Act, the water in the holding tanks was de-chlorinated prior to each release using a product called Vita-D-Chlor. The sodium ascorbate version of this dechlorinator was used in order that the pH of the water would not be affected. Dosage was determined using the free chlorine data routinely tested for in all park water systems by in-house certified water technicians.

Compliance for this project was required. Following a site visit with the State Water Resources Control Board and the US Army Corps of Engineers, the park was informed that permits would not be required from either agency. In correspondence with the US Fish and Wildlife Service, the agency informed the park that the project fell within, and was therefore permitted under, the Service's 2002 biological opinion in regards to grazing permits within Point Reyes National Seashore. NEPA compliance for this project was completed as well under a Categorical Exclusion approved by the Superintendent.

During the first season of implementation, we began delivering water in early September 2013 and continued to deliver water until January 2014. A total of 173,760 gallons of water were released to the ponds. Again due to poor rainfall totals, we began flowing water to the ponds in May 2014 and continued into November 2014. During this time period, a total of 167,970 gallons of water was delivered.

By the time that the project was first implemented in early September 2013, the main herd had been spending a majority of time on pastures in the center of C Ranch and near the main C ranch stock pond (Appendix B, Table 9). In order to introduce the elk to the newly watered ponds, we hazed the elk in the early morning, moving them to the non-permit area near D ranch and the preferred ponds. A detailed discussion of our hazing method is found later in this report. By October 2013, elk use shifted from light use of the Drakes Beach Tract and Outer Horrick areas near the pond project to heavy use, as illustrated by the two GPS collared cows (Appendix B). A year later the same seasonal use pattern occurred with the main elk herd shifting to increased use of C Ranch in July through September, however, the time spent on C Ranch was lower than the year before and the time spent in the Drakes Beach Tract and Outer Horrick areas increased (Table 9).

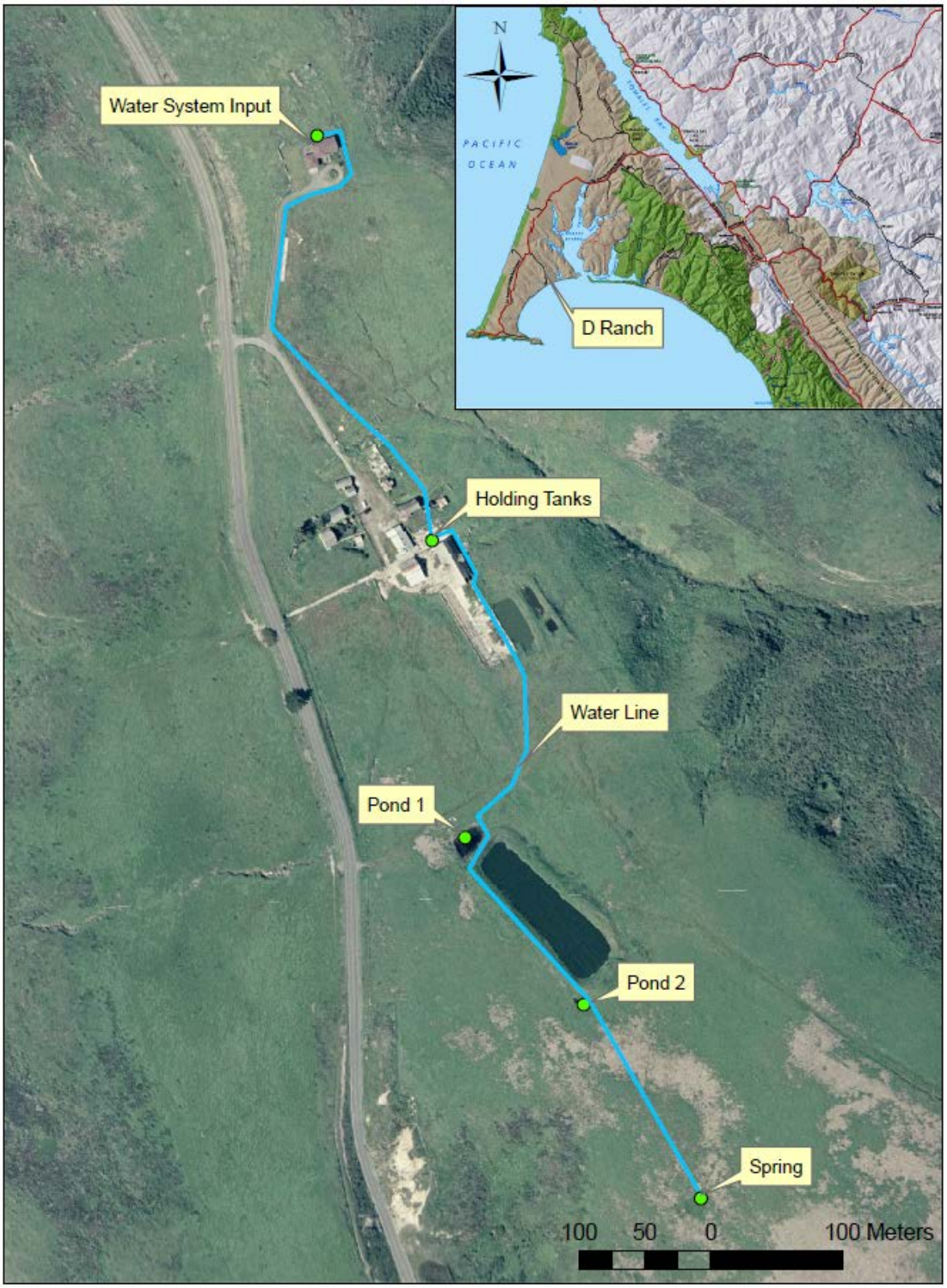


Figure 16. Map of D Ranch water project.

Table 9. Dry season locations of GPS collared elk cow 031739 in 2013 and 2014. Percent of time that elk cow 031739 spent on C Ranch versus the Drakes Beach Tract and Outer Horrick areas (DBT-OH) during June to November of 2013 and 2014. Also noted are the number of hazing attempts off C Ranch made during the month, and whether or not water was delivered to Outer Horrick during the month.

	Cow 031739 2013				Cow 031739 2014			
Month	C Ranch	DBT - OH	Haze	Water	C Ranch	DBT - OH	Haze	Water
June	8.4	55.5	0	N	0.8	61.4	0	Y
July	48.5	11.3	0	N	8.0	63.0	1	Y
August	42.8	39.5	0	N	18.6	18.1	6	Y
September	85.7	7.2	0	Y	47.6	30.0	3	Y
October	35.1	40.9	2	Y	16.9	63.6	3	Y
November	7.6	84.8	3	Y	4.2	89.9	1	Y

A number of factors may be driving the seasonal use patterns in the main herd and influencing the differences that may occur between years. The shift away from C Ranch in 2013 following project implementation provided hope that delivering water to the elk at Outer Horrick decreased the amount of time that the main herd spent on the ranch. A year later, with rainfall conditions even worse than the year before, the main herd spent less time on C Ranch while we provided water to Outer Horrick. Although the impact of elk to ranching operations has not been completely eliminated, these efforts appears to be reducing the amount of time that the elk are spending on C Ranch, and therefore the overall impact of elk on the ranch.

Johne's Disease Testing

In order to better inform elk management, Point Reyes began testing for Johne's disease in the Drakes Beach and Limantour elk herds in May 2014. Johne's disease, or paratuberculosis, is an infectious and incurable gastrointestinal disease caused by a bacterium found in domestic and wild ungulates. The disease has been documented in tule elk at Tomales Point since 1980 (Jessup et al. 1981, Cobb 2010), and considerable effort was made to quarantine the tule elk at Limantour in 1998-1999 and test them repeatedly for Johne's disease prior to releasing and creating the park's first free-range tule elk herd (Manning et al. 2003). However, very little Johne's disease testing occurred in the free-range elk since that time.

Beginning in May 2014, park staff began regular collections of fresh fecal samples from the free-range elk, alternating each month between elk in the Drakes Beach area and elk in the Limantour/Estero Road area. The samples are immediately sent to the Johne's Testing Center at the University of Wisconsin for culture analysis. After approximately eight weeks of incubation, the cultures are analyzed for the presence of *Mycobacterium avium paratuberculosis*, the bacterium that cause Johne's disease. Very few elk in the park are marked with collars or ear tags, but efforts were made to repeatedly sample from these animals when possible. Although most of the collections

were taken from “unknown” elk, considerable effort was made to sample unique individuals during every sampling effort in order to prevent instances in which an animal was double-sampled within the same sampling event. In order to accomplish this in the field, the elk herds were tracked very carefully during sampling efforts in order to watch for and visually mark fresh fecal droppings occurring from different individual elk within the herd. When the elk herd moved on, the staff would then move in with collection bags to collect the separate samples.

Between May 2014 and October 2014, the park collected 137 fecal samples, with 75 samples from Drakes Beach and 62 from Limantour/Estero Road. All samples tested negative for Johne’s disease. Johne’s sampling is on-going, continuing beyond the timeframe for this report.

Fences

Tomales Point

The elk herd at Tomales Point is contained within the tule elk preserve by a 2.2 mile, 8 foot high woven wire fence that transects the entire peninsula. This fence has been in place since the late 1970’s and varies in condition throughout its path. Park wildlife staff inspects and repairs the fence regularly, attempting to keep elk from leaving the preserve. Besides sporadic repair work in 2013 and 2014, a continuous stretch of over 1000 feet of the elk fence in the middle of the eastern side of the peninsula was completely replaced in 2013 by the park Roads and Trails staff with support from wildlife staff. Funding for the project was provided through Natural Resource Cyclic Maintenance (NRCM) in FY2012. The park receives periodic NRCM funding for more substantial repairs to the tule elk fence.

In order to maintain the organic status of the neighboring Kehoe dairy ranch, an additional buffer fence had to be constructed to establish a minimum 10 foot buffer between cattle and the newly installed treated posts used for repairs to the elk fence. Initially, an electric fence was erected for this purpose, but this was found to be impractical because the dairy cows were not trained on electric fence and easily damaged it. The electric fence was later replaced with a barbed wire fence, similar to the boundary fencing used by the Kehoes, and more familiar to the cattle. The cattle have not breached this fence and the buffer will remain for a minimum of three years to satisfy organic certification requirements.

Elk, particularly males, have been observed to escape from the Tomales Point containment fencing, usually in groups. Up to 18 have been observed at any one time outside the fence. It is sometimes possible to detect a breach in the fence and repair it, but at other times elk are observed on the south side of the fence with no apparent breach. It is possible that the elk cross the cattle guards installed at the elk fence on Pierce Point Road, they may swim or wade around the outer perimeter of the fence at Tomales Bay, or they may climb along the steep terrain on the western side where fencing cannot be erected. Cattle have also been observed to breach the fence and venture into the tule elk preserve.

When elk escape, wildlife staff attempt to return the elk or cattle to the designated side of the fence. In all cases where cattle have breached the fence, they can usually be returned immediately and the breach repaired, as they do not travel far from the fence. In the case of escaped elk, attempts to return them must be made when the elk are in locations where they may be hazed back towards the fence and guided into opened gates in the containment fence (three gates on the west stretch, one on the east). Attempts to haze elk back into opened gates have only been successful when elk are spending time very close to the fence, when a technician can open the gates without being detected, and when they can be run without panic along the fence directly in front of the opened gates. Successful attempts usually involve 1-3 persons on foot, coordinating with hand held radios and slowly coaxing the elk towards the fence, keeping a distance to prevent panic and fleeing behavior. Attempts during rutting season are most successful, as the male elk primarily stay close to the fence and are more apt to return to the reserve when possible. Past attempts using multiple personnel, vehicles and horses to more aggressively haze them back into the preserve have proven unsuccessful, as they quickly become panicked, run past the hazers, and ignore the gated openings even when very close to them.

In 2013, elk were successfully returned three times to the elk reserve after multiple attempts. In 2014 elk were again returned to the reserve several times. In addition, there were two incidents of cattle being returned to pastures on the south side of the fence. Cattle breached the fence on both the east and west sides of the peninsula on these occasions.

Natural flows of water and other erosive processes next to and under the fence on the ocean side of the peninsula, particularly in the bottom of the gulch and along the cliff edge, have undermined significant areas of the earthen footing for the fence, necessitating relocation and repair of the fenceline several times over the years. An incident occurred sometime in the spring of 2013 where a bull elk attempted to cross under the fence in an eroded side gully, the animal became entangled and perished in place (Figure 17). The carcass was discovered in April 2013. Because of the poor placement and condition of the elk fence through the gulch, the park is investigating the possibility of re-routing the fence to an area where it is easier to access and maintain.

Drakes Beach Area

Fence Repairs

Barbed wire fences along Drakes Beach Road prevent cattle from entering the roadway from adjacent leased pastures for most of the length of the road with the exception of the stretch between the D ranch compound and Drakes Beach parking lot. C Ranch grazes the west side of the road while the operators of A and E Ranches graze cattle to the east. Elk have been observed in all of the pastures next to Drakes Beach Road and frequently cross the road, requiring the elk to clear barbed wire fences on both sides of the road. The elk are known to damage the fences when jumping over if they are unable to clear the top fence wire. Continued pressure from elk can lead to more structural failures, particularly to fences that are not in good condition.

The operators of A and E Ranches have granted park wildlife staff permission to repair damaged or degraded cattle boundary fencing in these areas. Repairs are performed by wildlife staff when it is observed that the fence has lost effectiveness or aesthetics, regardless of evident causation, thus



Figure 17. Bull elk entangled under fence in water eroded area.

damage from weathering and cattle is repaired in these areas when detected. From November 2012 to October 2013, approximately 300 linear feet of boundary fencing along the roads were repaired to some degree, including replacement or repair of sagged or broken barbed wire, and replacement of degraded fence posts. Damage to fences along Sir Francis Drake road was additionally performed in 2014 to mitigate impacts from bulls crossing to the dunes side at certain times of the year. The total repaired in 2014 including the additional area was 460 linear feet. The most often observed damage was a sagged top strand. Less often observed, but also repaired commonly, were broken top and or/second strands. No completely breached sections were detected or repaired.

During the calving season, the main herd tended to use areas further away from Drakes Beach Road, particularly an area above Horseshoe Pond where a cattle fence delineates the boundary of the Nunes permit. Heavy use of the area and the crossing habits of the female/calf group, who tend to go through and under the fence rather than jumping over, resulted in significant fence damage. In an attempt to alleviate this damage, two wire/pole gates were installed at the elk crossing points. The gates can be left open when cattle are not present, to allow elk passage, and closed when cattle are reintroduced to the permit area.

Fence Crossings

Elk, particularly males, have been observed frequently crossing Drakes Beach road at crepuscular times (near sunrise and sunset) by jumping over the cattle boundary fences that surround the road. When elk are undisturbed by vehicle traffic or other threats, they have been observed to seek out the lowest areas of fence to traverse. In response to these observations, the profile of the existing fence in

a preferred crossing area was lowered by removing the top strand over 2 consecutive sections then reinforcing the second strand with a horizontal 4” wood beam at a height of 36-40 inches. The crossings were originally erected in June 2010 at two locations along Drakes Beach road. These modifications were made in an attempt to reduce the possibility of fence damage when elk cross the fence while retaining effectiveness as cattle containment.

Elk were observed and photographed using the crossings multiple times in 2013 and 2014 (Figure 18) and no cattle were known to have escaped a ranch permit boundary due to the presence of these facilitated wildlife crossings. Other areas where crossings would facilitate elk passage and reduce fence damage have been identified, but no additional crossings have been constructed due to rancher concerns.

Fence Removal

A stretch of abandoned barbed wire cattle fence along the lower, western side of Drakes Beach Road down to the parking lot was observed to be a hazard to elk crossing the road between the Drakes Beach Tract and Outer Horrick. Sections of this fence’s barbed wire were incrementally removed by wildlife staff during 2013. In addition, other sections of abandoned fencing and discarded fence materials have been removed in the Drakes Beach area in order to reduce wildlife hazards and restore natural conditions in non-permitted areas.



Figure 18. Bull tule elk at lowered elk crossing, Drakes Beach Road.

Hazing

A practice of hazing elk was instituted in late-summer 2012. When observed in the central pasture on the C ranch permit area or around the stock pond, elk groups, typically the entire main herd was hazed towards the non-permitted areas closer to Drakes Beach and the D Ranch Outer Horrick area (Figure 7). Hazing bachelor groups or individual elk was not attempted due to the unpredictable response observed in previous hazing attempts with these groups. Hazing during the time period of this report was performed in the early morning hours, generally as soon as there was enough light to locate the herd. Attempts at preventing movement of animals into undesired areas at sunset proved unsuccessful and were discontinued.

Hazing was performed by a single wildlife technician approaching the elk on foot from the direction of Sir Francis Drake walking at a normal rate using no other devices or distractors. Elk were directed towards the canyon to the east toward their preferred entry route until they moved over and below the top contour of the C ranch central pasture, at which time staff would disengage and return to Sir Francis Drake. This early disengagement was to allow the elk to continue out of the central pasture at their own pace, minimizing the possibility that hazing might injure the elk or exacerbate fence damage. Hazing was also discontinued if the elk persistently travelled in a non-desired direction or if the technician did not feel that the movements of the elk group were directed or controlled. Detection of an injured elk in the herd was also a criterion by which a hazing attempt was terminated. If elk appeared to settle in the north-east pasture of the C ranch permit area adjacent to Drakes Beach Road, the technician would, at his discretion, approach them again from Drakes Beach Road to encourage them to exit the permit area entirely. Hazing was kept to the minimum disturbance that would cause the elk to move in the desired direction. After repeated efforts, the elk are more prone to move in the desired direction immediately, and then continue to travel back to the non-permit areas without further hazing. Elk were not approached or disturbed when they were in the non-permit areas to further reinforce the desirability of remaining in those locations. Hazing of elk did not occur in any other area of the pastoral zone between November 2012 and October 2014.

Antler Protection

Antlers on male tule elk are shed and regrown annually, representing a significant investment of energy and resources and a key factor in the behavioral life cycle of the species. Tule elk at Point Reyes begin to shed their antlers in late January and early February, with the free range herds starting in advance of the elk on Tomales Point. Antler re-growth begins almost immediately, with velvet covered buds becoming visible within days of the antler shed. At this time, bachelor groups travel together seeking more mineral rich feed (forbs and other non-grasses) to nourish the rapid bone growth necessary to form a useful set of antlers. The formation of bachelor groups may also serve to prevent injury to the growing antlers, which would lead to deformation and loss of function in the fully developed appendages. In the midsummer, usually in July, the blood filled spongy antlers begin

to solidify and lose vascularity. Eventually the velvet is sloughed off revealing fully formed and hardened bone.

In a male elk's second year of life, antlers are typically composed of a single tine, or spike. Subsequent years show further morphometric development of antlers, typically attaining a mature formation of seven or more tines and weighing up to 9 lbs. per side. Older bulls tend to show more asymmetry in antler morphology, with non-linear tines, palmate formations, and non-typical sub-branchings of the main beam and tines.

The illegal removal, or poaching, of elk antlers by the public has been a significant resource management issue at Point Reyes for many years. While visitors may take antlers without realizing it is unlawful, many individuals have been apprehended over the years with clear intent to take as many antlers as possible and evade park law enforcement. The level of poaching appears to be very high, as evidenced by the few antlers found by wildlife staff after the shed season each year. NPS biologists have also documented the removal of antlers from elk carcasses.

Antlers play an important role in the ecosystem's nutrient cycling, providing minerals that are both limited and crucial for mammals, plants and birds. Tomales Point soils in particular are naturally deficient in a number of trace minerals, such as copper and selenium (Gogan et al. 1989). Removal of antlers from the system depletes it further, similar to extractive mining of minerals. In response, the park has conducted an annual antler round-up since at least 2006 using both park staff and volunteers to locate and collect as many antlers from the field as possible. The antlers are then cut into pieces and re-distributed by hand back out into the elk ranges (Figure 19). Antler collection attempts are initiated when shedding is first detected and maintained until all male elk have shed and there are no longer antlers being recovered. Antlers are collected by surveying areas with spotting scopes and binoculars and through ground surveys of areas where bull elk tend to predictably congregate.

Tomales Point

In 2013, of the possible 258 branched antlers (129 branch antler bulls census 2012), only 26 new antlers were recovered, one of the lowest recovery rates in recent years (10.1%). 23 older antlers were also found, but not included in this recovery calculation. The low recovery was possibly due to lower effort, but may also reflect an increase in illegal removal. Antler poaching seems to be occurring in most areas of the reserve, but may be most acute in the southern portion near Pierce Point Road and the northern area easily accessed by boat from across Tomales Bay, both areas where male elk congregate in larger groups and are easily observed. One case of antler poaching was reported to park law enforcement in the period of this report, and a citation was issued. Several carcasses were found to have had their antlers, ivories (vestigial canines), or entire skulls removed. Following the 2013 antler shed, a large metal sign advising against antler collection at the entrance of the Tomales Point elk reserve was illegally removed in July 2013.

In 2014, 54 antlers were recovered from Tomales Point of 190 possible branched antlers for a recovery rate of 28.4%. Only 3 older antlers were recovered, which are not included in the recovery calculation.



Figure 19. AmeriCorps volunteers spreading antler chips at Tomales Point.

Drakes Beach Area

An attempt was made to collect all the antlers shed from the Drakes Beach herd in early 2013. The first antler was recovered on February 1st. In total, only 6 branched antlers were collected over two months of attempted collecting, matching the numbers collected in 2012. When compared with the expected number of branch-tined antlers anticipated to have been shed in the area (32), this represents a recovery of only 19% (2012 recovery was 25%). One incident of antler poaching in this area was reported to park law enforcement in 2013. In 2014, 15 antlers were recovered in the Drakes Beach area, for a recovery percentage of 32.6%.

Estero Road Area

Branch antlered males of the Limantour herd are typically found near Home Ranch during the shed season, and most antlers recovered come from this area. In 2013, wildlife staff recovered 10 new antlers of a possible 56 (28 branch antlered bulls observed) for a recovery of 17.9%. The presence of these bulls near roads and trails has become more apparent recently, likely making the shed antlers more vulnerable to illegal removal each successive year. In 2014, 34 antlers were recovered in this area, for a recovery rate of 50%.

Mortalities

Tomales Point

Multiple carcasses were observed during the census events and while searching for antlers at Tomales Point. Because the elk at Tomales Point are not intensively monitored, most carcasses found in this area are in an advanced state of decay and/or have been thoroughly scavenged, so indications as to cause of mortality are usually indeterminable. Carcasses found fresh can be field necropsied, several were performed in the period of this report, but none were of particular note. Several prime bulls were found dead with intact antlers, and staff removed the antlers by sawing them off to prevent illegal poaching of skulls or antlers.

Drakes Beach Area

An adult female was discovered in the canyon between the C ranch main reservoir and Drakes Beach pond on October 15, 2012. The elk was very recently killed with foam exuding from the mouth and nostrils. A field necropsy was performed, revealing severe hemothorax and a broad area of subdermal hemorrhaging extending broadly across the ribcage, suggesting that a road strike followed by hemorrhagic asphyxiation as the cause of death. Distance from the road suggests that asphyxiation took several minutes during which the animal traveled to the location where the carcass was discovered. No vehicular collisions with an elk were reported on or near this date, but it is unlikely that any other event could have caused an injury of this nature.

An adult male carcass was found in the canyon between the C ranch reservoir and Drakes Beach pond on October 30, 2012. This bull had been observed for several weeks previous to have a severely swollen terminal front leg resulting in decreasing mobility and separation from the bachelor herd, likely due to an inability to traverse cattle fences. On post-mortem inspection, the affected leg had significant deformations of the terminal bones and hoof. It is unknown what nature of injury led to the deformations and the accompanying inflammation (Figure 20). Cause of death was most likely a dietary deficit from decreased mobility perhaps compounded by osteomyelitis, suggested by the severe bone deformation, followed by fatal sepsis.

An adult male carcass was discovered in August 12, 2013 near the D Ranch driveway. The carcass was partially decomposed and its antlers had been purposely removed, likely with a hand saw. Investigation revealed that the carcass had been moved from its original location to the location where it was discovered. Although human handling of the carcass was evident, no causation of death was determined.

An adult male carcass was found September 4, 2013 near the northern arm of Horseshoe Pond. The carcass was decomposed and scavenged. Inspection of the carcass revealed that the terminal left rear leg had severe deformations that were evident in abnormal morphology of the terminal set of bones and hoof. This elk was known by antler match to be an individual that was observed frequently in the area with a severely swollen and deformed lower left rear leg, and likely perished due to dietary deficit associated with decreasing mobility, which had been observed becoming more pronounced for several months, perhaps compounded by osteomyelitis, suggested by the severe bone deformation, followed by fatal sepsis. It is unknown what nature of injury led to the severe deformation of the leg



Figure 20. Hoof deformation of Drakes Beach bull male carcass.

(Figure 21), which was similar to the bull observed in October 2013 (see above) and with an almost identical progression of symptoms and eventual mortality.

An adult female's bone fragments were found August 15, 2013 on the southwest side Drakes Beach road. The bones were segmented and completely scavenged, no determinants to cause of death were observed. This elk was believed to be an easily recognizable elderly cow with completely deteriorated earflaps that was not observed alive after early 2013.

On September 11, 2014 a male raghorn was reported road struck during the night previous in the vicinity of C ranch on Sir Francis Drake by a local resident, who reported the incident. Law Enforcement officers took the report, investigated the scene and referred the carcass to wildlife staff early the next morning, who performed a field necropsy. Examination showed that the bull was struck in the hind quarters and most likely suffered paralysis, persisting for several hours until finally succumbing to other road-strike related internal injuries, including bleeding into the pleural cavity. Extensive road rash, subcutaneous hemorrhaging and limb fracturing were also observed, all injuries consistent with a fatal road strike. Johne's testing results by tissue histopathology were negative.

An adult female was observed for two weeks solitary from the herd in the center area of C ranch, she stayed within a small area and was seen to slowly decline in mobility until November 22, 2014 when she finally died. The carcass was retrieved and brought to the road where a field necropsy was performed. On examination it was observed that she had severe pleuropnuemonia. A non-operational radio collar showed that she was one of the original migrants from Limantour to Drakes Beach and was known to be of advanced age, having originally been captured and relocated from Tomales Point in 1998. Johne's results from tissue histopathology and culture were negative.



Figure 21. Raghorn male elk with severely deformed back left hoof.

Estero Road Area

The nature of the Limantour herd and its wide ranging habits where roads and trails are scarce makes detection of mortalities difficult, so carcasses are rarely found.

A mortality from the Limantour herd was discovered on February 14, 2013 on the southwest facing slope of Mount Vision, approximately half way in elevation from the Estero trail parking lot and Mt Vision Road. A well scavenged and decomposed prime bull carcass was found with a mass of barbed wire entangled around his head and antlers (Figure 22). This bull was not observed in this condition alive, and it is unknown at what date he became entangled. It is likely that he had become separated from the main bachelor herd as they were observed regularly. The wire was wrapped several times around the skull and was fused into the central area of both sides of the jawbone as well as entangled in the antlers such that the growth of the antler was deformed, branching erratically around the wires. This suggests both that the barbed wire was on the living animal for a considerable length of time, at least during the entire period of antler regrowth the previous year and that the entanglement was ultimately the root cause of mortality, as the penetration of the jawbone by the strand of wire likely prevented the mouth from opening more than approximately an inch, therefore limiting feeding motions. The wire mass also lacerated the facial skin and contacted/abraded the dorsorostral area of the skull causing a slight bone deformation similar to but less severe than the observed jaw/wire fusion. It is unknown if the barbed wire was contracted from a standing, currently maintained fence



Figure 22. Skull of bull elk entangled in barbed wire recovered from Mount Vision.

or from abandoned fence debris, which is commonly found in formerly and currently grazed areas of the park, but it is worthy of note that the barbed wire was recent enough not to have been oxidized (rusted).

On November 30, 2014 a bull elk, which had been observed roaming alone for some time near and over the top of Mt. Vision, was reported to be down on the side of Mt. Vision Road, lying on the shoulder of the road with his head up and alert. Attempts were made to haze the animal away from the road so that he might die naturally, but he could not get up and was showing clear signs of stress from the presence of vehicles and persons, so it was decided to euthanize the animal for humane and safety reasons. The bull was euthanized by gunshot and a field necropsy was performed. The bull had moderate pleuropnuemonia, resulting in significant lesioning of the lung tissue. An identifying ear tag revealed that the bull was of advanced age, having been born in the Limantour quarantine enclosure in 1999 when the free-range herd was established in the park. Johne's results from tissue histopathology and culture were negative.

Education and Outreach

For over 10 years, the Division of Interpretation and Resource Education at Point Reyes National Seashore has hosted a Tule Elk Docent Program at Tomales Point. The goals of the program are to:

- Provide opportunities for the general public to view tule elk at Tomales Point.
- Provide opportunities for the general public to interact with volunteers and park staff to learn about the many stories surrounding tule elk during the rut season.

The docent program runs from August through October and typically includes two training days in July. The docents station themselves at the Tomales Point Trailhead and Whites Gulch on weekends only, prepared with telescopes, antlers, and interpretive materials to teach the visiting public about the tule elk.

During the 2013 season, 17 docent volunteers contributed 801 hours to the docent program. The docents made an average of 325 visitor contacts per day, and 7154 visitor contacts for the entire 2013 season.

During the 2014 season, 15 docent volunteers contributed 662 hours to the docent program. The docents made an average of 238 visitor contacts per day, and 6417 visitor contacts for the entire 2014 season.

Point Reyes National Seashore wildlife staff presented a lecture and slideshow on past and present elk management in the park as a portion of both docent trainings in 2013 and 2014. In addition, wildlife staff gave the following presentations in the field regarding the history, management, and ecology of tule elk in the park:

- September 2013 – members of Conservation Corps North Bay.
- October 2012, November 2013, November 2014 – Sonoma State University students from the Ecology and Restoration Ecology classes.
- November 2014 – UC Berkeley Mammalogy class

In addition, Point Reyes National Seashore hosted two tule elk events at the park during this time period. In November 2013, the California/Pacific Section of the Society for Range Management held their annual meeting at the Red Barn, which included a panel discussion regarding elk and agriculture titled “Thinking About Elk”. Featured speakers included Dr. Jamie Bartolome and Dr. Dale McCollough from UC Berkeley and Stephanie Larson from UC Cooperative Extension. In April 2014, Frank Binney, an instructor with the Point Reyes Field Institute and a long-time volunteer with the park’s elk program, gave a talk as part of the park’s Science Lecture series titled “The History of Elk in Marin County”.

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Appendix A: Tomales Point Census Results, 2013 and 2014

2013 Census Data

12/4/2013	Total	Cows	Calves	Spike Bulls	Raghorn Bulls	Prime Bulls	Total Bulls	Unknown
South	118	60	20	1	4	33	38	0
Middle	76	61	10	2	2	0	5	1
North	162	74	16	2	13	57	72	0
Total	**356**	**195**	**46**	**5**	**19**	**90**	**115**	**1**

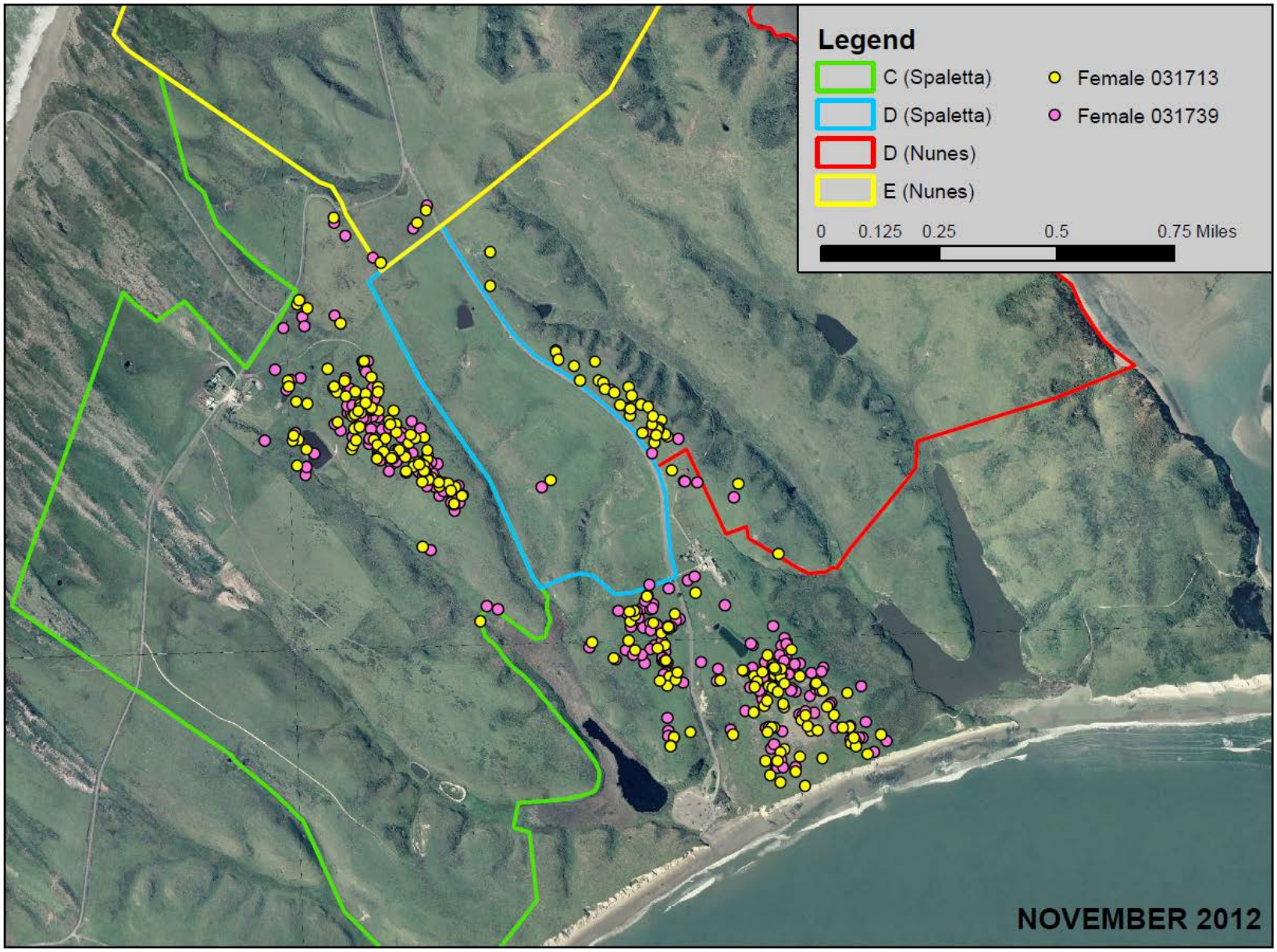
12/11/2013	Total	Cows	Calves	Spike Bulls	Raghorn Bulls	Prime Bulls	Total Bulls	Unknown
South	106	51	11	3	0	41	44	0
Middle	93	72	10	2	3	6	11	0
North	149	68	14	6	15	46	67	0
Total	**348**	**191**	**35**	**11**	**18**	**93**	**122**	**0**

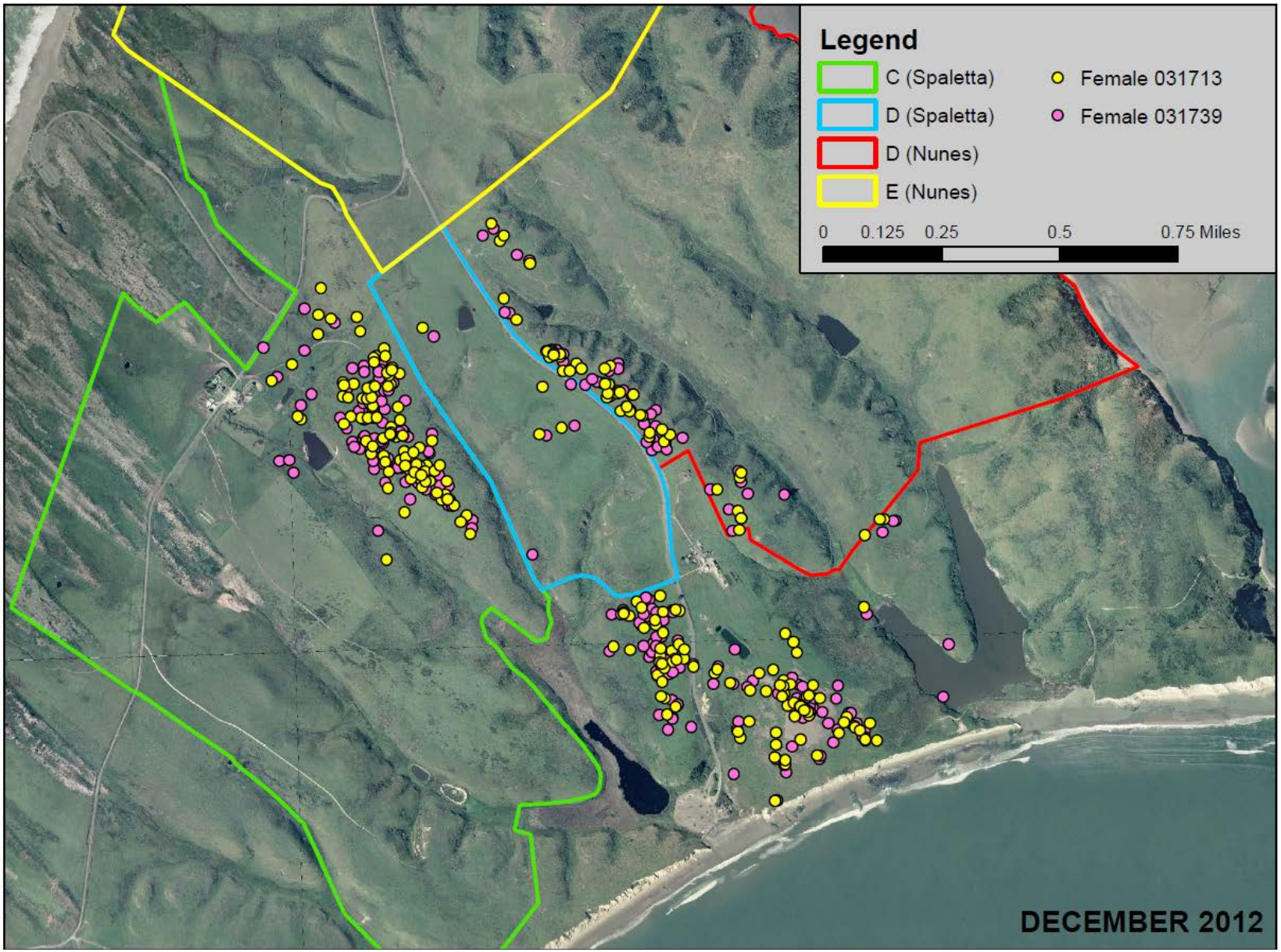
2014 Census Data

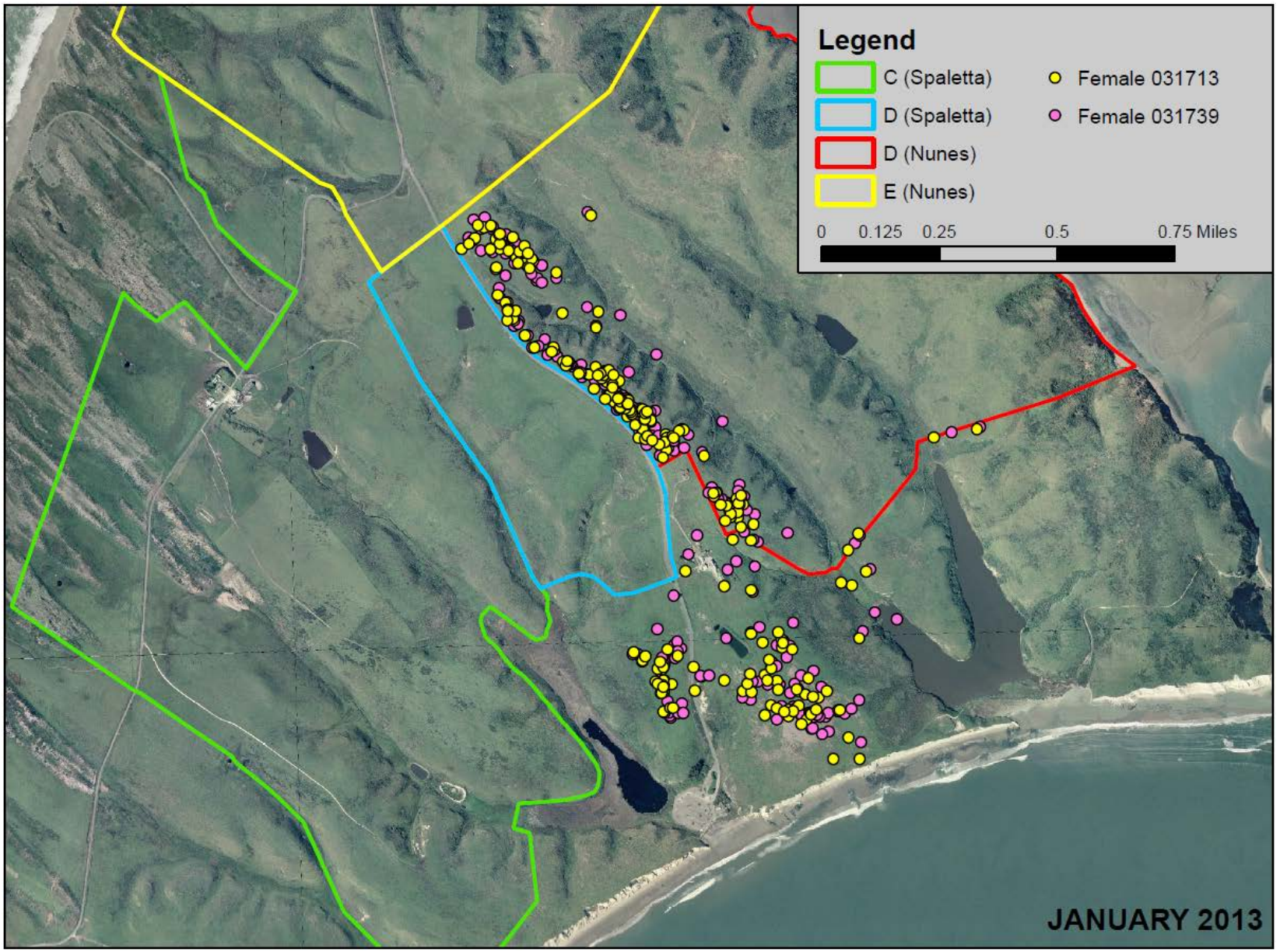
11/13/2014	Total	Cows	Calves	Spike Bulls	Raghorn Bulls	Prime Bulls	Total Bulls	Unknown
South	92	57	6	3	1	25	29	0
Middle	68	54	10	1	1	2	4	0
North	116	52	11	2	22	29	53	0
Total	**276**	**163**	**27**	**6**	**24**	**56**	**86**	**0**

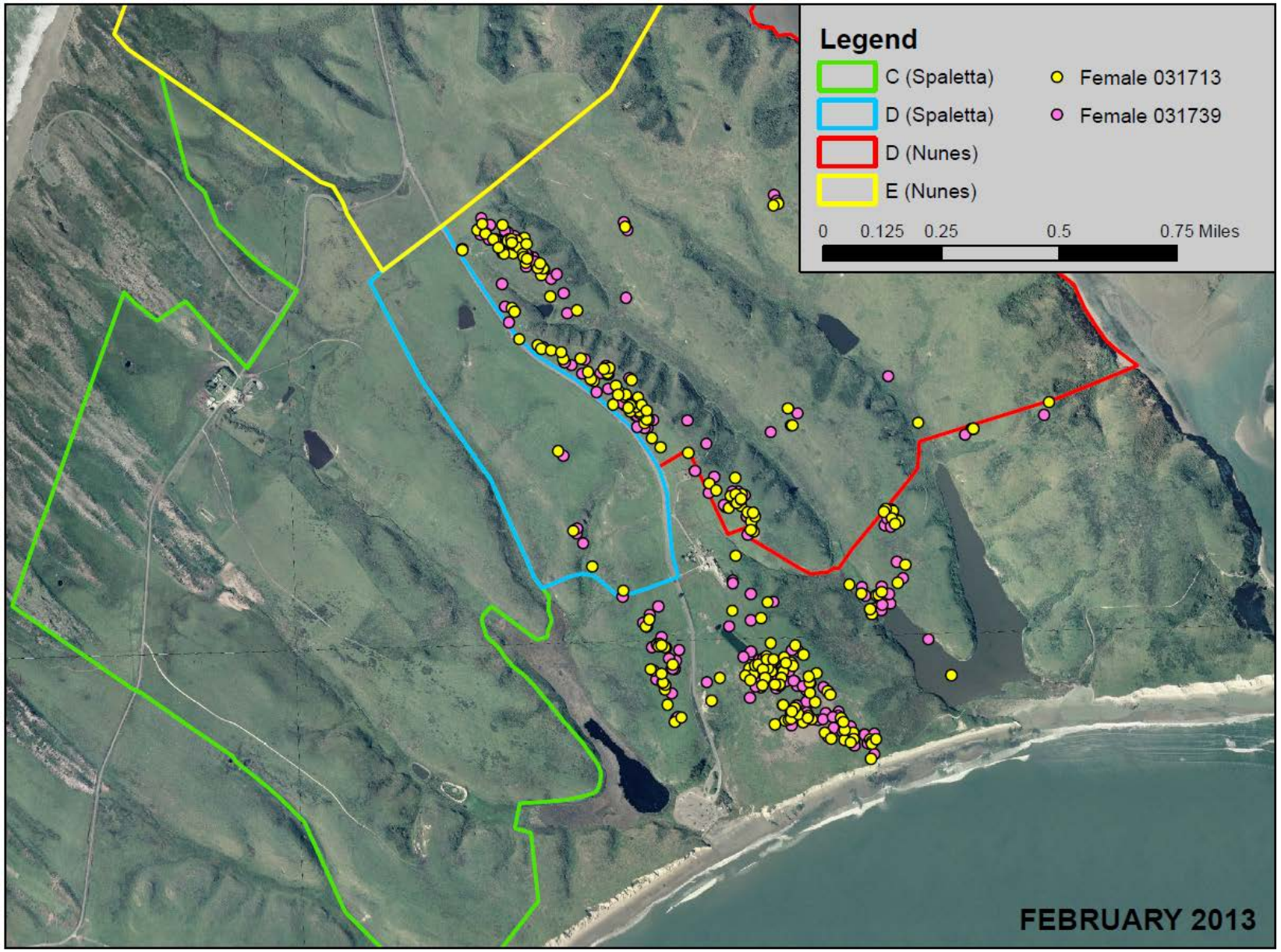
12/18/2014	Total	Cows	Calves	Spike Bulls	Raghorn Bulls	Prime Bulls	Total Bulls	Unknown
South	94	55	11	2	5	21	28	0
Middle	57	45	6	3	1	2	6	0
North	135	68	6	5	13	43	61	0
Total	**286**	**168**	**23**	**10**	**19**	**66**	**95**	**0**

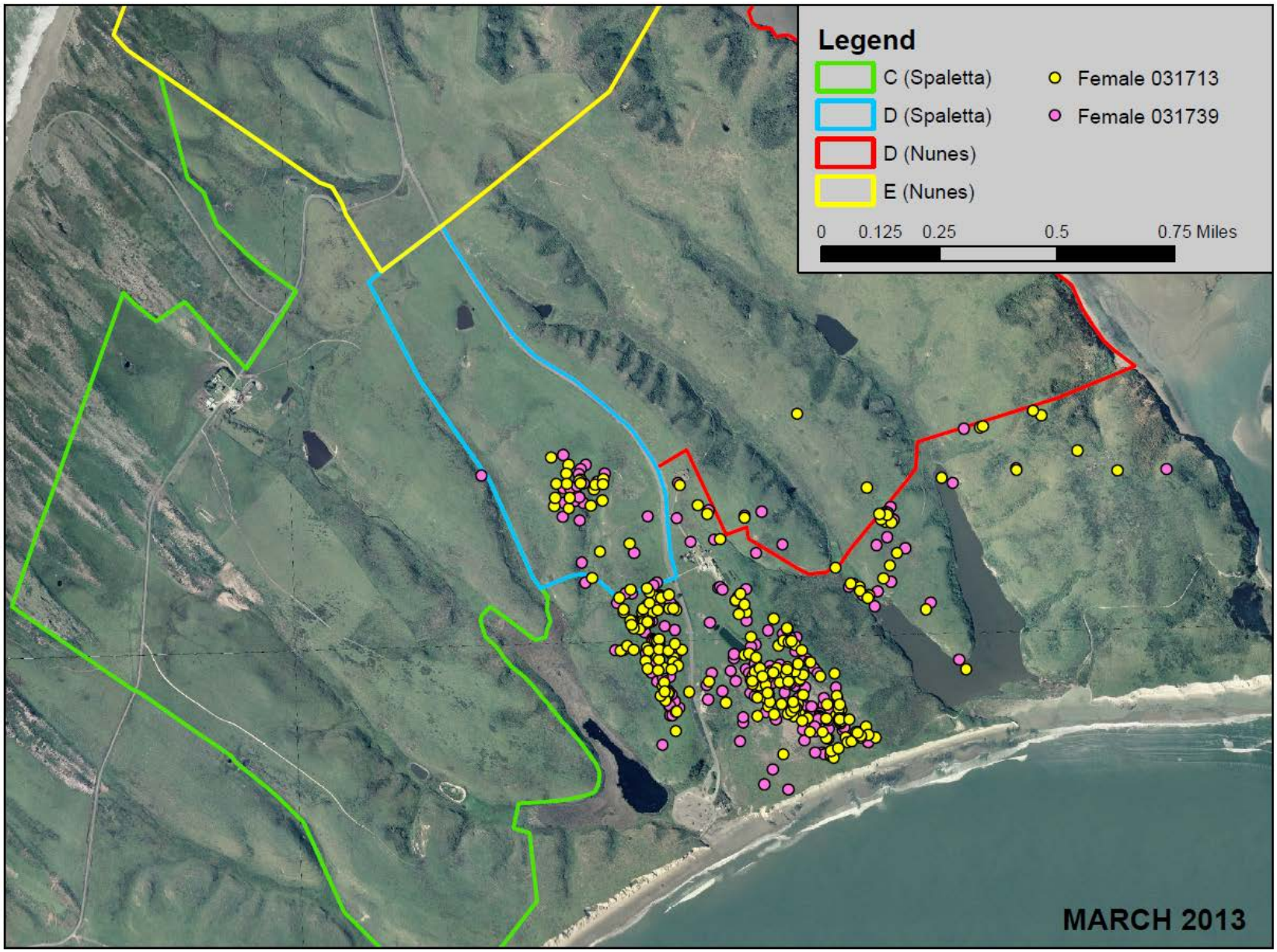
Appendix B: Monthly GPS collar maps of female elk 031713 and 031739 from November 2012 to October 2014

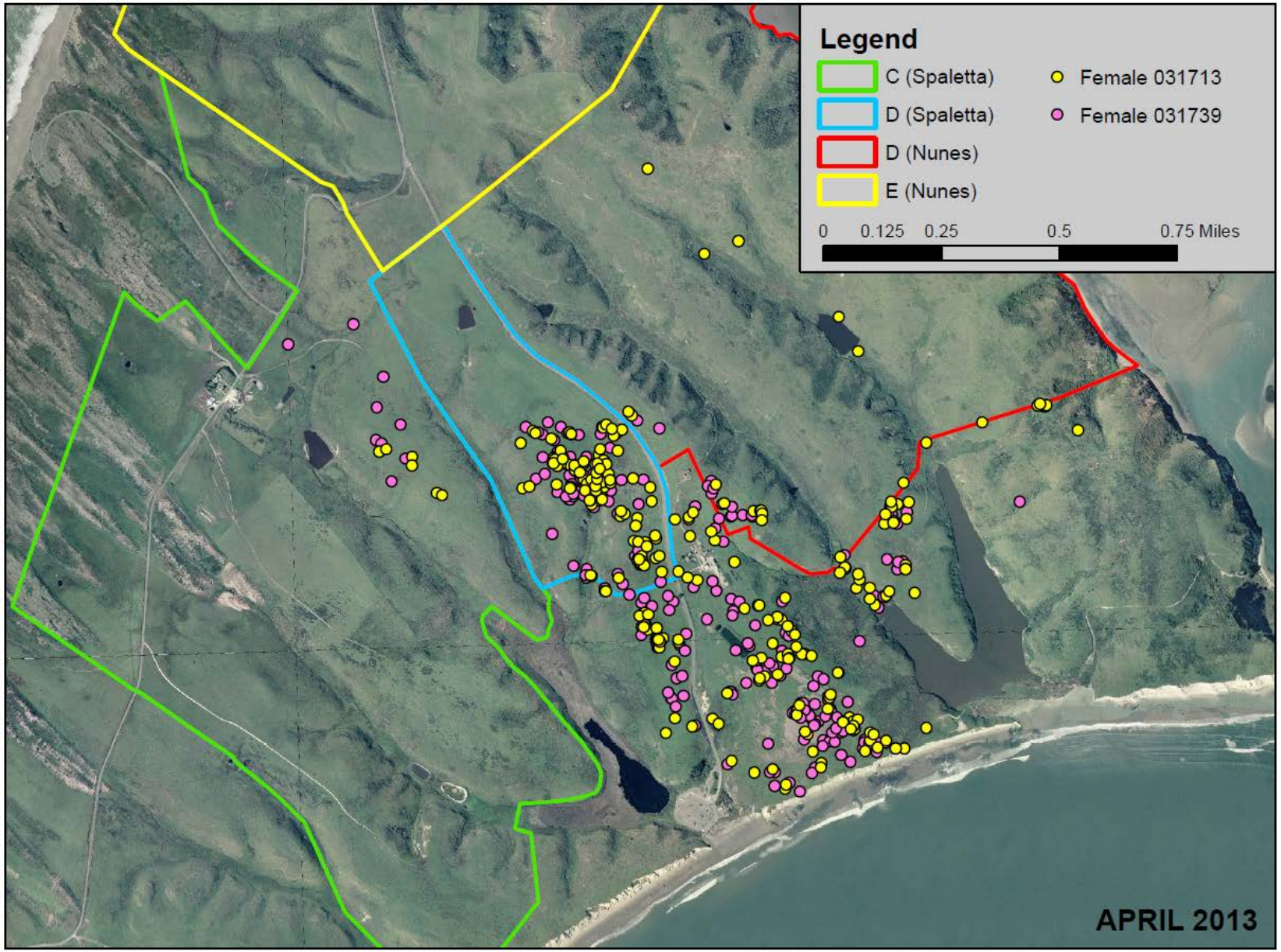

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
NOVEMBER 2012

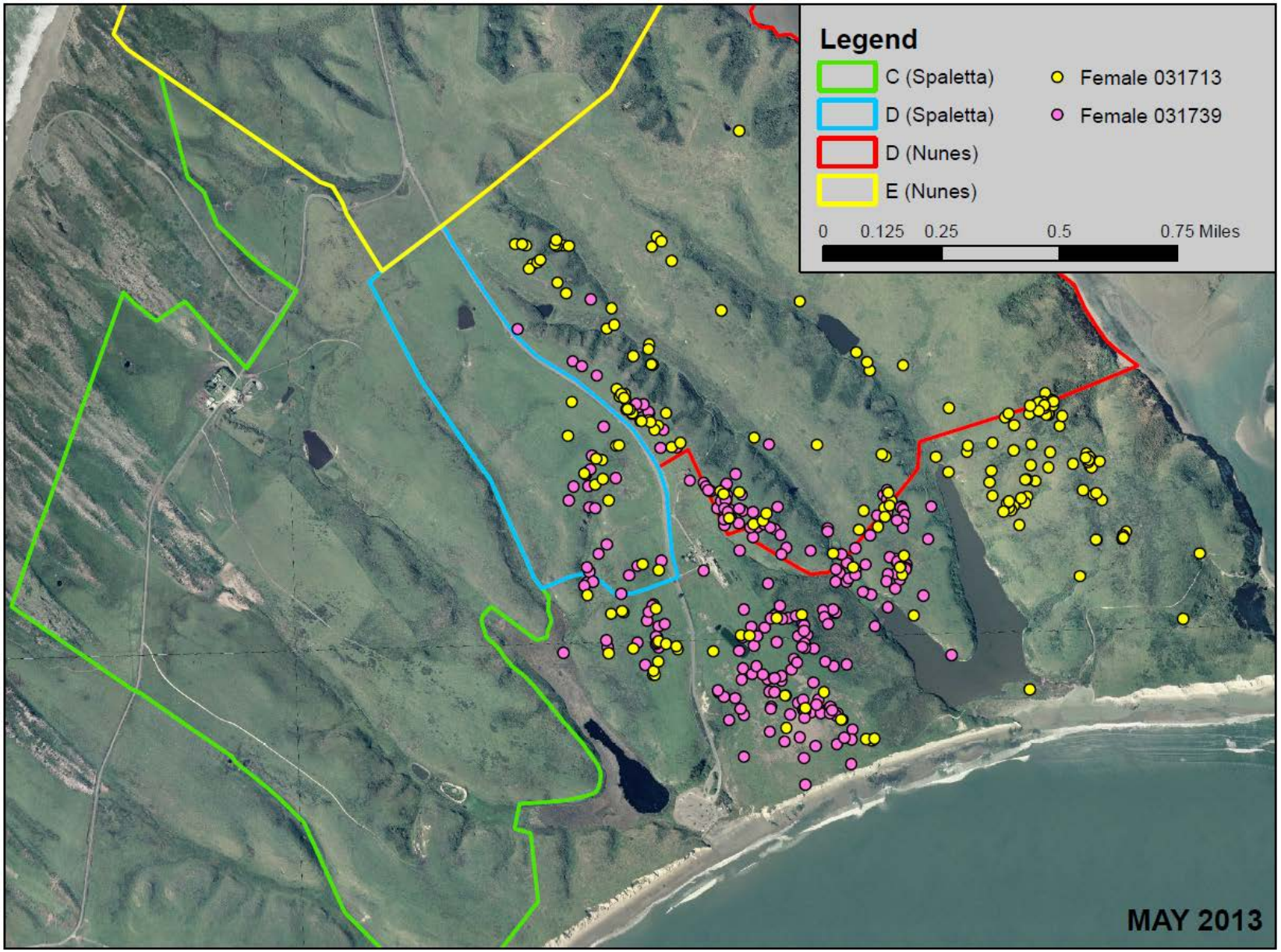

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
DECEMBER 2012

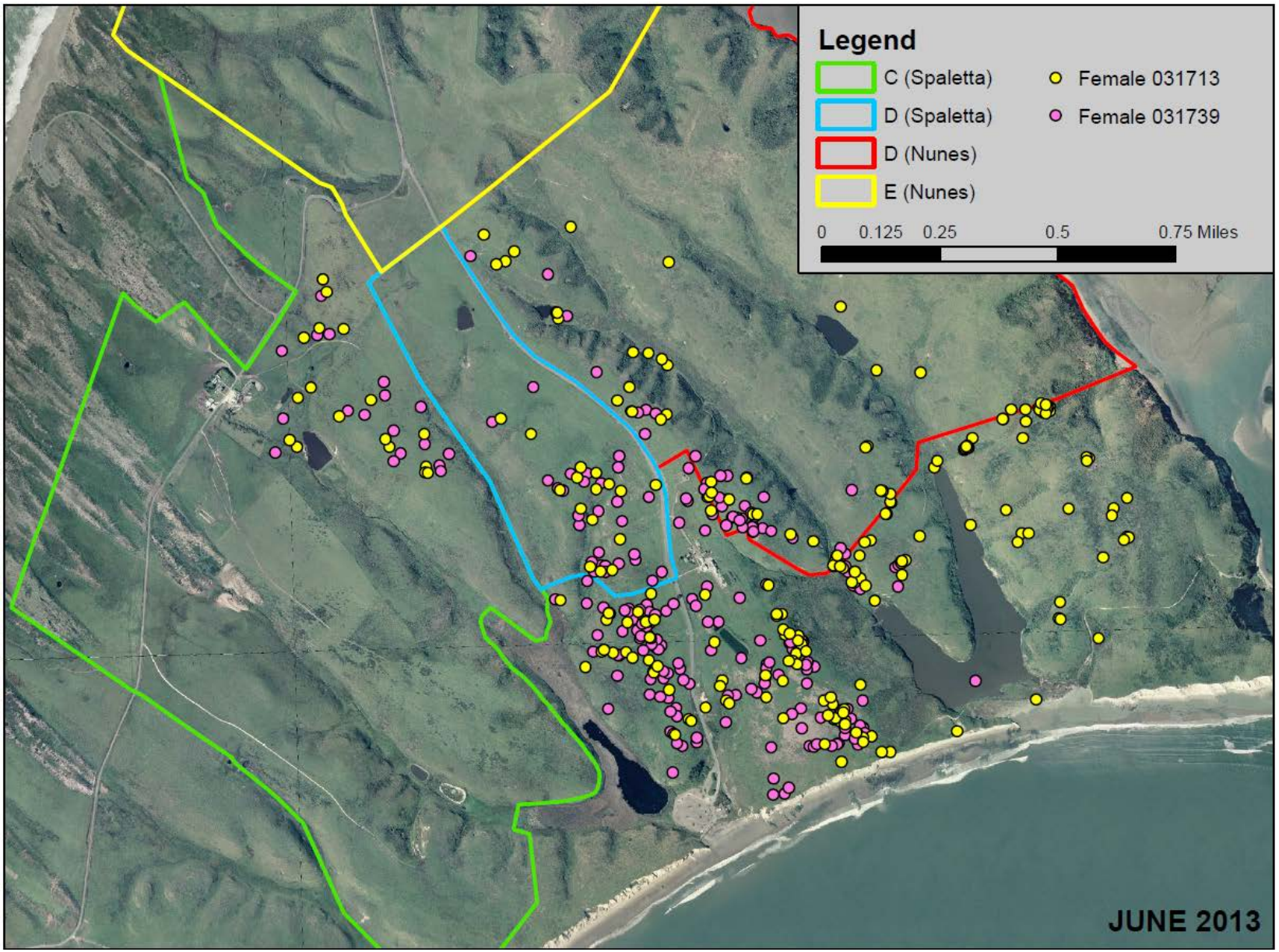

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
JANUARY 2013

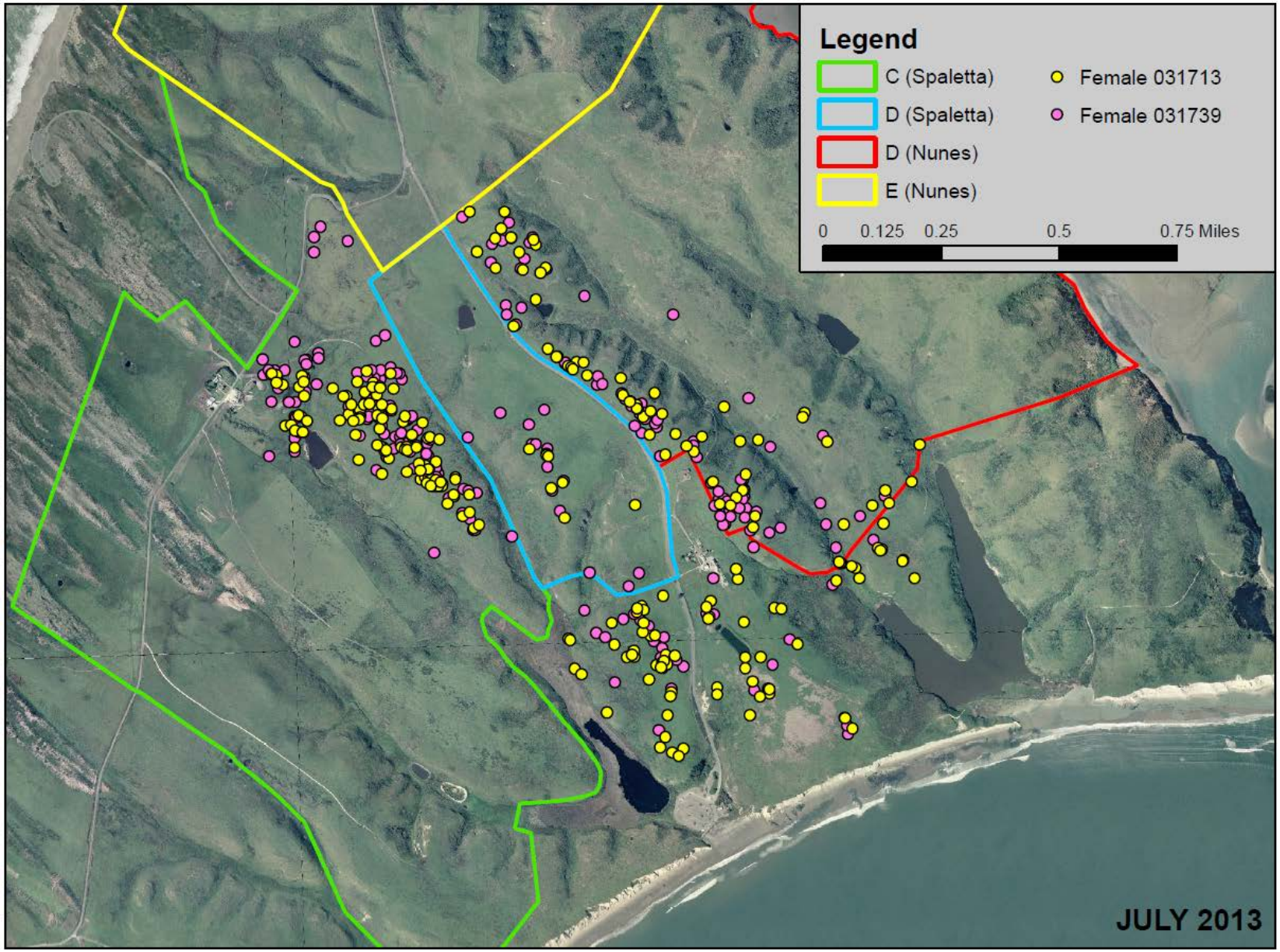

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
FEBRUARY 2013

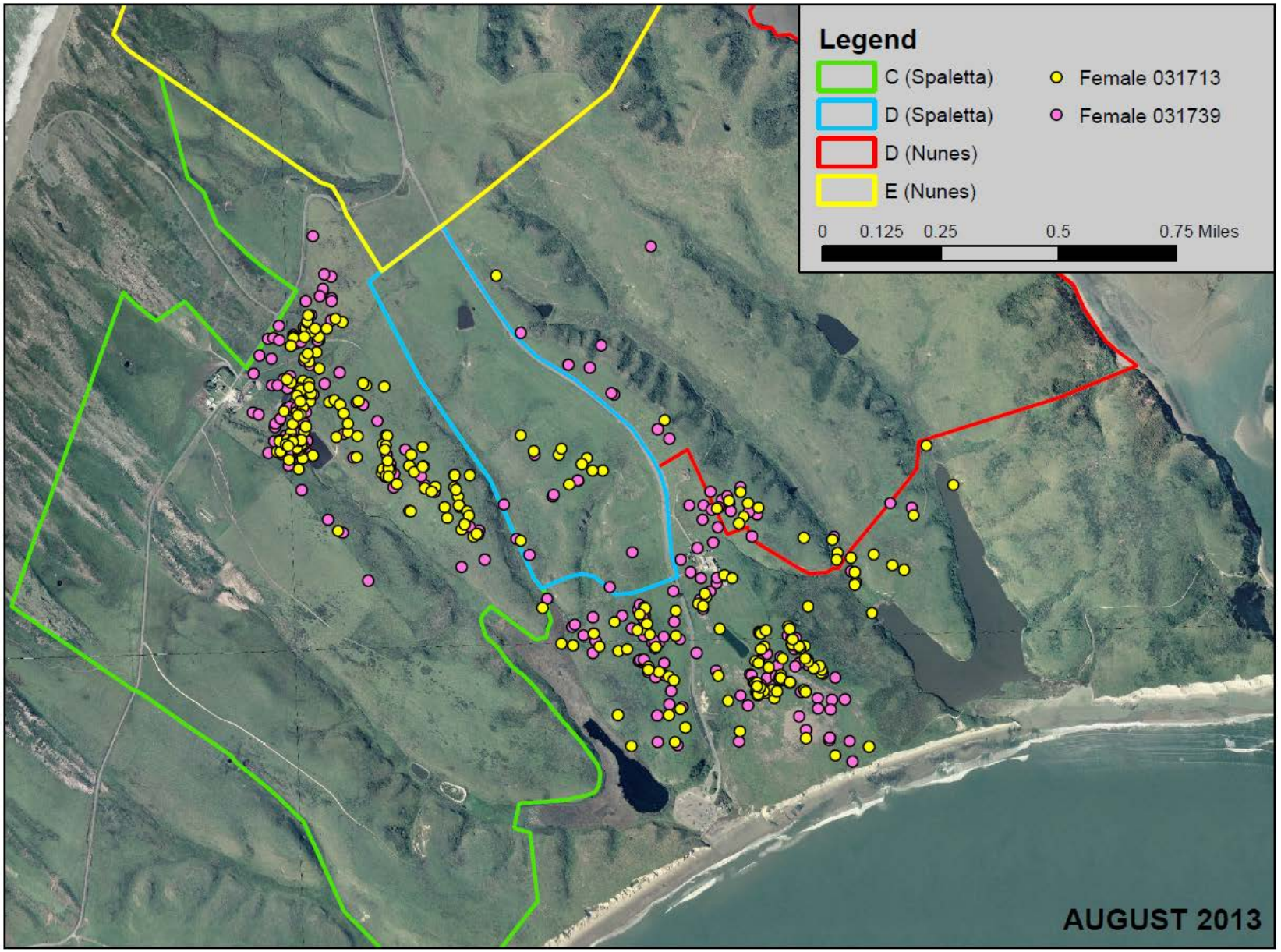

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
MARCH 2013

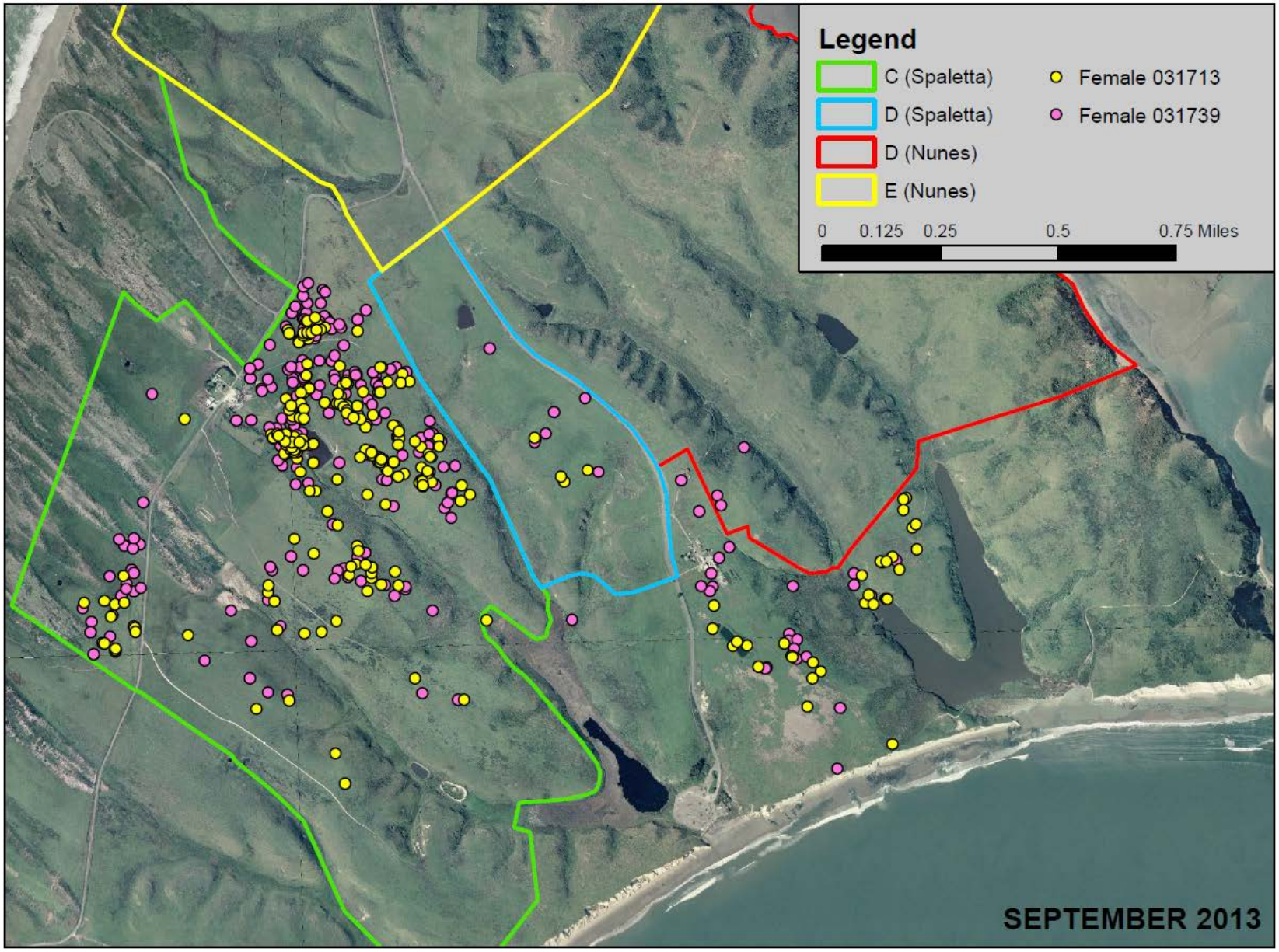

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
APRIL 2013

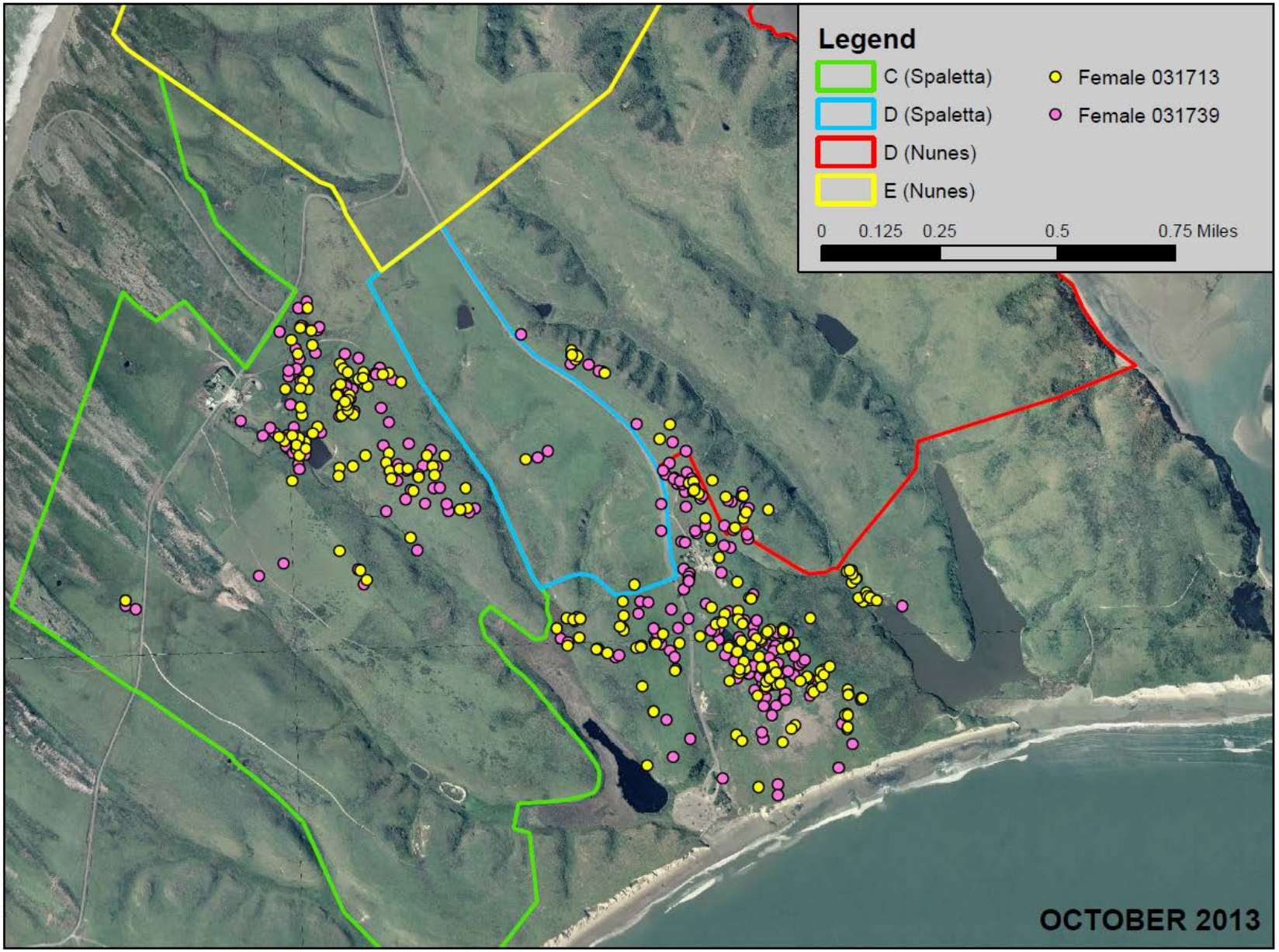

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
MAY 2013

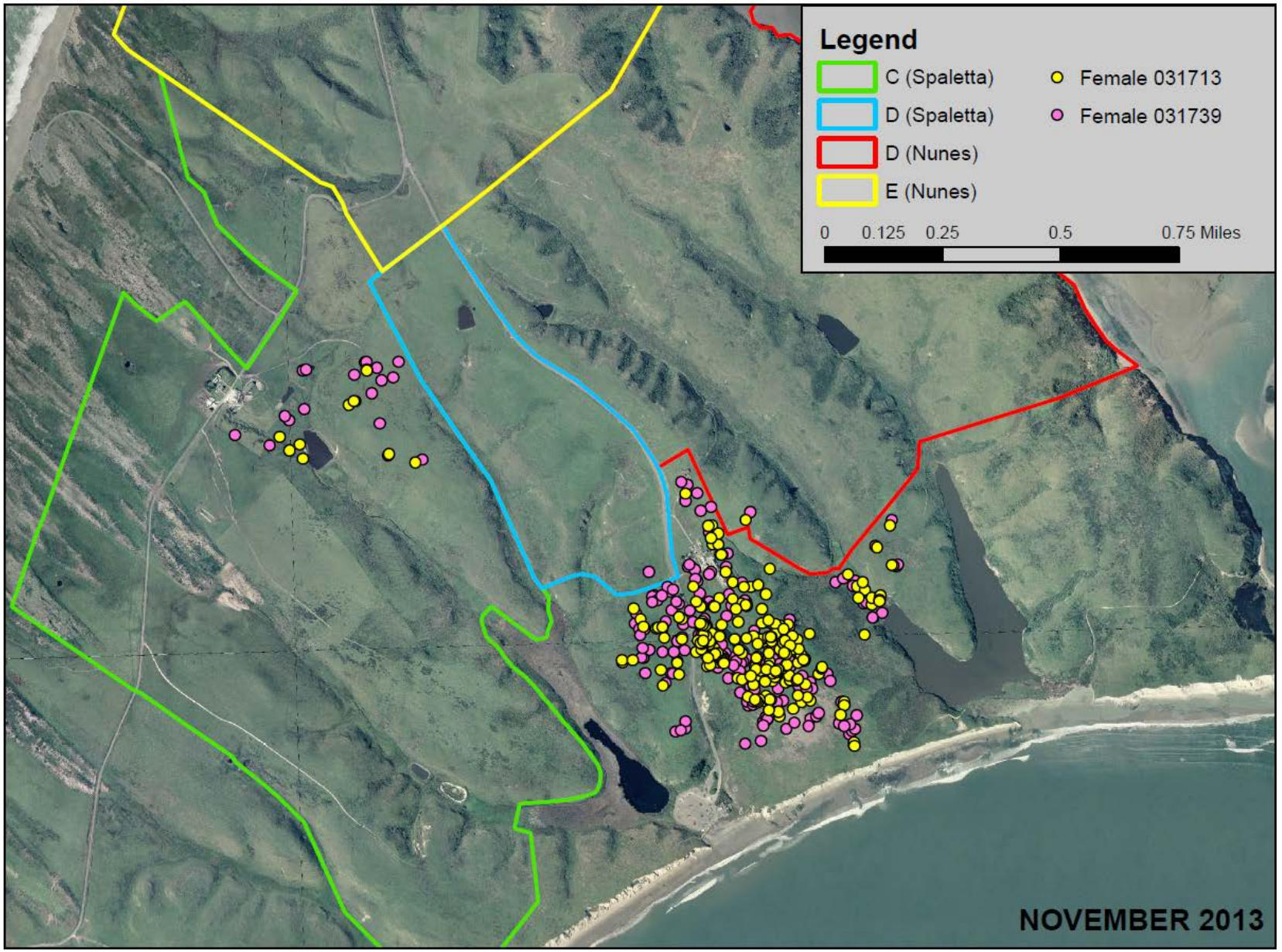

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
JUNE 2013

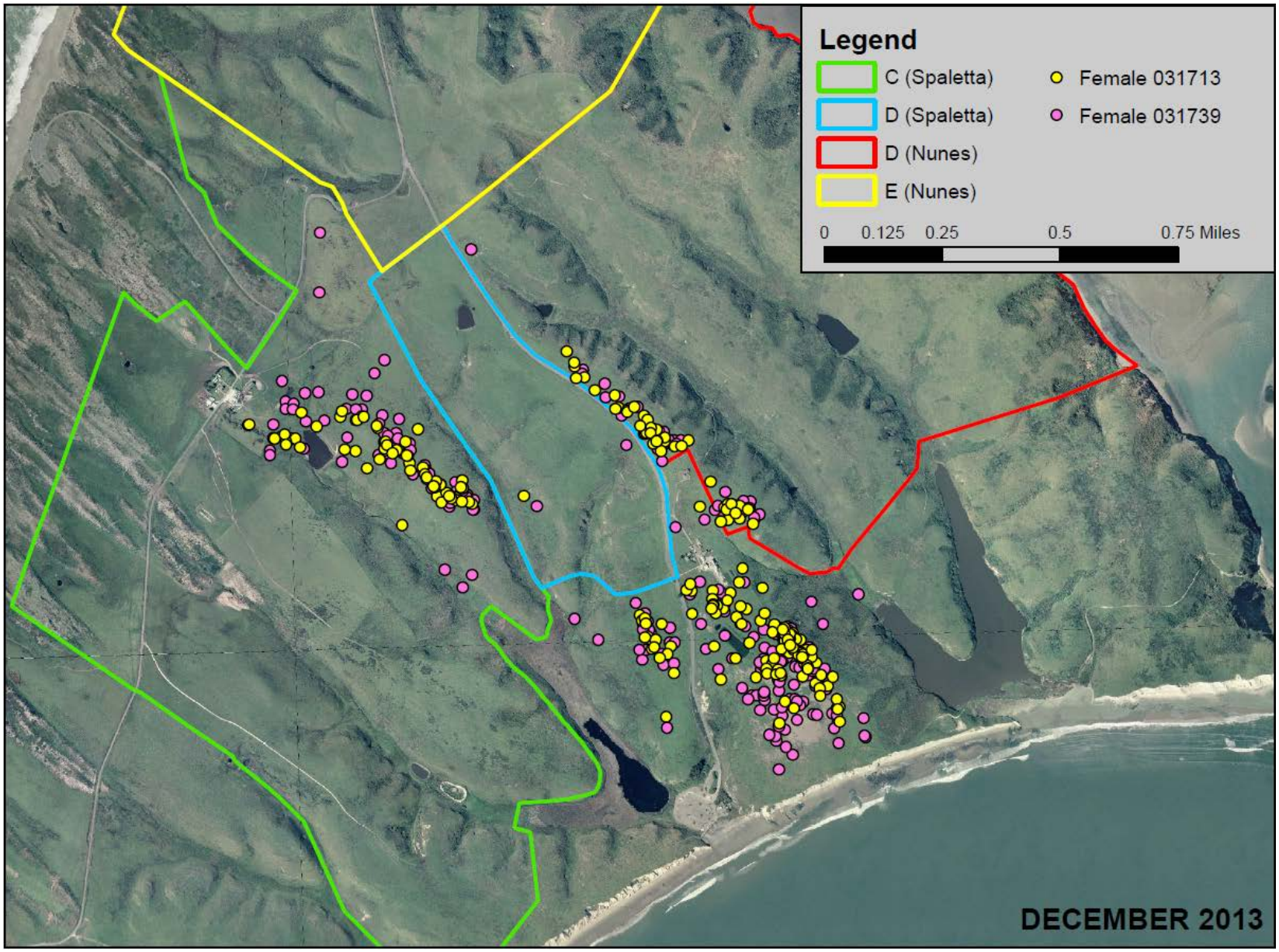

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
JULY 2013

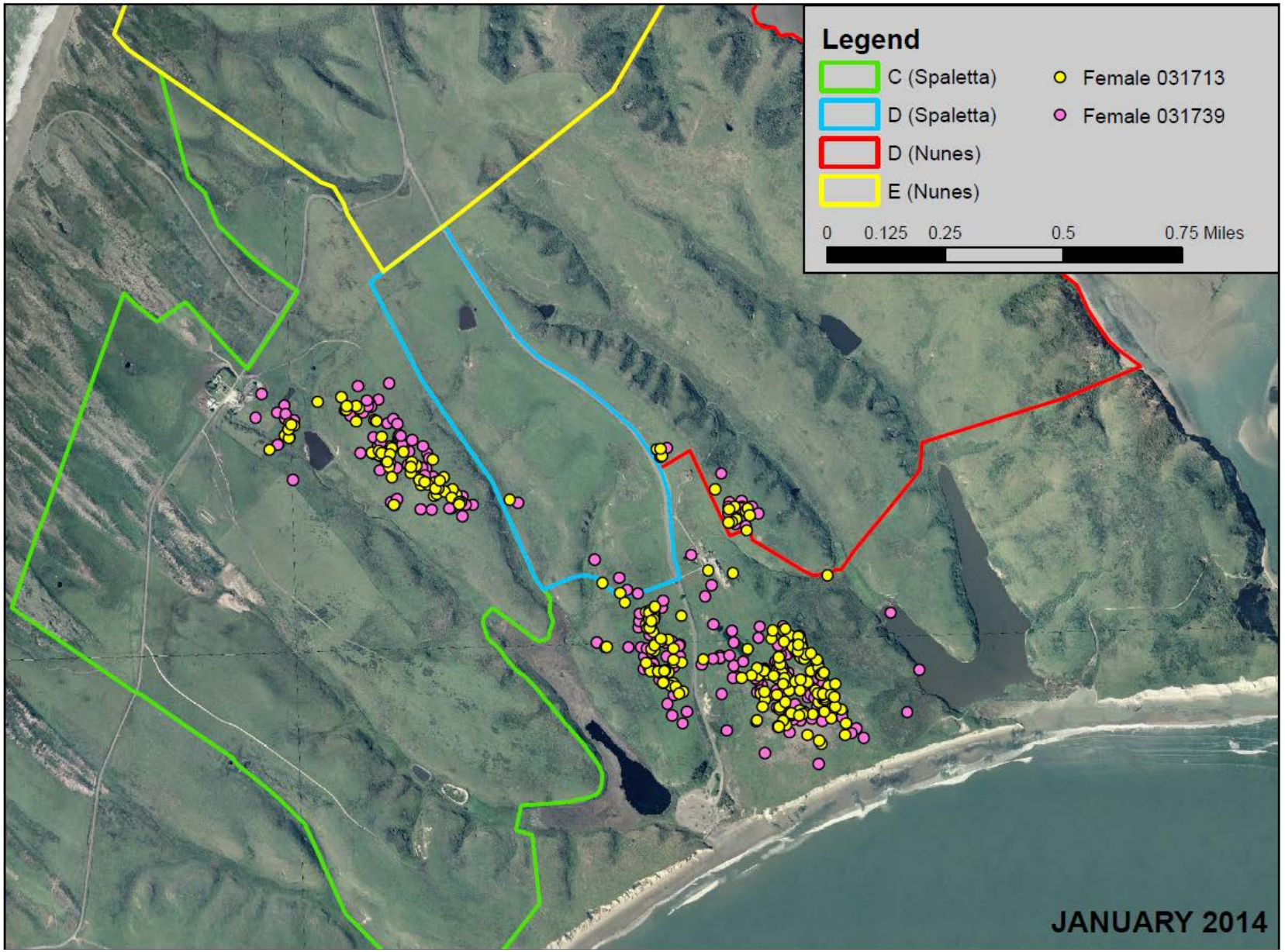

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
AUGUST 2013

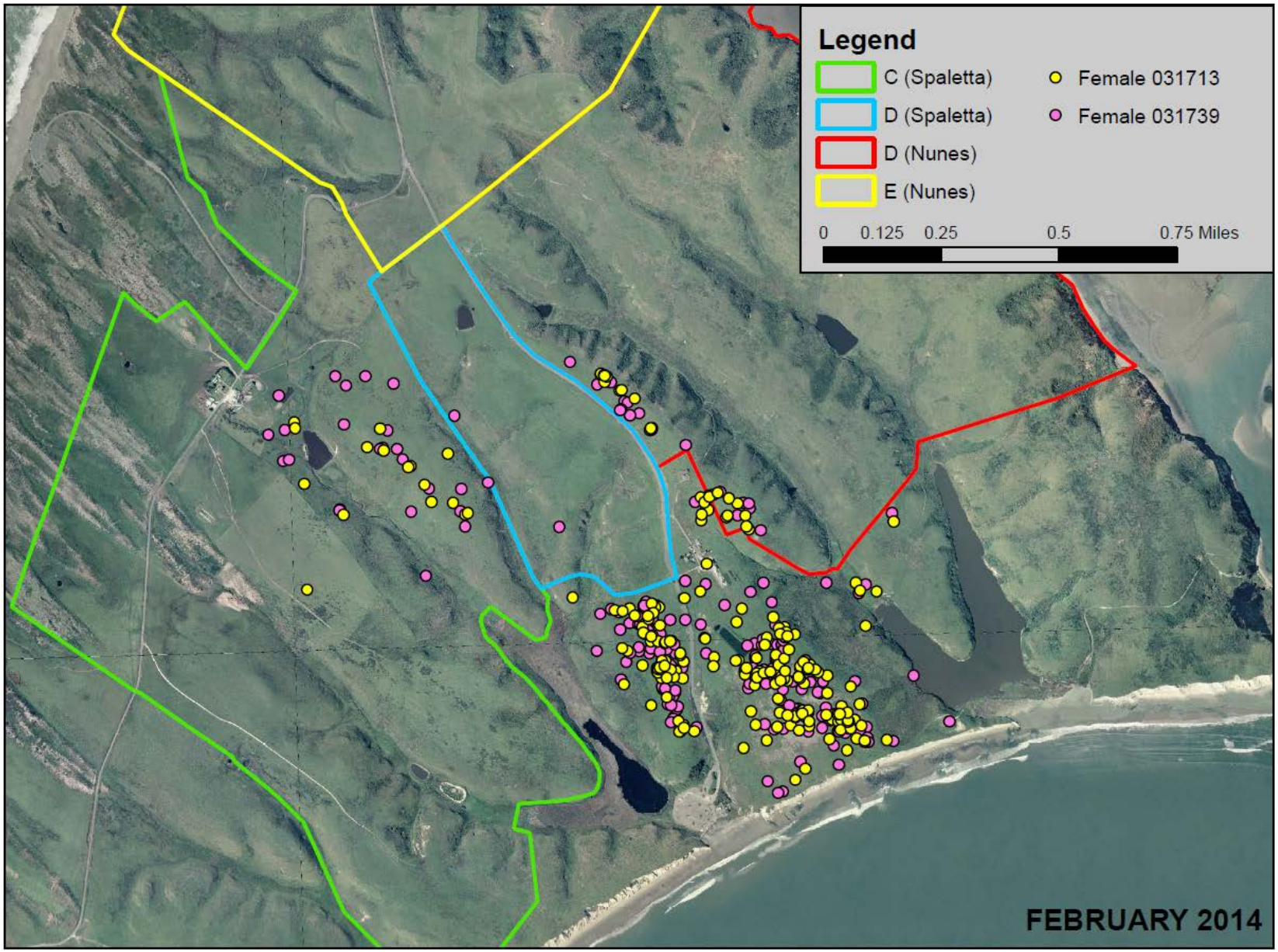

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
SEPTEMBER 2013

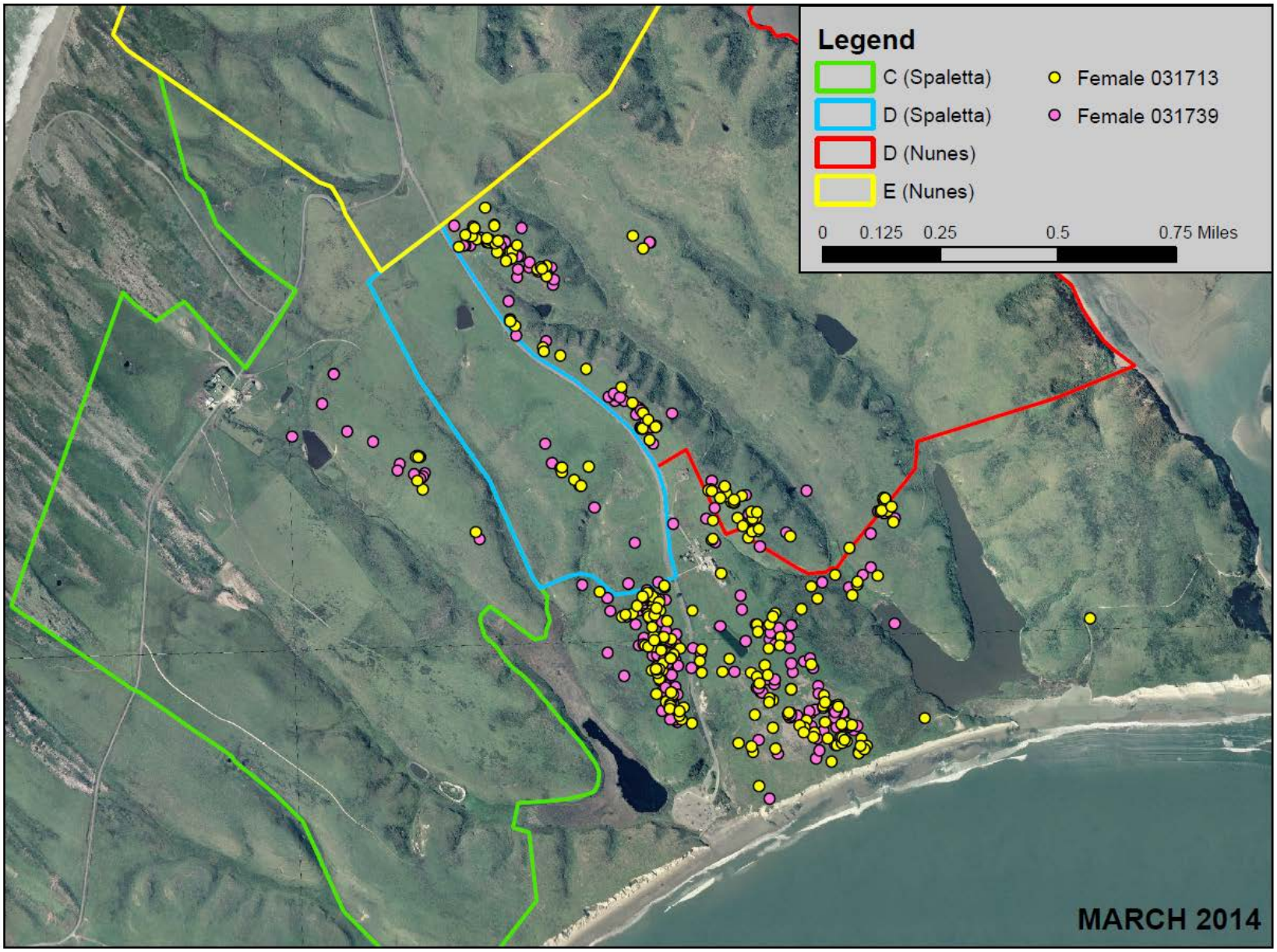

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
OCTOBER 2013

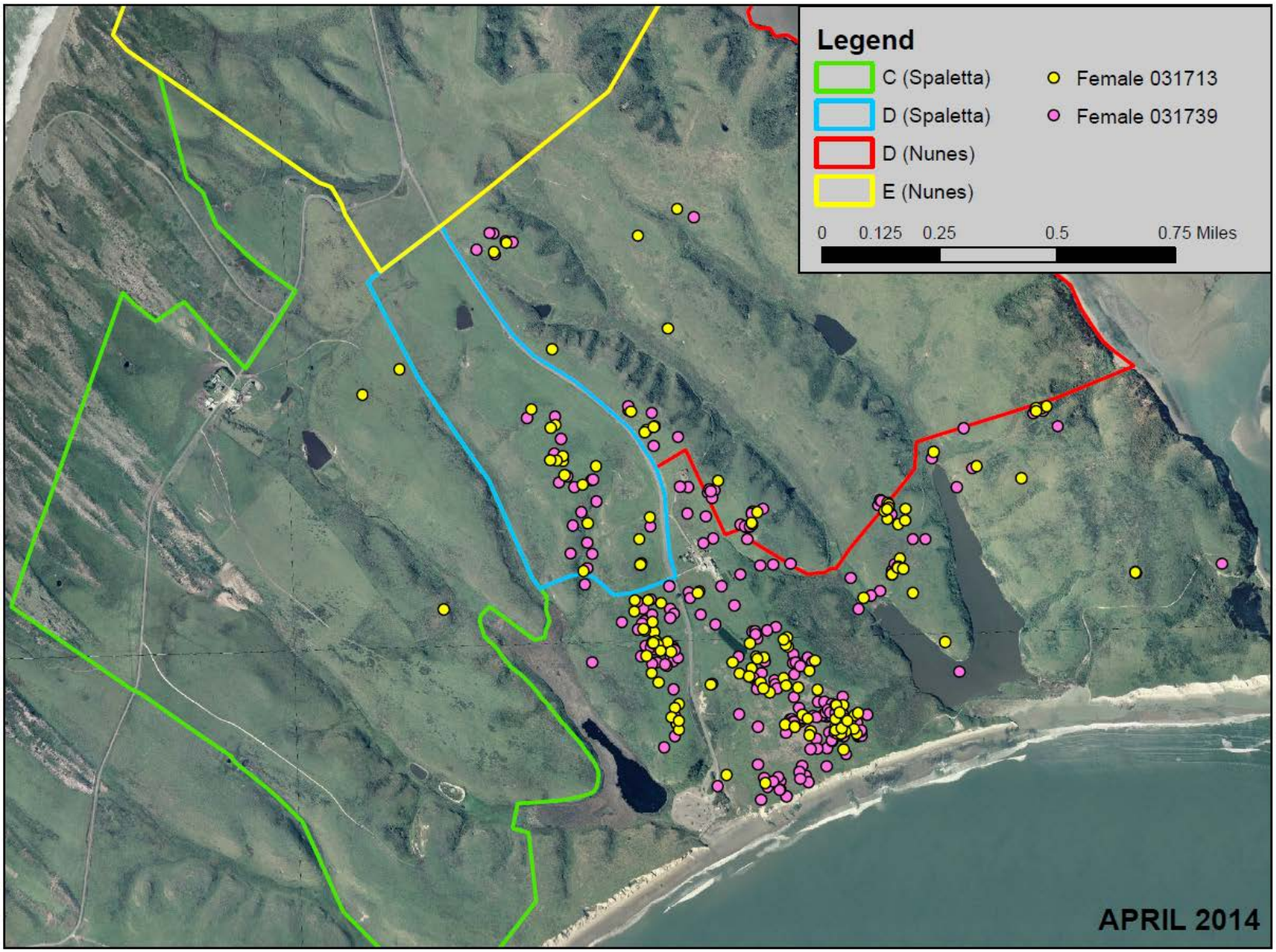

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
NOVEMBER 2013

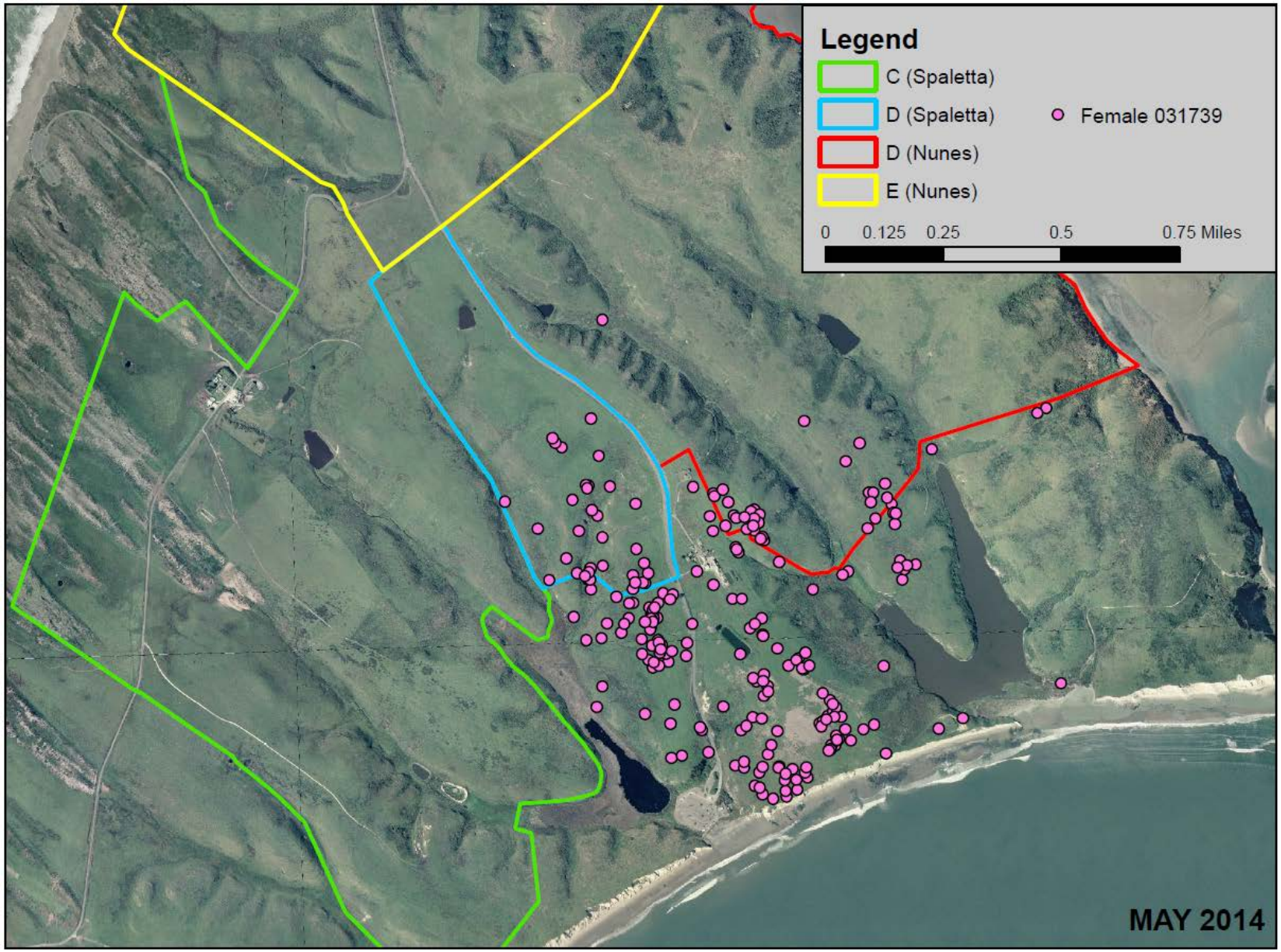

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
DECEMBER 2013

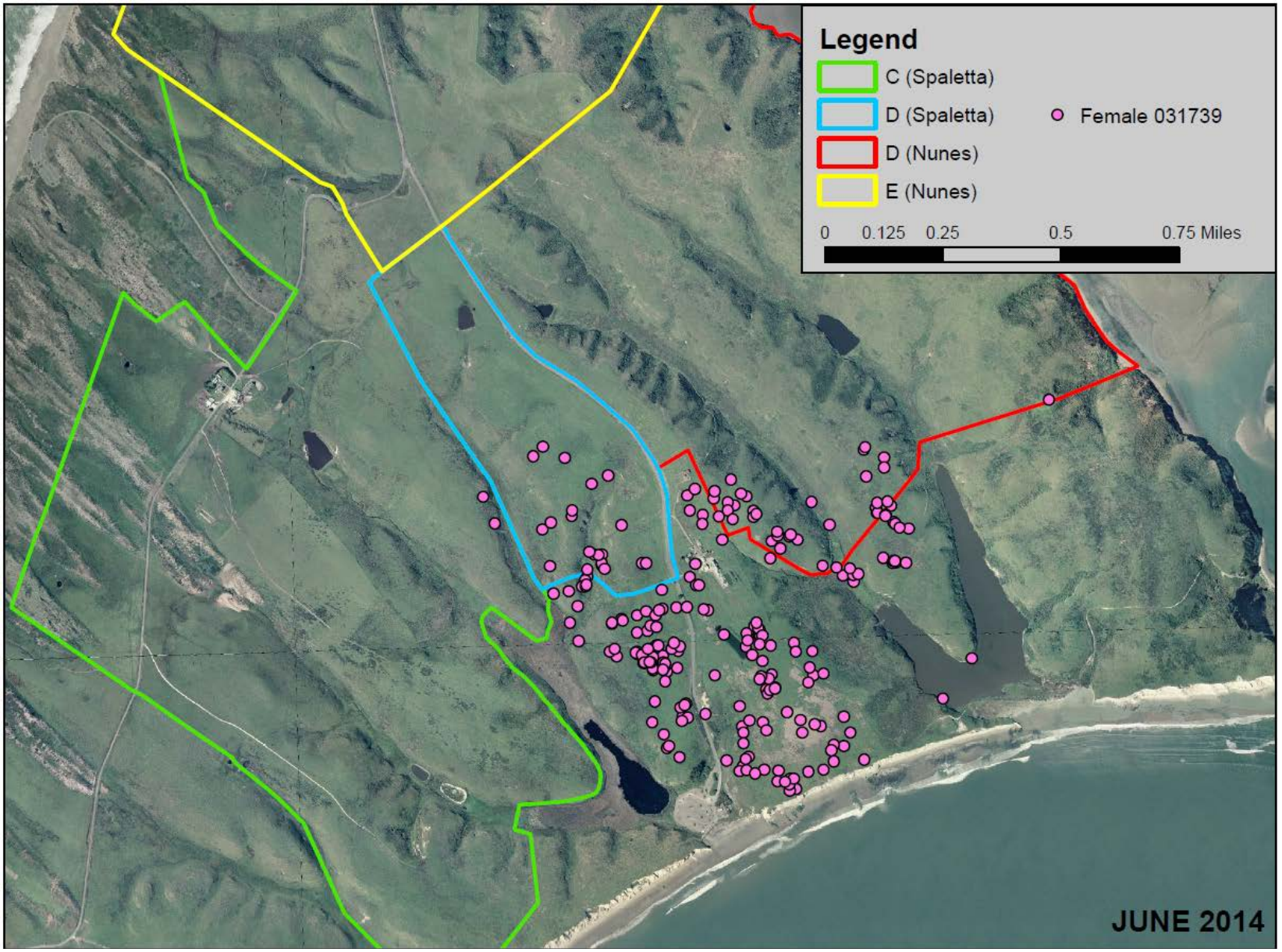

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
JANUARY 2014

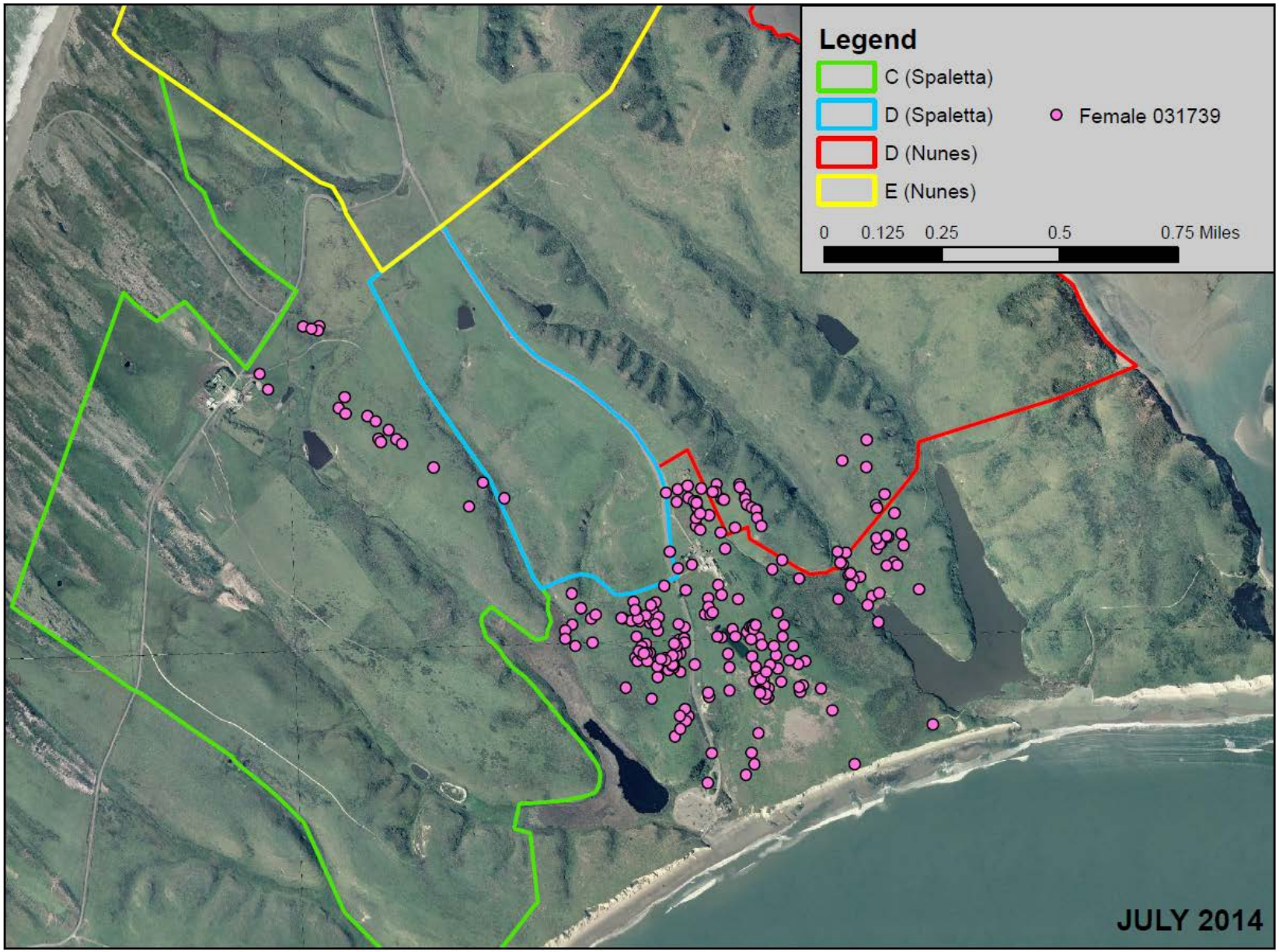

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
FEBRUARY 2014

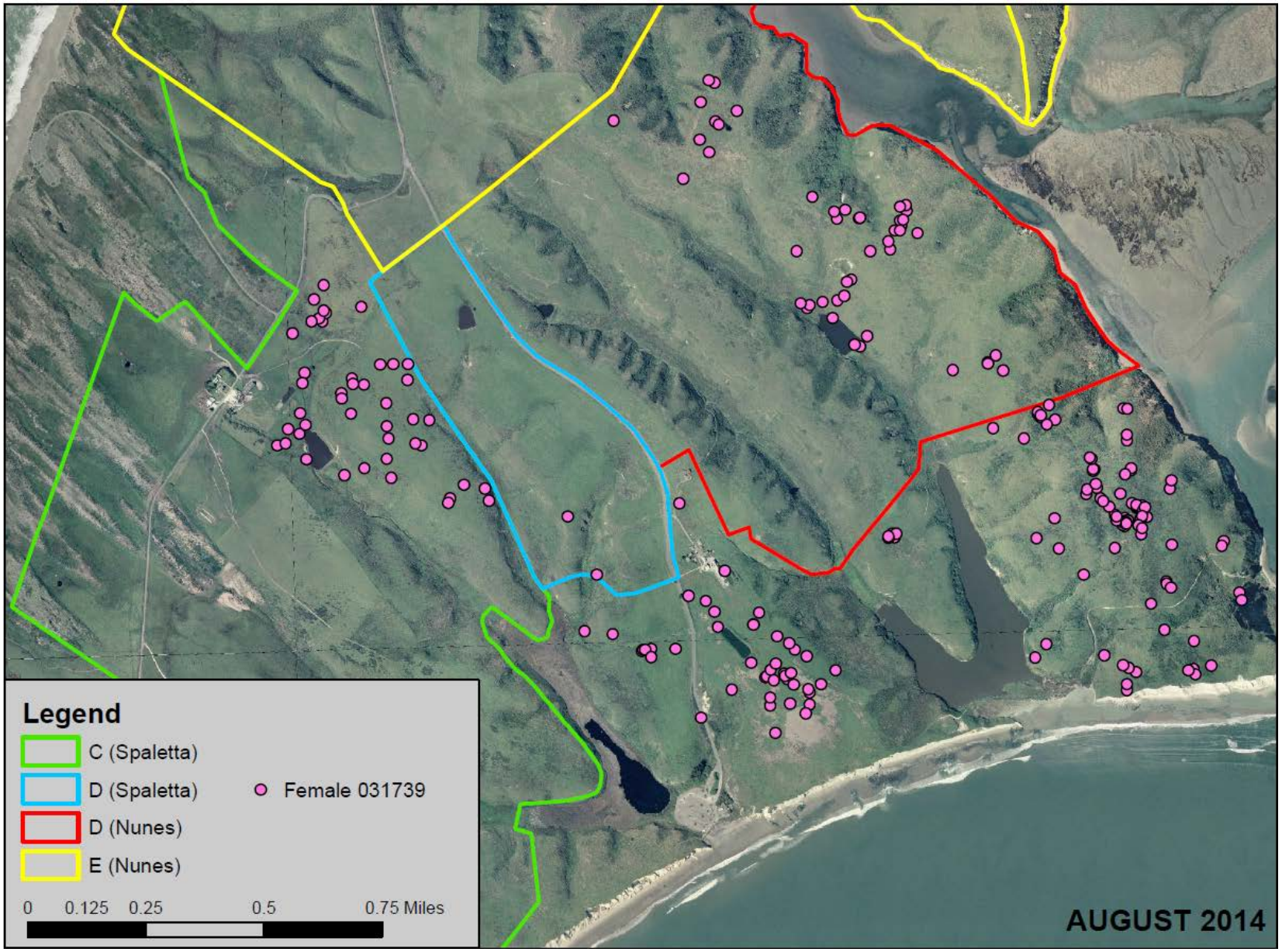

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
MARCH 2014

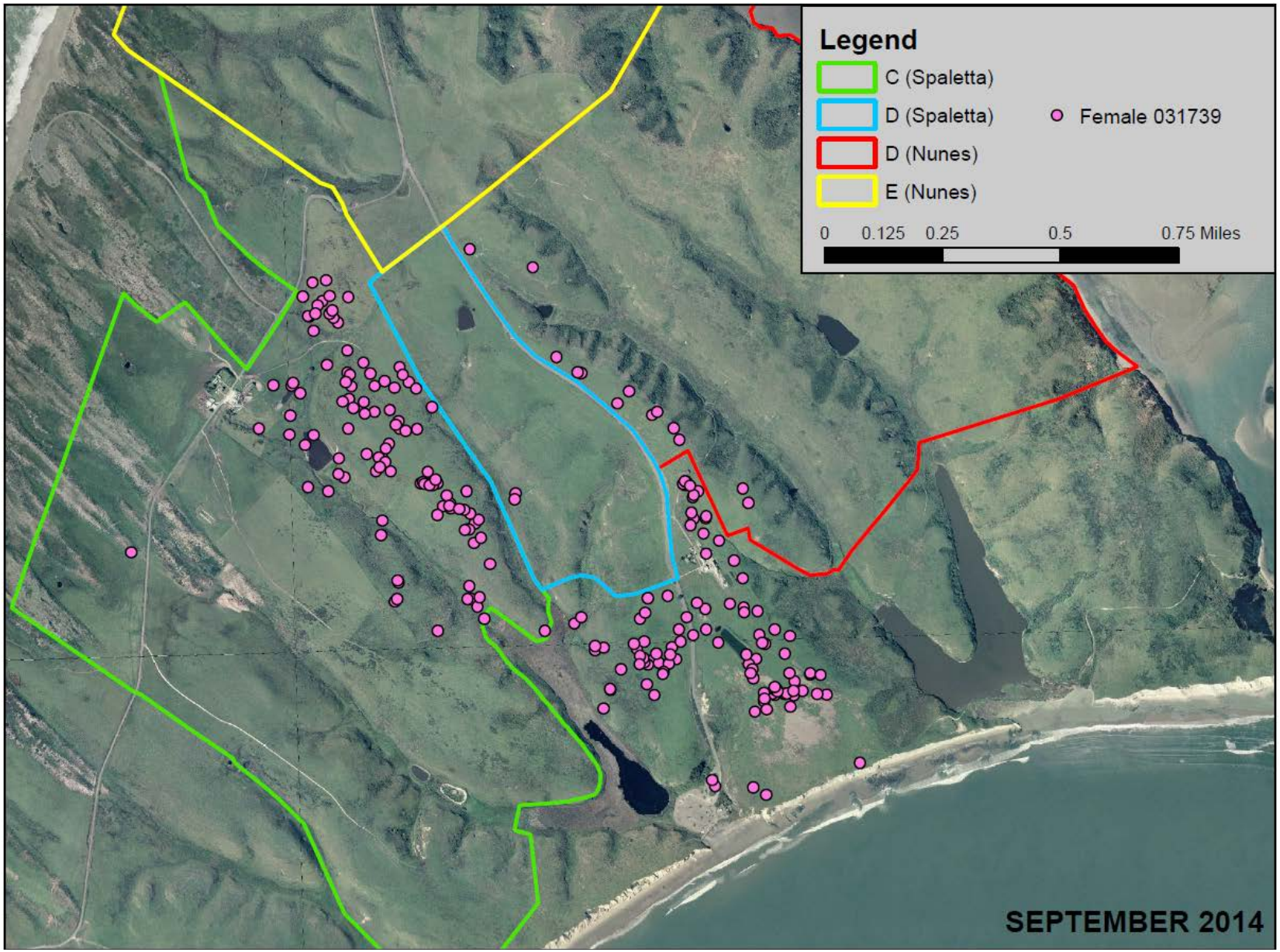

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031713
Female 031739
0 0.125 0.25 0.5 0.75 Miles
APRIL 2014

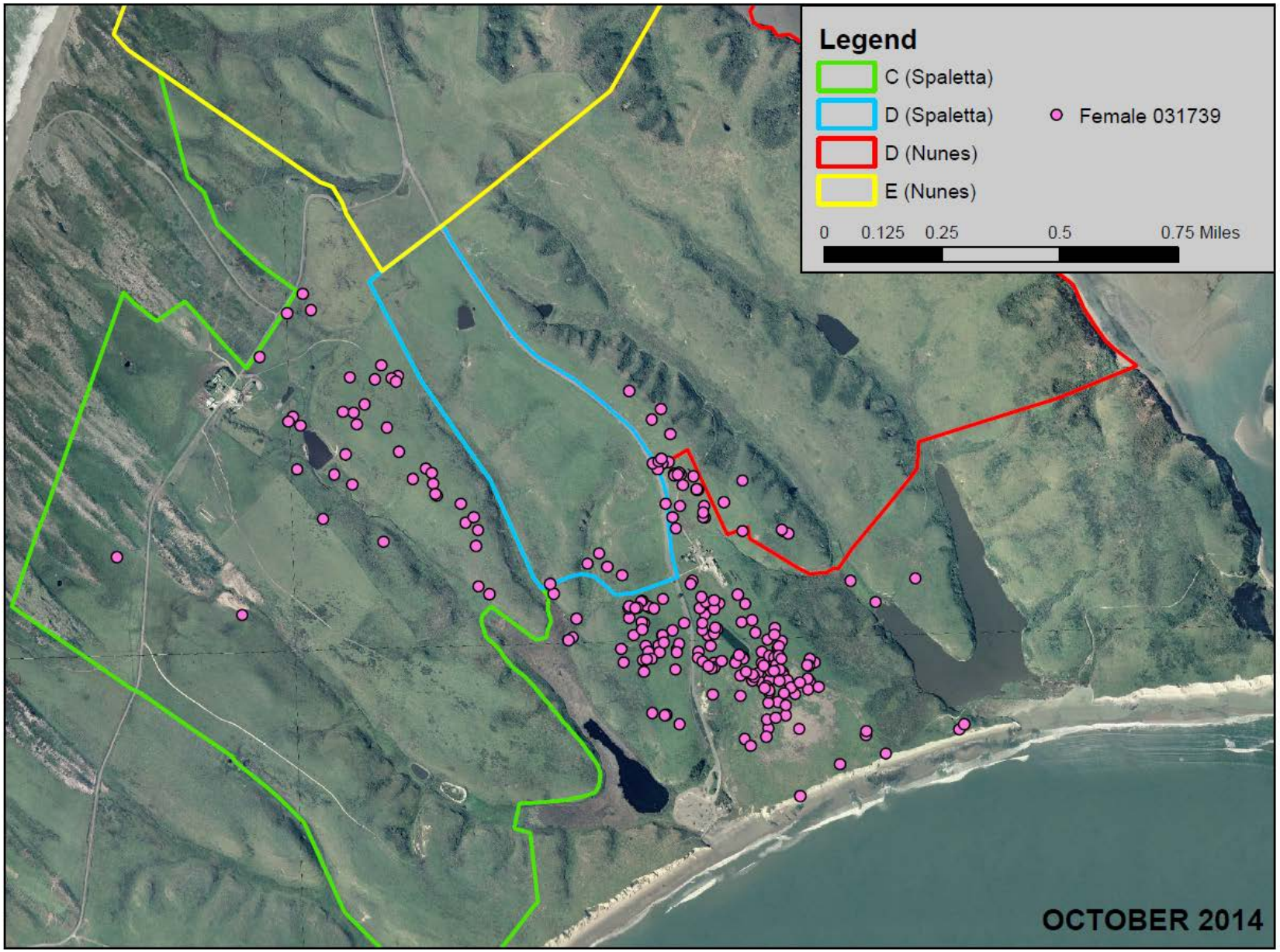

Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031739
0 0.125 0.25 0.5 0.75 Miles
MAY 2014


Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031739
0 0.125 0.25 0.5 0.75 Miles
JUNE 2014


Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031739
0 0.125 0.25 0.5 0.75 Miles
JULY 2014


Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031739
0 0.125 0.25 0.5 0.75 Miles
AUGUST 2014


Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031739
0 0.125 0.25 0.5 0.75 Miles
SEPTEMBER 2014


Legend
C (Spaletta)
D (Spaletta)
D (Nunes)
E (Nunes)
Female 031739
0 0.125 0.25 0.5 0.75 Miles
OCTOBER 2014

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 612/134722, October 2016

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov

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