2009 MONITORING OF *PAPAIPEMA ERYNGII*, THE RATTLESNAKE BORER MOTH, AT PRAIRIE RIDGE STATE NATURAL AREA AND TWELVE-MILE PRAIRIE

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And

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BY

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Figure #1 Adult *Papaipema eryngii* Moth Photograph by: Vernon LaGesse

INTRODUCTION

During insect surveys conducted in the Upper Little Wabash River Watershed, LaGesse & Associates Inc. documented several new populations of the rattlesnake master borer moth,

*Papaipema eryngii (*LaGesse & Wiker 2008*)*. This discovery was made late in the 2008 season and a thorough inventory of the area occupied by the species was not possible. Our objectives for 2009 were mapping and estimating population size of all locations where rattlesnake master, *Eryngium yuccifolium*, plants and caterpillars of *Papaipema eryngii* were located, establishing monitoring protocols for Prairie Ridge State Natural Area (PRSNA), and making recommendations for the conservation of *Papaipema eryngii* within grassland preserves of the Southern Till Plain Natural Division of Illinois.

LIFE HISTORY OF *ERYNGIUM YUCCIFOLIUM* RATTLESNAKE MASTER

Rattlesnake Master, *Eryngium yuccifolium* (Michx.), is a short lived perennial plant (5-8 years) that is characteristic of prairies in Illinois. It has leaf blades that have spinulose margins, and flower stalks form an umbel pattern (Mohlenbrock 1986). It occurs in prairies with a wide range of moisture gradients and different soil types (Mohlenbrock & Ladd 1978) in Illinois. At PRSNA, rattlesnake master occurs in remnant and restored prairies, ranging from wet, wet-mesic, mesic to dry-mesic conditions.

This plant reproduces by seed production and root spading. In Illinois, the plant grows 3-4 feet tall and can fall over to disperse seeds 3-4 feet. In Oklahoma, it has been observed by the senior author that bison are a natural dispersal mechanism for this species. Rattlesnake master seeds have evolved small hooked edges that become attached to bison fur (Figure 1). The seeds may become dispersed when the bison rolls on the ground in dusting activities or sheds its fur (V. LaGesse, pers. obs.). Immature plants grow in a rosette that form colonies and usually takes 2-3 years to mature. At this time, rattlesnake master bolts and begins flowering, with older plants typically producing more flowers. Plants emerge from winter dormancy in late April and begin to stalk in late June and early July. Flowers bloom during late July through early August and seed set starts in late September through October.

Figure 2. Close-up of Rattlesnake Master Seeds. Photo by: Tim Cashatt Illinois State Museum.

There are several insect species that host on rattlesnake master plants. *Papaipema eryngii*, the rattlesnake master borer moth and *Coeotechnites eryngiella*, a microlepidoptera moth, have significant negative impacts on this host plant species. *Coeotechnites eryngiella* can bore approximately 70% of rattlesnake master seeds (Danderson 2006, Molano-Flores 2001) and both of these species have been documented to occur at 12-mile prairie and the PRSNA prairie sites.

LIFE HISTORY OF *PAPAIPEMA ERYNGII*, RATTLESNAKE MASTER BORER MOTH

The Rattlesnake Master Borer Moth, *Papaipema eryngii* (Bird.), uses *Eryngium yuccifolium*, rattlesnake master, as a host plant exclusively. The female *Papaipema eryngii* lays eggs in October (Wiker 2008, Schweitzer 2001). These eggs overwinter on or near the host plant and hatch sometime in May in Illinois. These early instars feed on leaves of the host and after their second instars, the caterpillars begin boring downward into the stem/root of the host plants. At this time, *Papaipema eryngii* have been observed cannibalizing competing caterpillars. If a caterpillar encounters another caterpillar in the bored stem, the second caterpillar will survive by climbing over the first caterpillar, removing its head, and ejecting the body out the bore hole. This behavior can occur until the caterpillar has developed its chamber where it has room to turn around. In these cases, the intruding caterpillar is pushed back out of the plant.

In most cases this boring activity is fatal to the rattlesnake master plant. *Papaipema eryngii* caterpillars usually use one mature plant to sustain them through to adulthood, but they may use 6-8 immature plants to complete to adulthood (V. LaGesse, pers. obs.). By July the caterpillars have created a chamber in the root of the host plants, where they senesce until September, and then pupate inside the chambered plant or in the nearby soil (Bird 1917). Emergence takes between 18-21 days for adults to emerge after pupating (U.S.D.A. Forest Service 2003) and occurs in the middle to late October. After emerging, females appear to emit pheromones to attract male *Papaipema eryngii*. This species is not atracted to collecting lights and might not disperse outside of its host plant population unless its host plant populations are becoming unstable. In Oklahoma, The senior author has observed 2 and 4 mile dispersals for *Papaipema eryngii* after host plant populations have been significantly reduced.

Figure #3 The larval stages of *Papaipema eryngii*. Photo by: Vernon LaGesse

ILLINOIS CURRENT STATUS AND STATEWIDE DISTRIBUTION

Papaipema eryngii, Rattlesnake Master Borer Moth, Illinois State Endangered, (IDNR Database 2008)
Chicago Wilderness Insect Rarity Index - 5 (Panzer et. al., 2006)
The Nature Conservancy/NatureServe Rating of Globally Threatened -G1

Historically populations of *Papaipema eryngii* were documented in seven states (IL, AR, OK, KY, IN, IA and SC), but currently it is only found in four states (IL, AR, OK and KY). In Illinois, it was known from three sites in two counties (Will & Grundy) and one site and county from a reintroduction (Cook) (Herkert 1992, U.S.D.A. Forest Service 2003, IDNR 2008, Schweitzer 2007). Wiker and LaGesse (2008) documented 4 major subpopulations in Marion and Effingham counties in the Southern Till-Plain Natural Division of Illinois.

STUDY SITE

Prairie Ridge State Natural Area (PRSNA) is an Illinois Department of Natural Resources (IDNR) project to preserve the Greater Prairie-chicken, (*Tymphannchus cupido pinnatus)*, and other grassland species of conservation concern in Illinois. IDNR and partner organizations have acquired over 4,110 acres at two project areas in Jasper and Marion counties. The 28 separate tracts forming this network have a variety of different grassland types for grassland wildlife. In Marion County where Papaipema eryngii populations have been documented include, PRSNA comprises the Survey Pasture Tract, a 160-acre mixed grassland, the Soldner Tract, which is a 40-acre prairie restoration. Twenty-two miles of Twelve-Mile Prairie, parts are owned by Illinois Department of Transportation as a scenic easement, passes through parts of Effingham, Clay, Fayette and Marion Counties in Illinois. The Survey Pasture Tract uses cattle grazing and prescribed fire as a management tool to stimulate structural opening in the prairie grass. All of these properties are managed by IDNR. The Soldner Tract and 12-Mile Prairie are managed using rotational prescribed fire to maintain prairie communities.

METHODS

The project was to census and map rattlesnake master plants at Twelve-Mile Prairie, the Soldner Tract, and the Survey Pasture Tract. Wire flags were used to mark plants and to determine the perimeter of each sub-population of rattlesnake master plants. All plants showing signs of being bored by *Papaipema eryngii* were flagged with a different color wire flag. All caterpillar locations were then mapped using a Trimble Pro –RX with submeter accuracy and then exported into a GIS shape file. Isolated or small groups of plants were likely missed during this study, so our estimates of population size are conservative. All sub-populations were counted with the exception of sub-population 1.1 (Survey Tract Prairie) which was too large to count every plant. Two 110-meter transects were established through the high-density core of sub-population 1.1, and ten 5x5 meter plots were randomly sampled for rattlesnake master plants and evidence of *Papaipema eryngii* caterpillars.

RESULTS

A total of 67 discrete subpopulations of rattlesnake master were surveyed among Twelve-Mile Prairie, Survey Pasture Tract, and Soldner Tract. Thirty-three rattlesnake master sub-populations

hosted *Papaipema eryngii* caterpillars. Overall, we estimate this metapopulation covers some 4.5 ha, and includes more than 48,000 rattlesnake master plants and nearly 4,600 *Papaipema eryngii* caterpillars.

-PRSNA SURVEY PASTURE TRACT

Fourteen different subpopulations of rattlesnake master plants were documented on this 160-acre tract (Table # 1, Map #1), occupying a total of 26,550 meters^2. The smallest subpopulation sampled had 5 plants (6.5 meters^2) and the largest had more than 30,000 plants (13,767 meters^2). Nine subpopulations of rattlesnake master had *Papaipema eryngii* caterpillars present. The smallest subpopulation had 3 caterpillars; the core area of the largest population hosted a mean estimate of 3,413 caterpillars (95% confidence interval: 2,247 to 4,580). The other eight occupied areas had a total of 549 *Papaipema eryngii* caterpillars

Observations on June 13th, 2009, showed 85% of all caterpillars were near or at the ground surface boring downward towards developing their chamber in the root. At this time, 15% of *Papaipema eryngii* caterpillars would have been vulnerable to cattle grazing or trampling.

-PRSNA SOLDNER TRACT

Eighteen different subpopulations of rattlesnake master were documented from this 40-acre site (See Table # 2), occupying a total of 13,571 square meters. The smallest subpopulation sampled had 13 plants (20 Sq. meters) and the largest had 745 plants (3428 sq. meters). Fourteen subpopulations of rattlesnake master had *Papaipema eryngii* caterpillars present (range: 1 to 175 caterpillars). A total of 482 *Papaipema eryngii* caterpillars were documented from this site (See Map # 6).

-TWELVE-MILE PRAIRIE

Twenty-two miles of this railroad right-of-way prairie were surveyed, documenting 35 subpopulations of rattlesnake master plants (Maps #3, #4 and #5). These plants occupied 4,478 meters^2 with the smallest population having 28 plants and the largest population sampled had 449 plants (mean = 128 plants; Table #3). *Papaipema eryngii* caterpillars were documented in 9 of these sites (range 1 to 40, total of 124 caterpillars).

Four subpopulations in Marion County were documented with *Papaipema eryngii* caterpillars. An additional population was located in Marion County (Pop. 2.12), but later exterminated by small prairie ants. A total of 73 *Papaipema eryngii* caterpillars were documented in Marion County (Map #3 and #4). Five subpopulations, totaling 53 *Papaipema eryngii* caterpillars, were documented in Effingham County (Map #5). New dispersal populations were observed in the month of May 2009 in Clay and Fayette counties, but by the end of June they had been flooded, killing all caterpillars.

During a site visit in August 2009, we observed evidence of herbicide treatment at spots throughout the 22-mile length of Twelve-Mile Prairie. Some rattlesnake master plants with *Papaipema eryngii* and other conservative plants were affected. It may take several years to document the extent of damage to *Papaipema eryngii* and the natural community at Twelve-Mile Prairie.

DISCUSSION

The populations of *Papaipema eryngii* at PRSNA are the largest known populations of this species in the world. The northern populations in Illinois of *Papaipema eryngii* have been declining recently (R. Panzer, pers. comm.). Documenting the demographic status of other *Papaipema eryngii* populations in the state would be beneficial for developing more confidence in population comparisons.

***Papaipema eryngii* and Prairie Structure**

Papaipema eryngii appears to be associated with vegetation structure at PRSNA. For example, the Soldner Tract (Soldner NE corner Map) shows areas of high usage of *Papaipema eryngii* (predominantly remnant prairie) and other areas are unoccupied. We suspect the rank prairie grasses in the unoccupied restored prairie areas are too dense for the insects to utilize. In contrast, cattle grazing creates opening in the grassland structure in restored prairies at the Survey Tract. On this tract, unoccupied areas of populations 1.1 and 1.2 are characterized by dense populations of red clover, *Trifolium pretense*.

We recommend experimental management of portions of these unused areas (e.g, creating openings in dense grassy restorations, and reducing red clover density) and follow-up monitoring to determine whether *Papaipema eryngii* responds favorably to these manipulations. Grassland birds have well-described preferences for habitat structure (Herkert et al. 1993), particularly the heterogeneous structure created by light grazing (Walk and Warner 2000). Vegetation structure has been given little consideration in prairie management for native insects.

Prairie fires have been known to negatively impact *Papaipema* species in general (Decker 1931, Wiker 2008). Currently, nearly all the *Papaipema eryngii* at the Soldner Tract are in one fire unit. We recommend reconfiguration of fire breaks at the Soldner Tract so that a majority of rattlesnake master plants and *Papaipema eryngii* are not within a single burn unit.

Because they fly late at night, late in the season, and they are only rarely attracted to lights, adult *Papaipema eryngii* moths are difficult to observe in the wild. However, the caterpillars can be readily located. Developing observational factors for recognizing the impacts of *Papaipema eryngii* on rattlesnake master plants would assist other land managers in being able to identify this species. During this survey staffs from Illinois Department of Natural Resources and The Nature Conservancy were trained on how to locate this species. One of the factors to look for is a mature plant that is not stalking or flowering. These broader-leaved plants take on a darker blue/green to yellow color characteristic. During mid June, rattlesnake master sometimes exhibits a drooping stem when caterpillars are boring the stem or root. The orange/tan colored frass being ejected from the bored chamber is conclusive evidence of this species presence.

Establishing Additional *Papaipema eryngii* Populations at Prairie Ridge

Though the populations of *Papaipema eryngii* at PRSNA in Marion County are large, and likely viable, they occur in just two relatively small grassland parcels and are vulnerable to wildfires or

other catastrophic events. We recommend establishing additional populations in suitable unoccupied habitat at the Jasper County unit of PRSNA, and restoring areas of prairie vegetation with rattlesnake master populations in Marion County.

There are several potential reintroduction sites on protected lands in Jasper County. Large populations of rattlesnake master occur on the Galbreath, Donnelly-Walters, Woods, and YFM tracts. These rattlesnake master populations should be inventoried prior to reintroduction. Given the distance from occupied prairies in Marion County, natural colonization of the Jasper County areas is not expected. Translocating caterpillars to establish new populations are straight-forward and this approach has been successfully used in Cook County.

Collecting *Papaipema eryngii* caterpillars is easiest in May and June. Occasionally, multiple caterpillars can be found on one rattlesnake master plant in early May before they start down into the root ball. Since these caterpillars will kill all competing caterpillars they encounter, removing second or third caterpillars from plants will have no effect on the number of *Papaipema eryngii* that mature in any given season. The populations in Marion County are sufficiently large so translocating a small percent of caterpillars would be ample for establishing new populations with no overall effect on the donor population.

ACKNOWLEDGEMENTS
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Table #1. Rattlesnake Master and *Papaipema eryngii* populations on the Prairie Ridge State Natural Area Survey Tract, Marion County Illinois. All populations were completely censused except population 1.1, where the mean ± SE population estimates are reported for the sampled core area (3,110 plants and 333 *Papaipema eryngii* caterpillars were counted among the twenty 5x5m sample plots).

Population	Site	Plants	Area (m^2)	Caterpillars	Plants/Meter²	Caterpillars/Meter²
1.1	Survey	31,878 ± 3455	5125 a	3414 ± 595		
1.2	Survey	1540	3317	188	0.5	0.12
1.3	Survey	218	277	56	0.8	0.26
1.4	Survey	348	517	27	0.7	0.08
1.5	Survey	113	71	3	1.6	0.03
1.6	Survey	23	27	16	0.8	0.70
1.7	Survey	17	3.9	0	4.4	0.00
1.8	Survey	67	24	0	2.8	0.00
1.9	Survey	5	6.5	0	0.8	0.00
1.10	Survey	9	32	0	0.3	0.00
1.11	Survey	11	49	0	0.2	0.00
1.12	Survey	23	502	5	0.0	0.22
1.13	Survey	1383	2999	58	0.5	0.04
1.14	Survey	1736	495	196	0.4	0.11
Total		37,370	26,550	3963	13.3	1.4
Mean		2669.3	1896	283	1.0	0.11

a. This population extended at low density across an additional 8,642 square meters, where we did not attempt to estimate the abundance of rattlesnake mater plants of *Papaipema eryngii*.

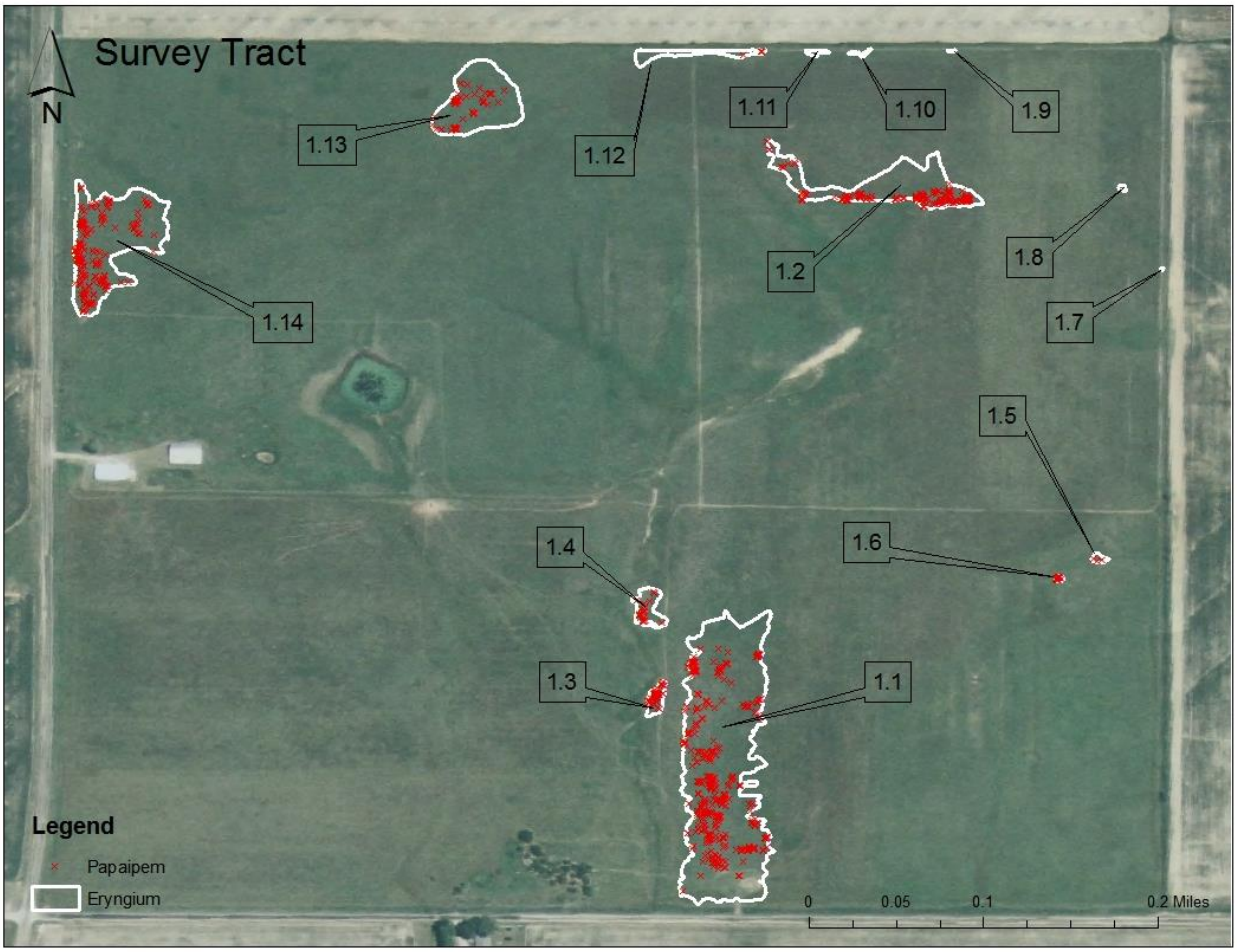
Table #2 Rattlesnake Master Plant Populations on the Prairie Ridge State Natural Area, 12-Mile Prairie in Marion, Fayette, Clay & Effingham Counties, Illinois.

PRSNA	12-MILE					
Population	Site	Plants	Meters²	Caterpillars	Plants/ Meter²	Caterpillars/Meter²
2.1	12-Mile	363	78.56	0	4.6	0.00
2.2	12-Mile	54	26.86	9	2.0	0.34
2.3	12-Mile	38	8.68	0	4.4	0.00
2.4	12-Mile	105	58.88	0	1.8	0.00
2.5	12-Mile	449	183.5	0	2.4	0.00
2.6	12-Mile	115	98.66	0	1.2	0.00
2.7	12-Mile	222	115.02	0	1.9	0.00
2.8	12-Mile	310	200.74	17	1.5	0.08
2.9	12-Mile	139	92.61	7	1.5	0.08
2.10	12-Mile	203	383.13	40	0.5	0.10
2.11	12-Mile	134	194.48	0	0.7	0.00
2.12	12-Mile	84	249.19	0	0.3	0.00
2.13	12-Mile	323	97.52	0	3.3	0.00
2.14	12-Mile	290	212.68	0	1.4	0.00
2.15	12-Mile	339	379.87	0	0.9	0.00
2.16	12-Mile	70	73.94	0	0.9	0.00
2.17	12-Mile	134	71.17	0	1.9	0.00
2.18	12-Mile	118	24.12	0	4.9	0.00
2.19	12-Mile	105	21.21	0	5.0	0.00
2.20	12-Mile	126	47.19	0	2.7	0.00
2.21	12-Mile	371	108.22	0	3.4	0.00
2.22	12-Mile	227	232.07	0	1.0	0.00
2.23	12-Mile	90	67.72	0	1.3	0.00
2.24	12-Mile	86	64.85	0	1.3	0.00
2.25	12-Mile	299	339.03	0	0.9	0.00
2.26	12-Mile	105	72.87	0	1.4	0.00
2.27	12-Mile	114	65.3	0	1.7	0.00
2.28	12-Mile	423	312.82	21	1.4	0.07
2.29	12-Mile	78	43.03	1	1.8	0.02
2.30	12-Mile	61	42.86	0	1.4	0.00
2.31	12-Mile	200	207.21	9	1.0	0.04
2.32	12-Mile	84	51.46	0	1.6	0.00
2.33	12-Mile	28	32.89	5	0.9	0.15
2.34	12-Mile	107	67.99	15	1.6	0.22
2.35	12-Mile	205	152.25	0	1.3	0.00
TOTAL		6199	4478.58	124	65.9	1.11
MEAN		177.11	127.96	3.54	1.9	0.03

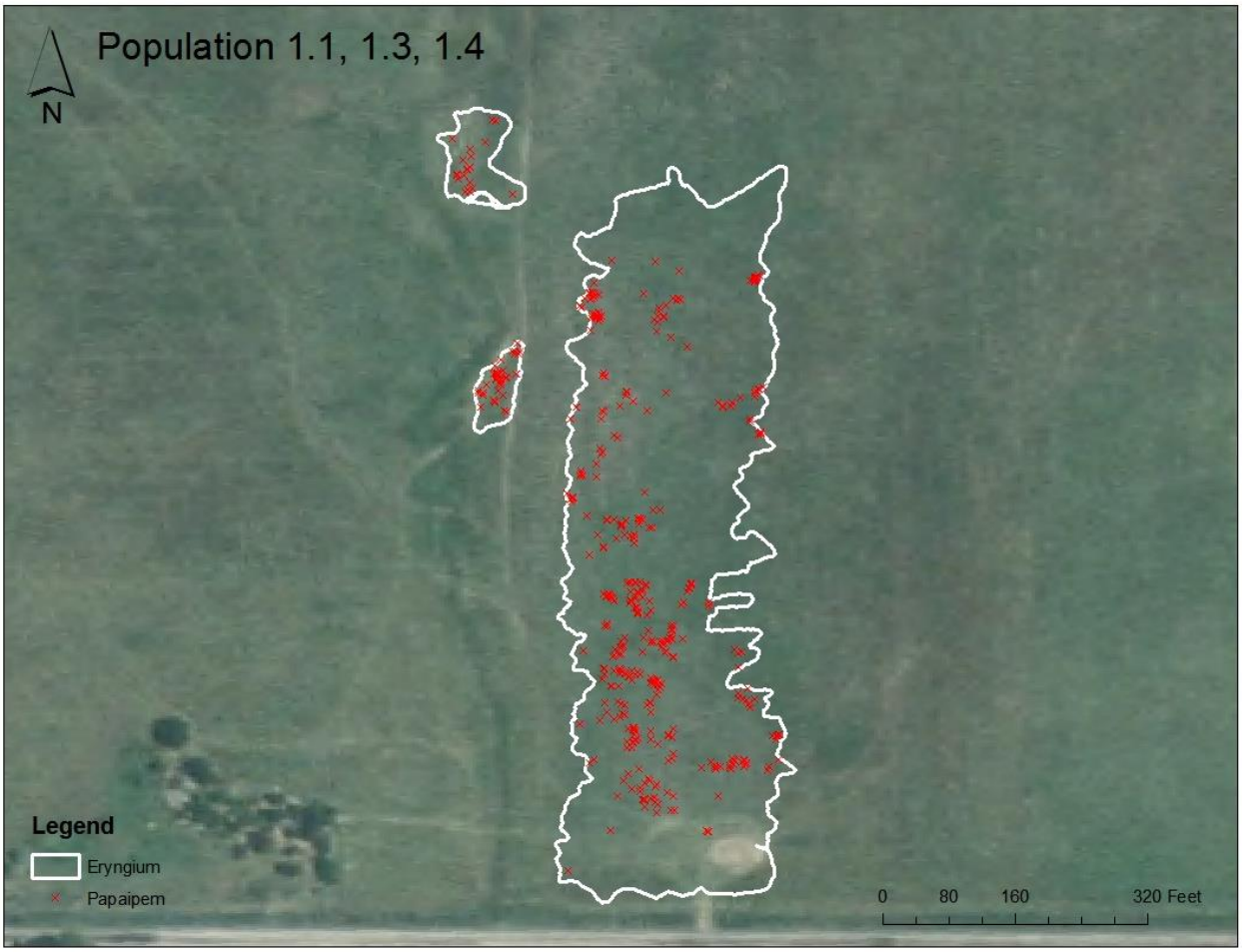
Table #3 Rattlesnake Master Plant Populations on Prairie Ridge State Natural Area Soldner Tract, Marion County Illinois.

PRSNA	SOLDNER					
Population	Site	Plants	Meters^2	Caterpillars	Plants/ Meter^2	Caterpillars/ Meter^2
3.1	SOLDNER	643	1134.03	175	0.6	0.15
3.2	SOLDNER	745	3428.23	139	0.2	0.04
3.3	SOLDNER	734	2408.79	9	0.3	0.00
3.4	SOLDNER	192	275.03	4	0.7	0.01
3.5	SOLDNER	263	830.16	41	0.3	0.05
3.6	SOLDNER	374	678.88	40	0.6	0.06
3.7	SOLDNER	16	105.19	0	0.2	0.00
3.8	SOLDNER	326	2132.7	7	0.2	0.00
3.9	SOLDNER	162	86.7	0	1.9	0.00
3.10	SOLDNER	153	127.09	1	1.2	0.01
3.11	SOLDNER	13	20.29	0	0.6	0.00
3.12	SOLDNER	182	357.01	7	0.5	0.02
3.13	SOLDNER	137	330.9	14	0.4	0.04
3.14	SOLDNER	106	122.2	0	0.9	0.00
3.15	SOLDNER	128	188.85	4	0.7	0.02
3.16	SOLDNER	156	186.54	13	0.8	0.07
3.17	SOLDNER	76	258.41	6	0.3	0.02
3.18	SOLDNER	411	900.01	22	0.5	0.02
TOTAL		4817	13571.01	482	10.7	0.53
MEAN		267.61	753.95	26.78	0.6	0.03

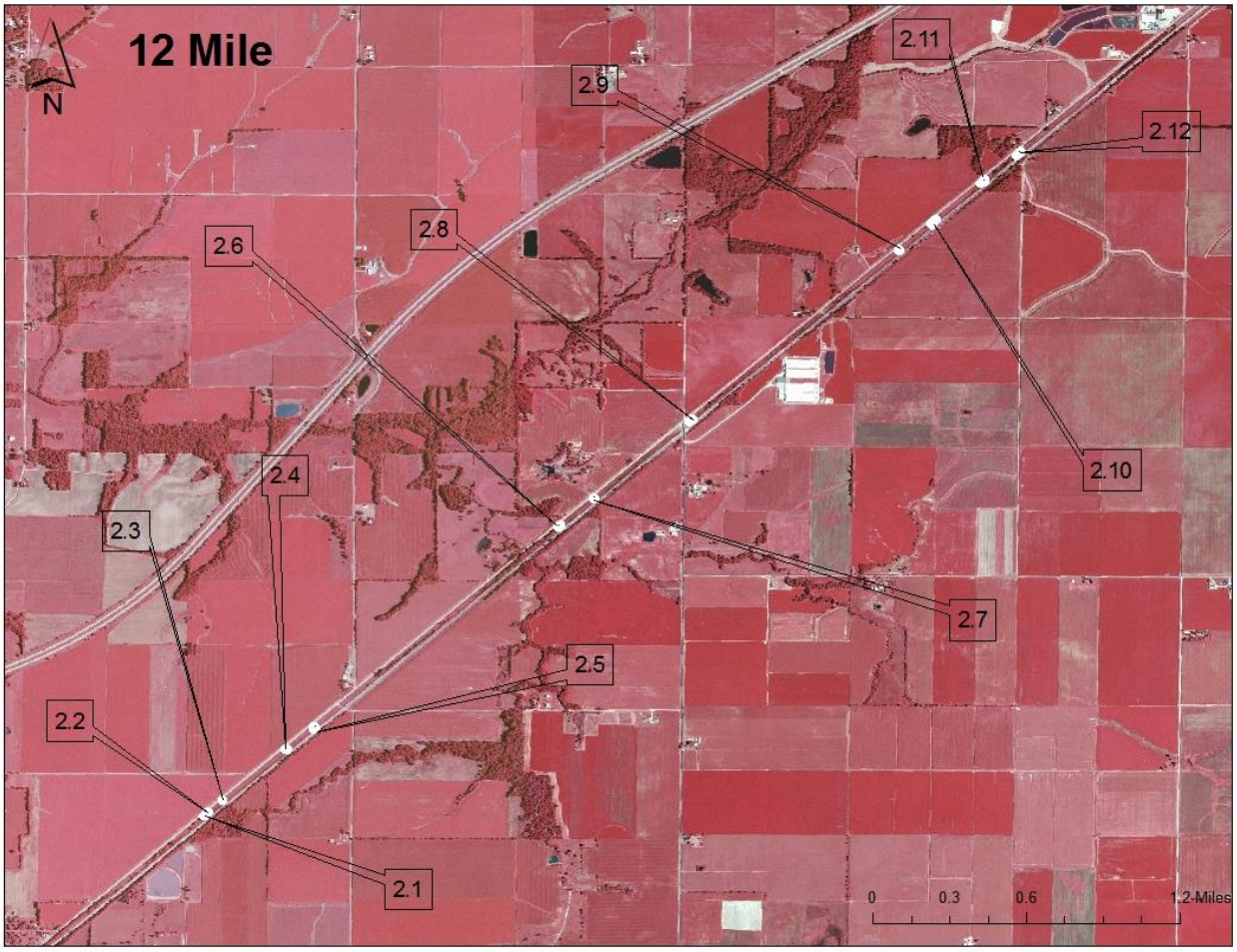
MAP # 1. Survey Tract General Map, Marion County, Illinois 2009.



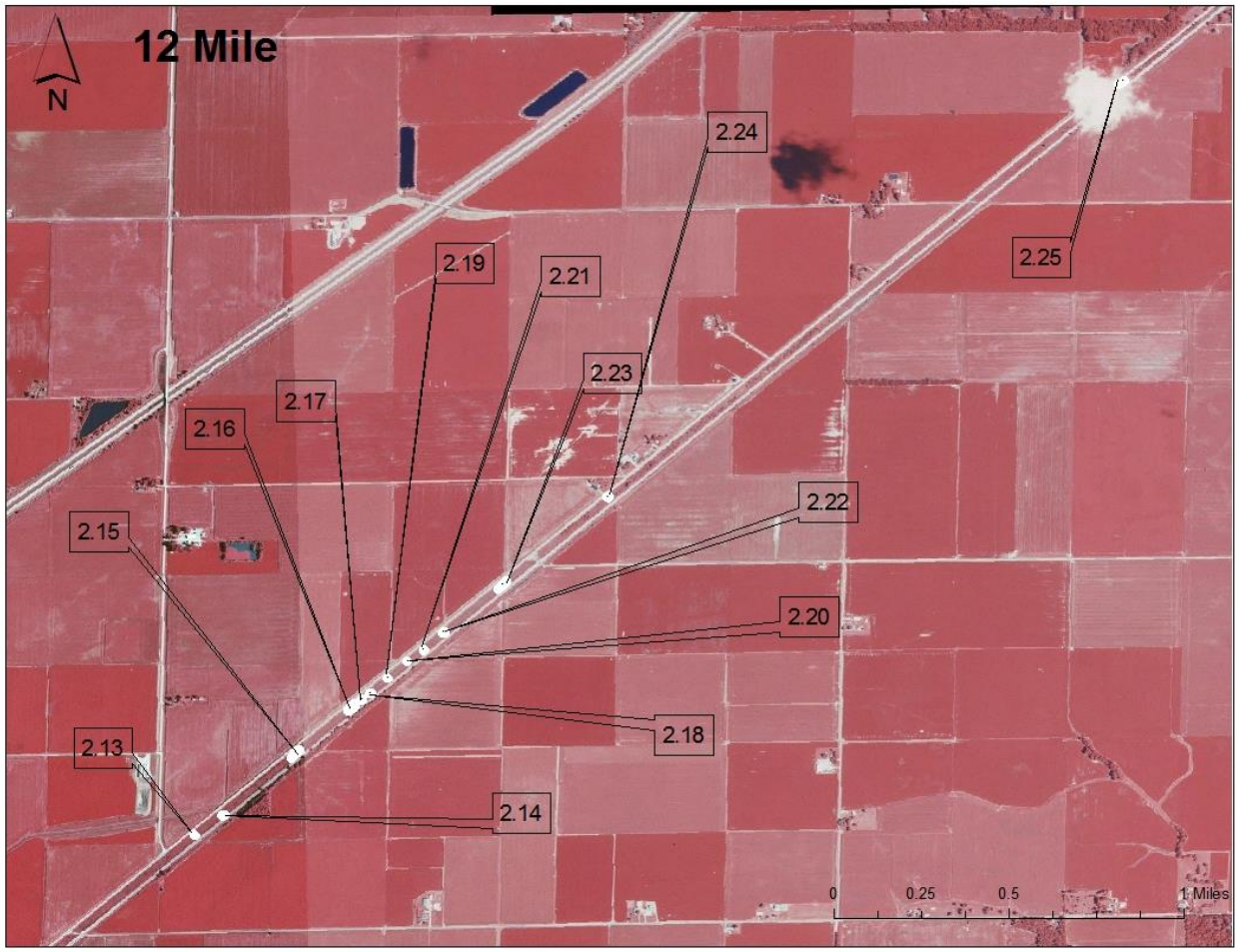
MAP # 2. Survey Tract, Marion County, Illinois 2009.



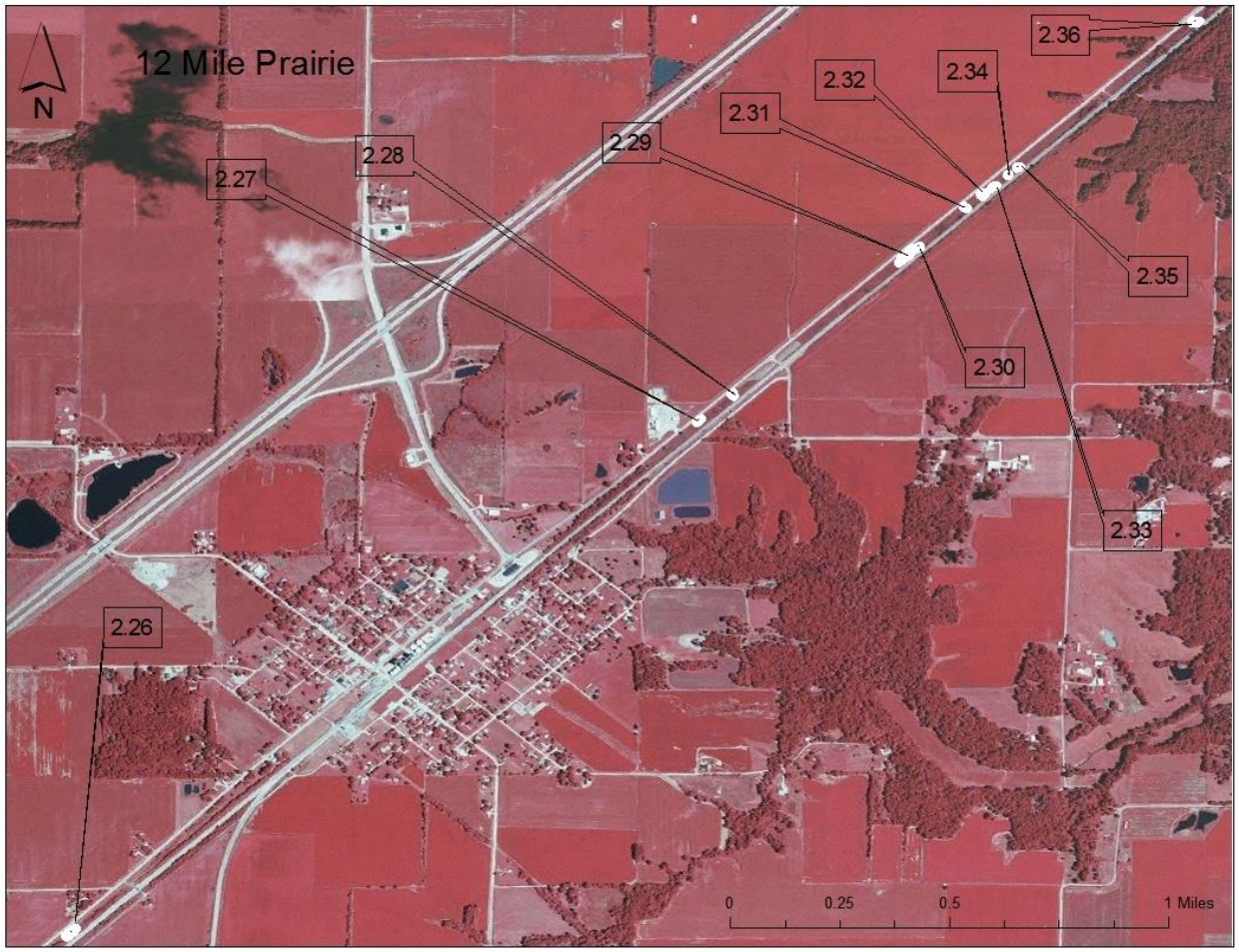
Map # 3. 12-Mile Prairie, Marion County, Illinois 2009.



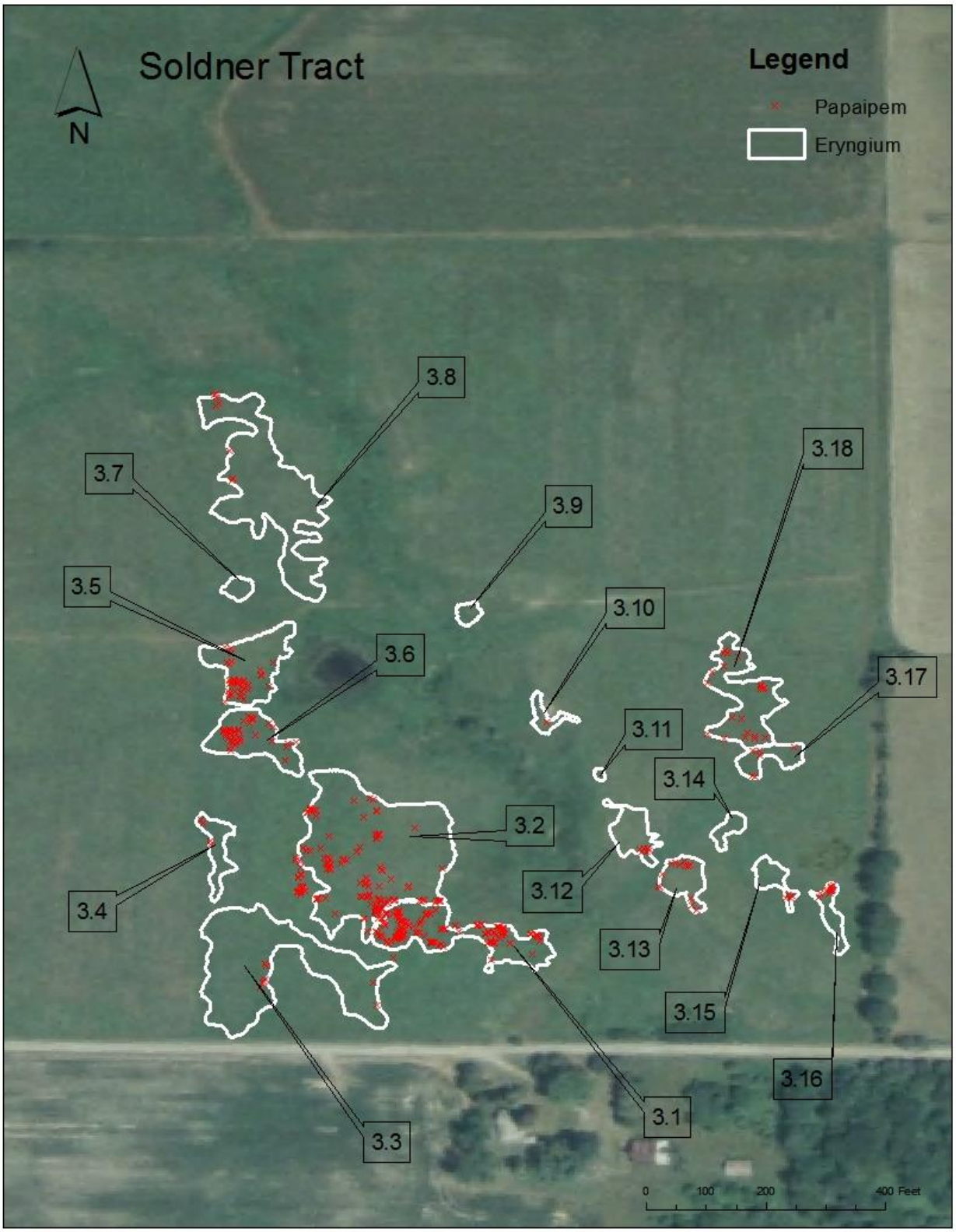
Map # 4, 12-Mile Prairie, Marion County, Illinois, 2009



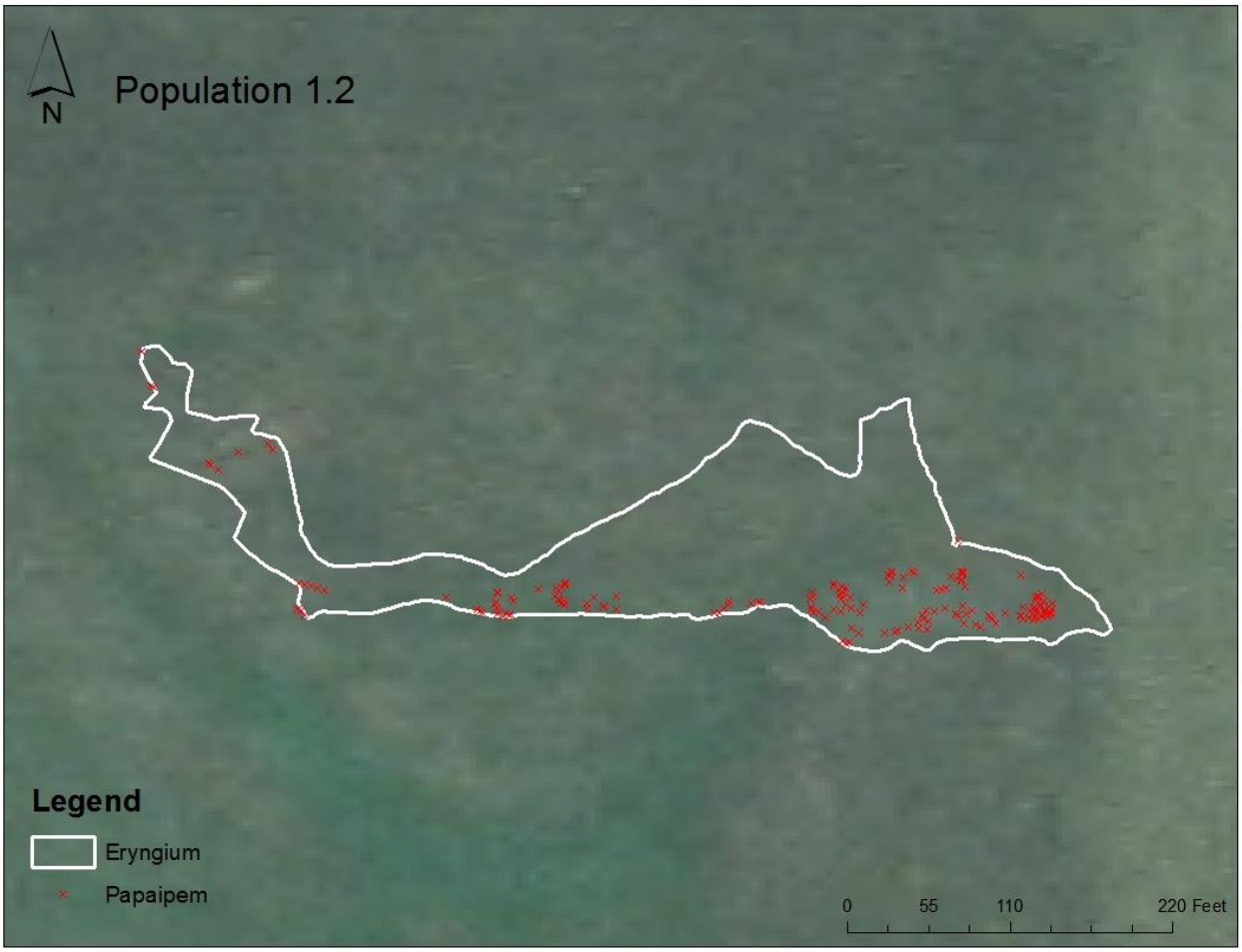
Map # 5, 12-Mile Prairie, Effingham County, Illinois, 2009



Map # 6, Soldner Prairie General Subpopulation Map, Marion County, Illinois, 2009

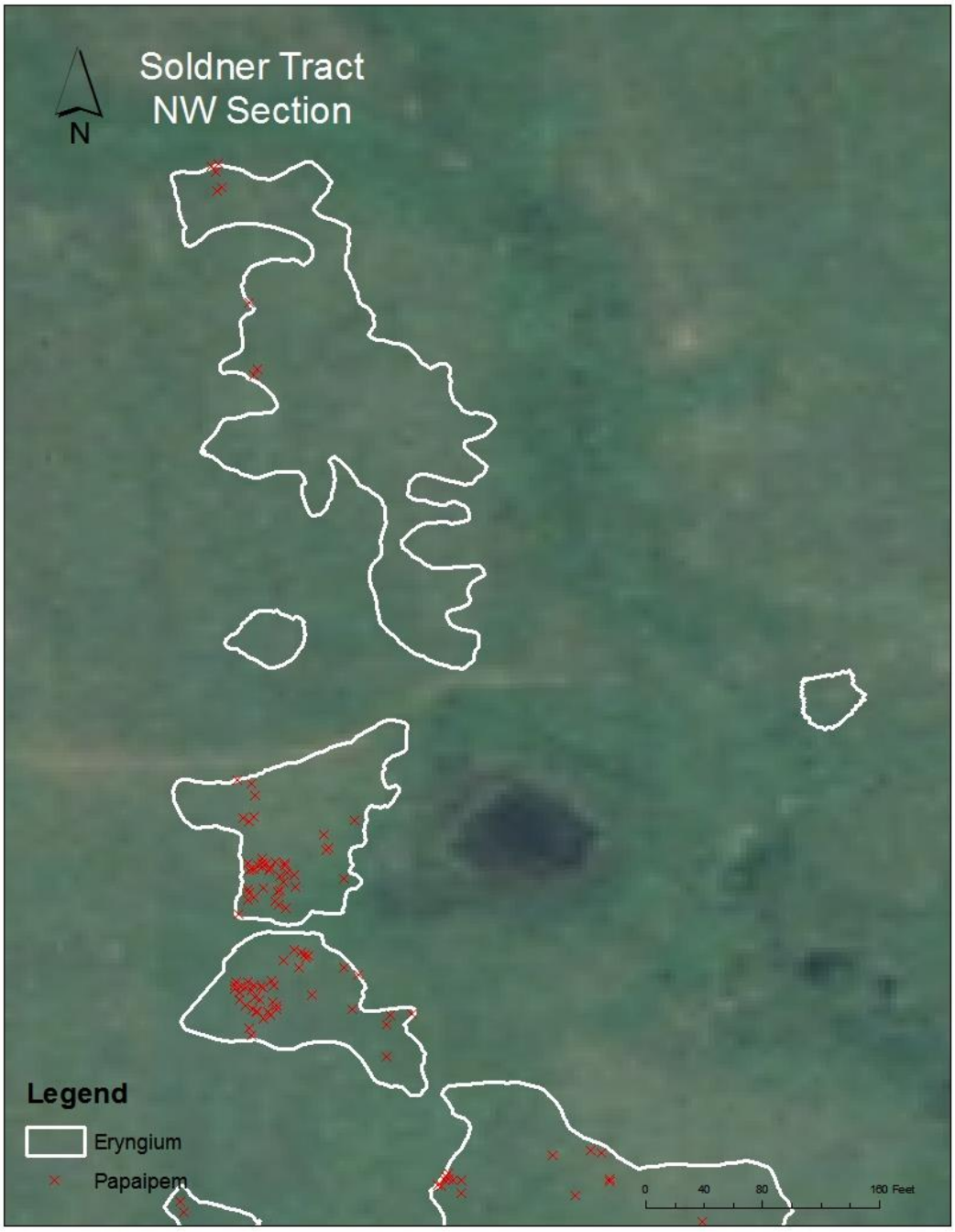


Map # 7. Survey Tract, Marion County, Illinois 2009



Map # 8. Survey Tract, Marion County, Illinois, 2009.

Map # 9. Soldner Tract, Marion County, Illinois 2009.



Map # 10, Soldner Tract, Marion County, Illinois 2009.