

**Monitoring of the Threatened
Delta Green Ground Beetle at the
East Wilcox Ranch (Solano County, CA)
in 2010**

Submitted By:

Richard A. Arnold, Ph.D.
Entomological Consulting Services, Ltd.
104 Mountain View Court
Pleasant Hill, CA 94523
(925) 825-3784
US Fish & Wildlife Permit #797233

Submitted To:

Benjamin Wallace
Conservation Project Manager
Solano Land Trust
1001 Texas Street, Suite C
Fairfield, CA 94533-5723

Final Report Date:

January 2011

INTRODUCTION

In 2007 the Solano Land Trust implemented a four-year program to monitor special-status species associated with the vernal pool and Valley Grassland habitats that occur at its East Wilcox Ranch property south of Dixon, CA. This ranch covers 1,342 acres and is located east of Travis Air Force Base within a biotic region of Solano County that is referred to as the Jepson Prairie.

This report describes the findings of the fourth and final year (2010) of monitoring for the Delta Green Ground Beetle (*Elaphrus viridus*, Coleoptera: Carabidae), a federally-listed threatened species that is known to occur at the East Wilcox Ranch. One of the goals of the beetle (hereafter referred to by the acronym DGGB) monitoring was to develop a methodology to estimate population numbers of the beetle. Because adults seem to normally occur at low levels, their cryptic coloration, and shy behavior, many standard population estimation techniques cannot be used due to inadequate sample sizes to accurately estimate population numbers. Also, monitoring funds are limited so it is difficult to increase the sampling efforts to obtain the samples sizes necessary for accurate population estimates. For these reasons during the past four years a few different survey methods have been tested in the field to determine the most cost-effective approach to accurately estimate DGGB population numbers. Refinement of a suitable survey methodology relied on information collected throughout this initial four-year monitoring period. This report presents a method that can be used in future DGGB monitoring efforts to estimate the beetle's density and population numbers.

Arnold (2007) presented background information on the DGGB and characterized habitat conditions along the shoreline of the 18 playa pools at East Wilcox Ranch. During 2007 and 2008 I attempted to revisit each playa on multiple survey dates to estimate DGGB population numbers (Arnold 2007 and 2008). However, in doing so, the amount of time spent at each playa on a particular survey date was inadequate to detect sufficient beetles to estimate their population numbers. So in 2009 I changed my survey sampling approach. Each playa was more intensively sampled on a single survey date to increase the number of DGGB observations. The greater number of beetle observations enabled me to estimate density for each playa (Arnold 2009). As explained in the next section, during 2010 the beetle counts were associated with the habitat strata identified in 2007 (Table 1) to refine the density estimates and generate a DGGB population estimate for each playa.

STUDY METHODS

Presence-absence surveys for the DGGB were conducted at the 18 playas at East Wilcox Ranch (#1 - #18 in Figure 1) and at 6 playas at the Jepson Prairie Preserve (#49 - #54 in Figure 2). The "squat and stare" survey technique, as described in Arnold (2007), was used to sample for DGGB adults. During the squat and stare technique, the surveyor selects an approximately square meter patch of ground and observes it for a period of 3 minutes to detect any DGGB adults. A sampling frame is not placed on the ground to avoid disturbing any DGGB adults that are present and the 3 minute survey period has been found to be sufficient to allow the shy beetle

to resume its normal behavior, which improves detectability of cryptic adults. Surveys were conducted on six dates in February, March, and April 2010.

During my 2007 and 2008 surveys I attempted to visit several playas during a single sampling visit and observed rather limited numbers of DGGB adults. I changed my survey approach during 2009 and 2010 in an effort to increase the number of DGGB observations at each playa. Instead of visiting as many playas as time and weather allowed during each survey visit, my sampling efforts were focused on only a few neighboring playas during a single survey visit to increase my survey time at each playa. Although each playa was visited only once during the DGGB's adult activity period due to budget constraints, the increased survey effort on a single date enabled me to make more beetle observations than a comparable survey effort scattered among several survey dates.

The number of sampling stations for the squat and stare technique varied depending upon the area of a particular playa pool at East Wilcox Ranch. Playas measuring less than 0.5 ha in size had 20 sampling stations, playas less than 1.3 ha had 30 stations, playas less than 3.2 ha had 40 stations, and playas 3.2 ha or larger had 50 stations (Table 2). Since the six playas at the Jepson Prairie Preserve were used as controls, fewer sampling stations were utilized at these wetlands as I was merely concerned with demonstrating that DGGBs were present and active. As soon as a DGGB adult was observed, I did not conduct any additional sampling at the Jepson Prairie Preserve playas on that particular day, so my survey efforts at these six playas was not consistent throughout all survey dates .

In 2007, I identified four different habitat strata at the playas of East Wilcox Ranch, including bare or grassy ground on gently sloping or flat shoreline sectors, and bare or grassy ground on steep shoreline sectors (Table 1). During my 2010 DGGB surveys, I allocated the number of sampling stations of each stratum at a particular playa based on the percentage of the total shoreline habitat characterized by each stratum (Table 2). For example at playa #6, 30.4% of its shoreline is characterized by sloped bare ground, so 9 (30.0%) of the 30 sampling stations at this playa were located within this stratum. The locations of sampling stations within a particular habitat stratum were selected at random along the shoreline. If a playa lacked one or more habitat strata, then all sampling stations occurred only in those strata that characterized that particular wetland. For example, playa #1 lacks both steep bare and steep grassy strata, so all sampling stations were allocated between the sloped bare and sloped grassy strata.

Portions of shorelines of a few playas exhibited extensive hoof marks from grazing animals, which left depressions in the soil or otherwise altered the micro-relief at these locations. When sampling for the DGGB, I tried to avoid such areas to the extent practical because my prior experience with the DGGB indicates that it's life stages are unlikely to occur in such altered shoreline areas.

In 2009 DGGB density was calculated based on the area of a particular playa. This was refined in 2010 to calculate a DGGB density for each habitat stratum represented at a particular playa. Density was first estimated as the number of adults observed in the total number of square meter sampling stations for each stratum. If we assume that DGGB density is similar in other, unsampled portions of that same stratum, then this density can be converted to the estimated

number of beetles that might occur throughout the entirety of that stratum at that playa. The total number of DGGB adults for a playa is then derived by summing these estimates for all strata that characterize a particular playa.

RESULTS AND DISCUSSION

As summarized in Table 3, 59 DGGB adults were observed at the 18 playas on East Wilcox Ranch in the spring of 2010 between February 15 and April 8. Most of the adults were observed on flat or gently sloping ground that was bare or sparsely vegetated (i.e., grassy of Table 3). Table 4 provides information on weather conditions for every survey date and each playa pool. Locations of adult observations at East Wilcox Ranch are presented in Figure 3.

An additional, eight DGGB adults were observed at six control pools (#49 - #54 in Figure 2) at the Jepson Prairie (2 beetles in #49, 1 in #50, 1 in #51, 1 in #52, 1 in #53, and 2 in #54) during this same period. Locations of these eight observations were not mapped due to a malfunction with my GPS unit.

One of the original goals of the DGGB monitoring program at East Wilcox Ranch was to estimate the beetle's abundance. Unfortunately during 2007 and 2008, the number of beetle observations were too low to calculate accurate estimates of abundance. However, with the change in the sampling procedure in 2009, more adult DGGBs were observed, so beetle densities (i.e., number of DGGB observations/playa area or playa perimeter) were calculated for each playa. As discussed in the STUDY METHODS section, this approach was further modified during 2010 to calculate densities for each habitat stratum and estimated beetle population numbers per playa. Results for 2010 are presented in Table 5. Estimated DGGB population numbers ranged from 16.2 at playa #7 to 312.8 for playa #1.

Because the DGGB is cold-blooded, adults are often more active and detectable when ambient air temperatures are $\geq 60^{\circ}\text{F}$; however, this is not an absolute threshold as wind speed and cloud cover can also influence beetle activity. Many insects, including the DGGB, can be active at slightly lower temperatures, especially when there is full sunlight and little or no wind. All DGGB observations during 2010 occurred when the ambient air temperature was $\geq 58^{\circ}\text{F}$, so temperature should not have influenced detectability of DGGB adults. Indeed, as evidenced by the activity of other ground-dwelling insects, all survey dates had suitable weather conditions for observing DGGB adults. Nonetheless temperatures below the mid-50's F range are probably too cold for adult activity. This may explain why adults have not been observed at light traps because nocturnal temperatures during the late winter and early spring activity period of the beetle are generally colder than the mid-50's F.

Various factors besides habitat type may influence annual numbers at East Wilcox Ranch or at a particular playa pool. For example, springtails (Collembola) are the primary prey of both DGGB larvae and adults. My incidental observations suggest that springtails are ubiquitous at the East Wilcox Ranch playas. Because springtails were widespread, surveys to determine prey availability or abundance were not conducted as part of this study.

Table 6 compares presence-absence survey findings for the DGGB for years 2002, 2007, 2008, 2009, and 2010 using the playa identifiers as illustrated in Figure 1. The 2002 DGGB surveys were conducted by Larry Serpa, while the 2007 - 2010 surveys were conducted by me. Interestingly, 2010 is the only year during which DGGB adults were observed at all 18 playas of the East Wilcox Ranch.

Table 7 summarizes the numbers of DGGB adults that were observed at each playa pool by habitat stratum during my 2007-2010 monitoring surveys. Because the survey design and sampling intensity changed from 2007 to 2010, the greater numbers of beetles observed in 2009 and 2010 compared to 2007 and 2008 do not indicate an actual change in abundance of the beetle. However, the more intensive sampling efforts of 2009 and 2010 surveys do indicate that the DGGB was observed at higher frequencies in the sloped bare and sloped grassy habitats versus the steep bare and steep grassy habitats. Approximately 49% of all 143 DGGB observations during this four-year study occurred on sloped, bare portions of playa shorelines, with 34% on sloped, grassy areas, 14% on steep, bare areas, and slightly less than 3% on steep, grassy areas. These findings indicate that the DGGB is strongly associated with bare to sparsely-vegetated patches of ground along the immediate shorelines of the playa pools.

The four habitat strata identified in 2007 were based on a subjective, ocular assessment of habitat features (notably vegetative cover, including weeds, and micro-relief) based on my prior experience with the DGGB rather than any quantitative data analysis. During 2010 I did not conduct a reassessment of these habitat features to determine if my original ratings of pool potential for the beetle might have changed during the past four years. However, as I originally noted in my 2007 annual report, I remain concerned about the influx of various weeds and annual grasses at East Wilcox Ranch that are invading the playa shorelines since these are the primary areas that support the DGGB. Given the beetle's association with bare or sparsely-vegetated shoreline areas, increased vegetative cover is likely to diminish habitat values as previously bare ground is colonized by invasive plants.

RECOMMENDATIONS

To more accurately estimate seasonal population numbers for the beetle and determine population trends between years, beetle densities should be assessed at every playa on multiple survey dates throughout the entire seasonal activity period of the DGGB. Unfortunately, the cryptic behavior of the adult beetle requires a time intensive sampling procedure for successful detection of DGGBs that are present, and budget constraints limited the number of survey visits that I could perform. It took me five days to complete one round of sampling for all playas at East Wilcox Ranch. If more accurate population estimates and assessment of year-to-year trends in the DGGB population remains a goal of the monitoring program, then one permitted surveyor would need to sample all playas at two-week intervals throughout the beetle's adult activity period, which is generally from about mid-February through mid-April. A minimal total of six to eight rounds of surveys for every playa is recommended. Weekly surveys would be preferable, but are probably cost-prohibitive.

Alternatively, if five permitted surveyors were available, then all playas could be sampled on a single day and surveys could be repeated at weekly or every other week intervals throughout the entire DGGB season. This latter approach is preferred to reduce the within season variation for a single round of sampling at all of the playas, but at this time I don't believe that there are five entomologists who are permitted by the US Fish & Wildlife Service to work with the DGGB. As more information about the beetle's natural history becomes available, perhaps a less time consuming survey approach for detecting the DGGB can be devised to more efficiently make numerous observations and provide the larger sample sizes necessary to more accurately estimate the beetle's population size.

Another alternative would be to survey only a subsample of the 18 playas at East Wilcox Ranch for DGGB in a single year. For example, if only six of the 18 playas were sampled in any particular year, hopefully the annual monitoring budget would allow for multiple visits to repeatedly sample the same six playas in that year. In a particular year I suggest selecting playas located in different portions of East Wilcox Ranch so some monitoring is performed throughout all portions of the preserve annually, as well as a mixture of different sized playas. During the second and third years, different subsamples of playas should be monitored to complete one full cycle of monitoring all 18 playas over a three-year period. Although this approach surveys all playas over a three-year period, comparisons of population estimates between years are complicated because the same playas are not surveyed every year. Thus it will be difficult for the population estimates to detect year-to-year variation in abundance of the DGGB as well as trends in population numbers of the DGGB over a period of years.

One goal of the original scope of work for this project was to "formulate threshold levels to be used in determining when low abundance or negative findings should trigger extra monitoring, additional studies, or management actions." As I have discussed elsewhere in this and prior annual monitoring reports, there are several inherent difficulties in obtaining accurate population estimates of the DGGB that were probably not realized by the well-intended people who drafted this goal. While the 2010 survey methodology for monitoring the DGGB allows us to estimate the beetle's population numbers on a single date within its seasonal activity period, population numbers of most insects with a single, discrete generation per year may fluctuate substantially throughout their annual period of activity and 10-fold or more between annual generations. Seasonal population numbers may follow a normal bell curve, a gaussian curve, or some other type of curve, with periods of inactivity or lower abundance due to cool temperatures, rain, high winds, or other inclement weather conditions. Although the survey approach utilized in 2010 to estimate DGGB numbers works well given the budget and manpower limitations, more intensive sampling would be necessary to accurately estimate of seasonal DGGB population numbers.

Similarly, more intensive sampling is necessary over a period of DGGB generations (i.e., probably several decades of sampling) to determine the range of annual variation in the beetle's population numbers and an appropriate threshold level of low abundance that might trigger additional studies or corrective management actions. Many insects characterized by a single generation per year and whose population numbers have been continuously monitored for decades at a particular location have demonstrated as much as an order of magnitude difference in population levels between consecutive generations. Such extreme differences may be within

the normal range of population fluctuations between generations and need to be distinguished from changes in habitat conditions that are correlated with changes in abundance of the DGGB. Vegetation features, such as the cover and abundance of introduced weeds and annual grasses versus the cover and abundance of native forbs and grasses growing in the shoreline areas of every playa, should be monitored at East Wilcox Ranch in addition to DGGB abundance to assist in distinguishing changes in habitat conditions that influence DGGB population numbers versus weather conditions. Similarly, annual and seasonal variation in weather factors, such as rainfall, degree days, etc.; may also affect DGGB abundance. Thus, lacking substantial additional funds and more surveyors to conduct more intensive and repeated sampling of the beetle and these habitat features, it will be difficult to achieve this goal.

ACKNOWLEDGEMENTS

I thank Ben Wallace, Conservation Project Manager at the Solano Land Trust, for sponsoring this study. I also thank Solano County for allowing me to use its color aerial photography. This work was conducted under US Fish & Wildlife Service permit #797233 issued to Richard Arnold.

REFERENCES CITED

- Arnold, R.A. 2007. Monitoring of the Threatened Delta Green Ground Beetle at the East Wilcox Ranch (Solano County, CA) in 2007. Report prepared for the Solano Land Trust.
- Arnold, R.A. 2008. Monitoring of the Threatened Delta Green Ground Beetle at the East Wilcox Ranch (Solano County, CA) in 2008. Report prepared for the Solano Land Trust.
- Arnold, R.A. 2009. Monitoring of the Threatened Delta Green Ground Beetle at the East Wilcox Ranch (Solano County, CA) in 2009. Report prepared for the Solano Land Trust.

TABLES AND FIGURES

Table 1. Playa Pool Habitat Characteristics at East Wilcox Ranch

Playa Pool ID #	Area of Playa (ha)	Perimeter (m)	Habitat Strata (Percentage of Playa Perimeter)			
			Flat or Gently Sloped and		Steep and	
			Bare	Grassy	Bare	Grassy
1	10.08	1,742	32.5%	67.5%	0.0%	0.0%
2	3.18	858	0.0%	100.0%	0.0%	0.0%
3	0.53	268	0.0%	0.0%	0.0%	100.0%
4	2.46	824	23.2%	32.4%	28.9%	15.5%
5	0.62	423	49.5%	10.1%	40.5%	0.0%
6	1.22	1,020	30.4%	41.3%	19.4%	8.9%
7	0.30	324	0.0%	100.0%	0.0%	0.0%
8	0.38	248	52.0%	26.1%	0.0%	21.9%
9	2.40	680	9.2%	0.0%	66.1%	24.6%
10	1.29	572	0.0%	80.2%	4.7%	15.1%
11	2.46	714	34.9%	39.7%	0.0%	25.4%
12	1.20	440	26.0%	0.0%	74.0%	0.0%
13	5.39	1,190	7.8%	28.2%	64.0%	0.0%
14	6.10	1,137	4.8%	8.6%	71.6%	15.1%

Playa	Area of Playa	Perimeter	Habitat Strata (Percentage of Playa Perimeter)			
15	1.18	752	11.4%	88.6%	0.0%	0.0%
16	1.06	390	24.3%	51.1%	24.6%	0.0%
17	0.75	421	65.8%	34.2%	0.0%	0.0%
18	11.84	1,885	21.7%	78.3%	0.0%	0.0%

Table 2. Playa Pool Habitat Characteristics at East Wilcox Ranch

Playa Pool ID #	Number of Sampling Stations	Number of Sampling Stations by Habitat Strata			
		Flat or Gently Sloped and		Steep and	
		Bare	Grassy	Bare	Grassy
1	50	16	34	0	0
2	40	0	40	0	0
3	30	0	0	0	30
4	40	9	13	12	6
5	30	15	3	12	0
6	30	9	12	6	3
7	20	0	20	0	0
8	20	10	5	0	5
9	40	4	0	26	10
10	30	0	24	2	4
11	40	14	16	0	10
12	30	8	0	22	0
13	50	4	14	32	0
14	50	2	4	36	8

Playa	Number of	Number of Sampling Stations by Habitat Strata			
15	30	3	27	0	0
16	30	7	15	8	0
17	30	20	10	0	0
18	50	11	39	0	0

Table 3. Numbers of DGGB Adults Observed in 2010 at East Wilcox Ranch

Playa Pool ID #	Number of DGGB Adults Observed by Habitat Strata			
	Flat or Gently Sloped and		Steep and	
	Bare	Grassy	Bare	Grassy
1	2	7	0	0
2	0	4	0	0
3	0	0	0	1
4	1	1	0	0
5	2	0	1	0
6	1	0	0	0
7	0	1	0	0
8	1	1	0	0
9	1	0	1	1
10	0	2	0	0
11	2	2	0	1
12	1	0	1	0
13	1	2	1	0
14	0	1	2	1
15	1	4	0	0

Playa	Number of DGGB Adults Observed by Habitat Strata			
16	1	1	0	0
17	1	1	0	0
18	2	5	0	0

Table 4. Weather Conditions at East Wilcox Ranch and Jepson Prairie in 2010

Playa Pool ID #	Survey Date	Air Temp °F	Wind Speed mph
1	Feb. 15	58-67	0-9
2	Feb. 15	58-67	0-9
3	Feb. 15	58-67	0-9
4	Feb. 16	58-67	0-6
5	Feb. 16	59-67	0-6
6	Feb. 16	58-67	0-6
7	Feb. 16	58-64	0-6
8	Feb. 16	58-64	0-6
9	March 14	58-65	0-12
10	March 14	58-65	0-12
11	March 14	58-65	0-12
12	March 16	58-71	0-10
13	March 16	58-71	0-10
14	March 16	58-71	0-10
15	March 21	58-70	0-13
16	March 21	58-70	0-13
17	March 21	58-70	0-13
18	March 21	58-70	0-13
49	April 8	58-68	0-14
50	April 8	58-68	0-14
51	April 8	58-68	0-14
52	April 8	58-68	0-14
53	April 8	58-68	0-14
54	April 8	58-68	0-14

Table 5. Estimated Densities and Population Numbers of DGGB Adults at East Wilcox Ranch in 2010

Playa Pool ID #	Densities of DGGB Adults by Habitat Strata				DGGB Numbers by Habitat Stratum				Total DGGB Numbers by Playa
	Flat or Gently Sloped and		Steep and		Flat or Gently Sloped and		Steep and		
	Bare	Grassy	Bare	Grassy	Bare	Grassy	Bare	Grassy	
1	0.125	0.206			70.8	241.9	0.0	0.0	312.8
2		0.100			0.0	85.8	0.0	0.0	85.8
3				0.033	0.0	0.0	0.0	8.9	8.9
4	0.111	0.077	0.000	0.000	21.3	20.6	0.0	0.0	41.8
5	0.133	0.000	0.083		27.9	0.0	14.3	0.0	42.1
6	0.111	0.000	0.000	0.000	34.4	0.0	0.0	0.0	34.4
7		0.050			0.0	16.2	0.0	0.0	16.2
8	0.100	0.200		0.000	12.9	12.9	0.0	0.0	25.8
9	0.250		0.038	0.100	15.7	0.0	17.3	16.7	49.7
10		0.083	0.000	0.000	0.0	38.2	0.0	0.0	38.2
11	0.143	0.125		0.100	35.6	35.4	0.0	18.1	89.2
12	0.125		0.045		14.3	0.0	14.8	0.0	29.1
13	0.250	0.143	0.031		23.2	47.9	23.8	0.0	95.0
14	0.000	0.250	0.056	0.125	0.0	24.4	45.2	21.5	91.0
15	0.333	0.148			28.5	98.7	0.0	0.0	127.2

Playa	Densities of DGGB Adults by Habitat Strata				DGGB Numbers by Habitat Stratum				Total
16	0.143	0.067	0.000		13.5	13.3	0.0	0.0	26.8
17	0.050	0.100			13.8	14.4	0.0	0.0	28.3
18	0.182	0.128			74.2	189.3	0.0	0.0	263.6

Table 6. Summary of DGGB Observations at East Wilcox Ranch (2002, and 2007 – 2010)

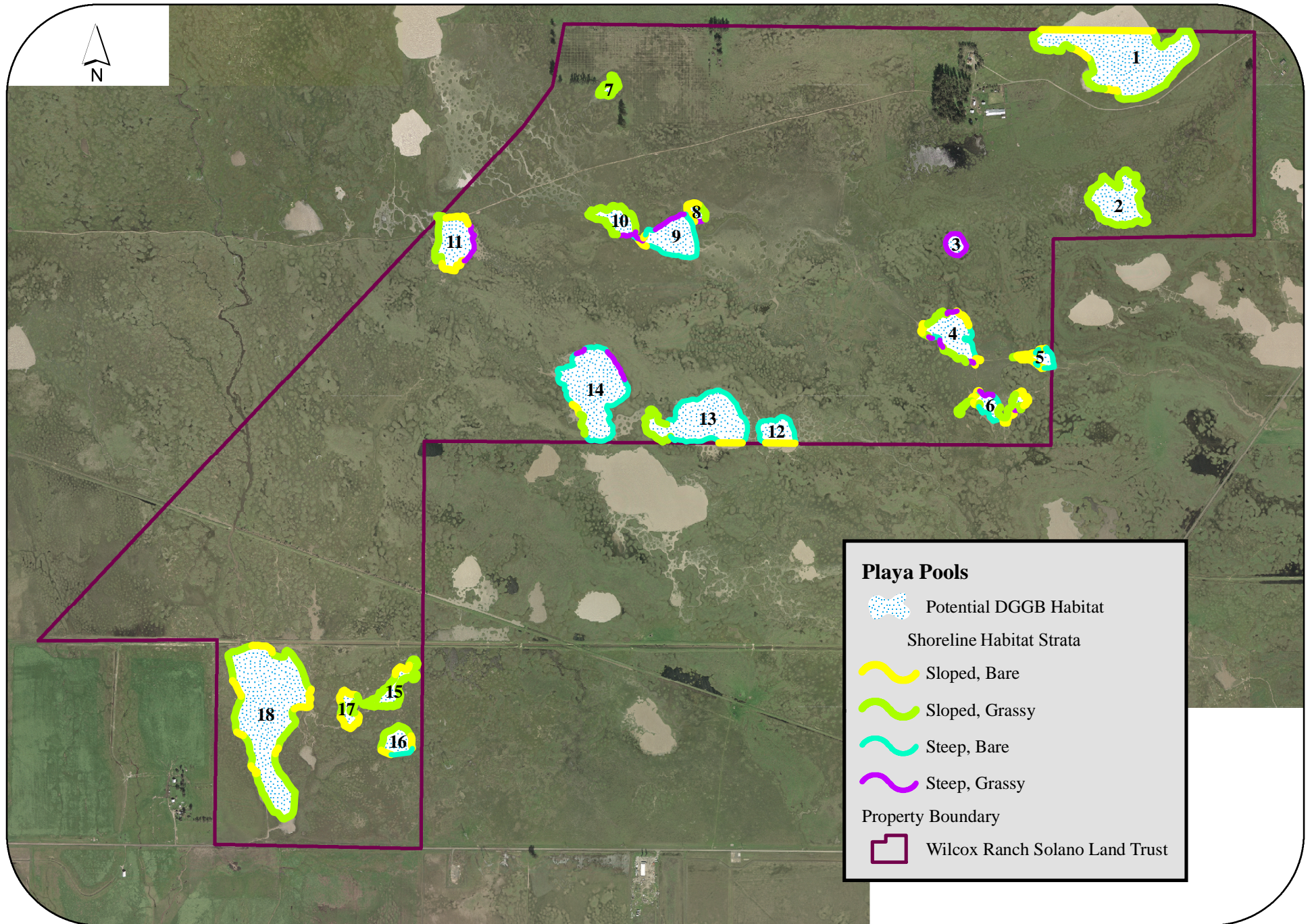
Playa Pool Id	Summary of DGGB Observations (+ or -) at 18 Wilcox Ranch Playas				
	Serpa 2002	Arnold 2007	Arnold 2008	2009	2010
1	-	+	+	+	+
2	+	-	-	+	+
3	-	-	-	-	+
4	-	+	+	+	+
5	-	+	+	-	+
6	-	+	-	+	+
7	-	-	-	-	+
8	-	+	+	+	+
9	-	+	-	+	+
10	-	-	-	+	+
11	+	+	+	+	+
12	+	-	-	+	+
13	+	+	+	+	+
14	+	+	+	+	+
15	-	-	-	+	+
16	+	-	-	+	+
17	-	-	-	+	+
18	+	-	+	+	+

Note: + = present and - = absent.

Table 7. Summary of DGGB observations by habitat strata.

Playa Pool Id	Potential for DGGB	Number of DGGB Observations by habitat stratum				
		Sloped, bare	Sloped, grassy	Steep, bare	Steep, grassy	Totals by Playa
1	Low	13	14			27
2	Low		8			8
3	Low				1	1
4	Medium	4	2	1		7
5	High	4		1		5
6	Medium	4				4
7	Low		1			1
8	Low	3	2			5
9	Medium	3		5		8
10	Medium		5			5
11	Medium	7	3		1	11
12	High	3		2		5
13	Medium	3	2	5		10
14	High	3	2	6	2	13
15	Medium	2	6			8
16	Medium	3	1			4
17	Medium	4				4
18	Low	14	3			17
Totals by Stratum		70	49	20	4	143

Figure 1: Delta Green Ground Beetle Study at Wilcox Ranch for Solano Land Trust
Playa Pools and Habitat Strata



0 1,250 2,500 5,000 Feet

September 17, 2007
Entomological Consulting Services, Ltd.

Figure 2. - DGGB Jepson Study Area: Pools 50 - 54

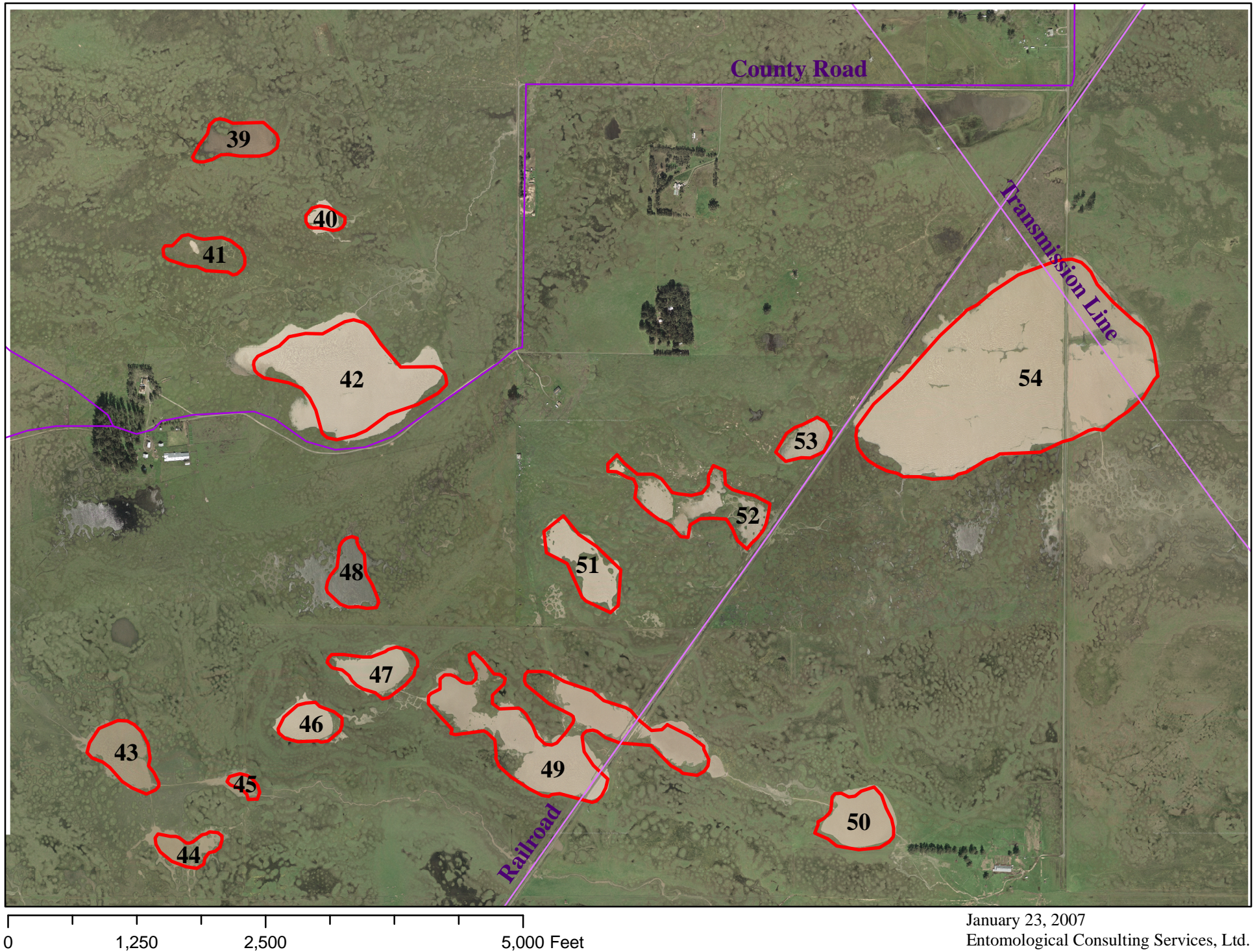
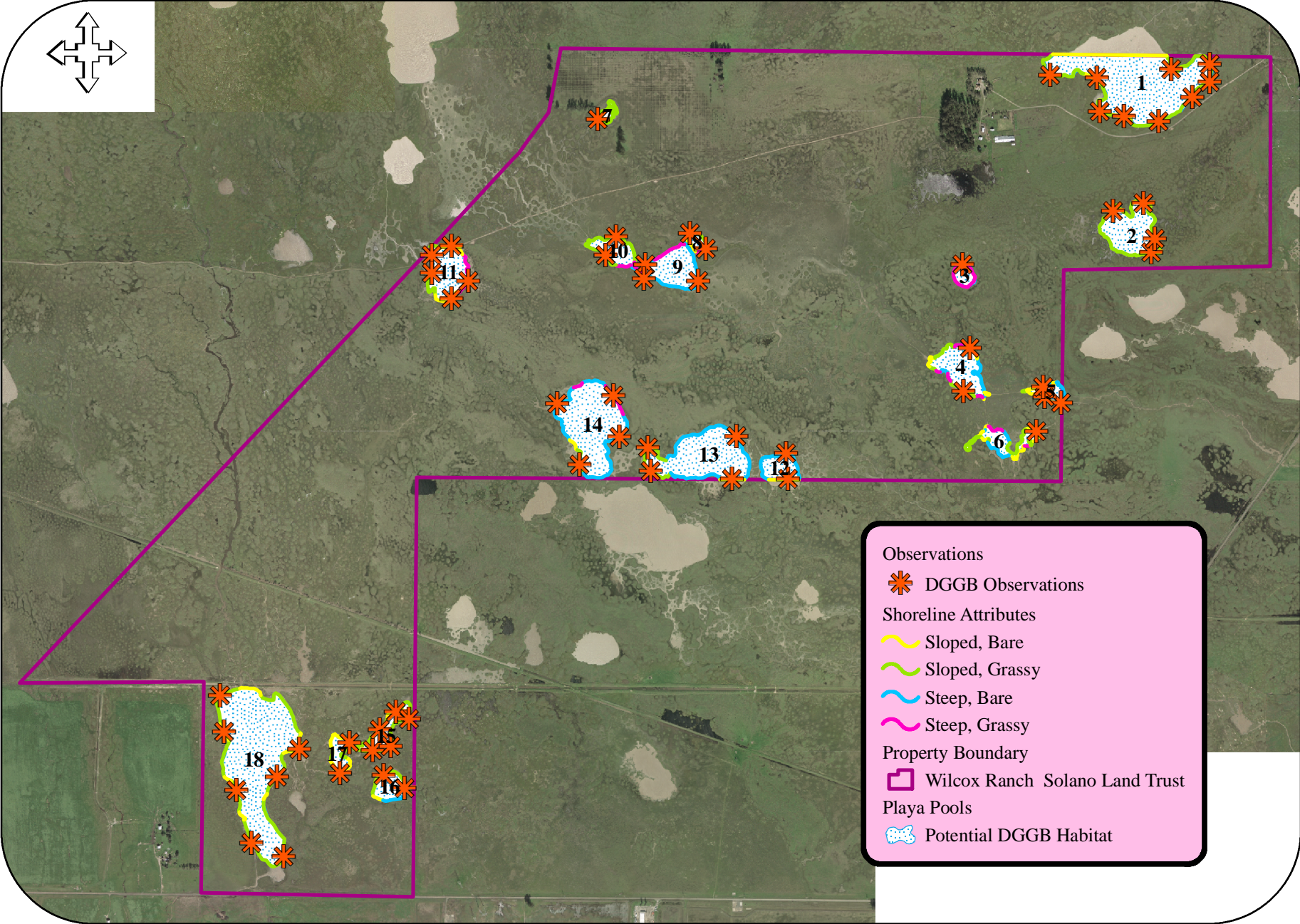


Figure 3: Delta Green Ground Beetle Observations at East Wilcox Ranch in 2010



0 1,250 2,500 5,000 Feet