MARDON SKIPPER (*POLITES MARDON*) DISTANCE SAMPLING SURVEYS AT FOUR SENTINEL SITES IN OREGON AND WASHINGTON: YEAR 3

STATUS REPORT TO THE U.S. FOREST SERVICE, BUREAU OF LAND MANAGEMENT, AND THE INTERAGENCY SPECIAL STATUS / SENSITIVE SPECIES PROGRAM (ISSSSP)

Mardon skippers mating at Peterson Prairie, WA. Photo by Michele Blackburn, the Xerces Society.

PREPARED BY RICH HATFIELD, CANDACE FALLON, AND MICHELE BLACKBURN

THE XERCES SOCIETY FOR INVERTEBRATE CONSERVATION

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XERCES SOCIETY
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SUMMARY

In May and June of 2016 Michele Blackburn and Rich Hatfield (Xerces Society) revisited two established mardon skipper monitoring sites to set up sampling transects and/or provide distance sampling training to Forest Service biologists and biological technicians. These sites included Windy Valley (Rogue River-Siskiyou NF, OR), and Peterson Prairie (Gifford Pinchot NF, WA). The Xerces Society also provided logistical support to BLM biologists and contractors to continue monitoring the Howard Prairie Site Complex in Southern Oregon, and to Forest Service biologists to continue monitoring Conrad Meadows (Okanogan-Wenatchee NF, WA).

Agency staff or contractors then completed 5-7 distance sampling visits at each of these sites over the course of the adult flight period (May through July). A fourth site, Peterson Prairie (Gifford Pinchot NF, WA), was monitored by Michele Blackburn for the entirety of the 2016 flight period. Data from all four sites were provided to Xerces at the end of the season for analysis and reporting. This is the third consecutive year that distance sampling has been conducted at these sites. At all sites except the Peterson Prairie complex, total population numbers were higher in 2015 than in 2014. From 2015 to 2016, Peterson Prairie population numbers increased, while all other sites reported lower population numbers. Population and density estimates for each site for 2014, 2015, and 2016 can be found in Table 1. See the Data Interpretation section for more information about these statistics, and the Site Results and Discussion section for more site-specific details. **Note:** the total number of mardon skipper detections for 2016 was less than 30 butterflies in Peterson Prairie West and Howard Prairie – this low number of detections violates the assumptions of Distance Sampling. As such, the population estimates for these meadows are unreliable, and the pooled data should instead be used for the two sites.

Table 1: Population and density estimates for all survey sites. Estimates from 2014 and 2015 are provided for comparison.

		2014				2015				2016			
Site	**Estimate**	**Pop. size**	**% CV**	**95% CI**		**Pop. size**	**% CV**	**95% CI**		**Pop. size**	**% CV**	**95% CI**	
Windy Valley	Density (N/HA)	2,070.6	14.07	1,566.1	2,070.6	3,314	14.10	2,441	4,499	333.47	22.19	208.9	532.4
	Population (N)	1,837.0	14.07	1,390.0	1,837.0	2,940	14.10	2,166	3,992	296	22.19	185	472
Howard Prairie	Density (N/HA)	137.5	34.7	49.9	137.5	170.65	18.65	106.53	273.36	***147.9***	***431.8***	***4.61***	***4,741***
	Population (N)	794.0	34.7	288.0	794.0	986	18.65	616	1,580	***855***	***431.8***	***27***	***27,403***
Lily Glen	Density (N/HA)	52.4	28.7	27.2	52.4	51.87	***181.3***	4.20	641.18	35.81	26.61	19.68	66.16
	Population (N)	443.0	28.7	230.0	443.0	452	***181.3***	37	5,585	312	26.61	171	568
Pooled Estimate	Density (N/HA)	189.8	26.4	92.6	389.1	115.35	26.93	66.91	198.85	46.15	17.69	32.45	65.64
	Population (N)	1,097.0	26.4	535.0	2,249.0	1,671	26.93	696	2,881	669**	17.69	470	951
Peterson Prairie North Meadow	Density (N/HA)	633.5	21.8	367.8	633.5	71.25	30.63	21.66	71.25	124.85	25.74	66.05	236.0
	Population (N)	2,433.0	21.8	1,412.0	2,433.0	151	30.63	83	274	479	25.76	254	906
Peterson Prairie West Meadow	Density (N/HA)	121.2	18.3	82.8	121.2	6.79	***49.87***	2.58	17.85	***44.19***	***49.83***	***12.7***	***153.3***
	Population (N)	255.0	18.3	174.0	255.0	14	***49.87***	5	37	***93***	***49.83***	***27***	***322***
Pooled Estimate	Density (N/HA)	452.4	19.8	276.3	740.7	25.53	26.96	15.13	43.08	18.97	20.92	12.4	29.0
	Population (N)	2,687.0	19.8	1,641.0	4,400.0	152	26.96	90	256	563	20.92	368	861
Conrad Meadow	Density (N/HA)	1,593.1	15.84	1,060.0	2,316.7	2,291	10.56	1,858	2,824	712.14	13.76	537.3	943.9
	Population (N)	6,135.0	15.84	4,081.0	8,919.0	9,875	10.56	7,999	12,189	2,742	13.76	2,069	3,635

**Note: This includes all skippers detected during distance sampling (not just mardon skippers). It is possible that the same individuals were counted on multiple site visits. See Table 6 for daily adjusted population estimates.Numbers in bold have a high coefficient of variance, and not accurate population estimates.

Map 1: Mardon skipper range map

INTRODUCTION

Mardon skippers are grassland and open meadow obligates endemic to four distinct regions within Washington, Oregon, and California. These small, stout butterflies have tawny-orange and brown hairy bodies and wingspans generally less than an inch wide. They can be differentiated from other grass skippers by their ventral hindwing bands, which are longer than broad and often diffuse yellow to off white (Pyle 2002). They are univoltine and adults are active, depending on location and micro-site conditions, in late May to early July; they likely live from five days to two weeks (Potter et al. 2002). Females have been observed depositing eggs on multiple graminoid species and larvae feed exclusively on these. Adults are known to use a variety of nectar species, including *Potentilla diversifolia*, *P. gracilis*, *Wyethia augustifolia*, *Dichelostemma capitatum*, *Eriogonum umbellatum*, *Delphinium* spp., *Horkelia fusca*, *Plectritis congesta*, *Vicia* spp., and *Calochortus* spp., among others (Beyer & Black 2007; Kerwin 2011; Barrett 2015, pers. obs.; Fallon 2015, pers. obs.). Flight periods can vary from year to year based on population size and weather conditions, ranging from 10 days to more than a month (Potter et al. 2002).

The historic range of this species has been poorly documented, but it is thought to be in decline (Hatfield et al. 2013a). The mardon skipper is currently known from four major areas (Map 1): (1) southern Puget Sound, (2) the east side of the Cascade Mountains in Washington, (3) the Cascade Mountains in southern Oregon, and (4) in Del Norte California and the southern coast of Oregon. Although previously listed as a federal candidate species under the Endangered Species Act, it was removed in the fall of 2012 (DOI, FWS 2012). It remains a State Endangered Species in Washington (WNHP 2014), and an OR/WA Bureau of Land Management and U.S. Forest Service Region 6 Sensitive Species (ISSSSP 2015). It has a global rank of G2G3T2T3 (imperiled) and state ranks of S1 in Washington and S2 in Oregon (ORBIC 2016, WNHP 2014).

Additional research on the effects of different management strategies is needed in order to develop long-term management strategies for this species. However, knowing the population estimates for each site is a critical first step. Previous one-day counts do not provide enough detail to detect changes in population size over time (Hatfield et al. 2013a). Distance sampling is a method of surveying that has the ability to provide an accurate population estimate as it incorporates the detectability of the butterfly, thus accounting for those butterflies that were missed in the course of a survey. In the case of a small, low flying butterfly like the mardon skipper,

detectability in surveys is quite low (Potter & Olson 2012; Fallon & Hatfield 2013; Fallon & Hatfield 2014; Fallon & Hatfield 2015); thus incorporating detectability into population estimates is essential.

From May through July of 2016, Xerces staff, agency biologists, and contractors conducted distance sampling surveys at four sentinel sites in Oregon and Washington: Windy Valley, Howard Prairie, Peterson Prairie, and Conrad Meadows. All four of these sites were surveyed using distance sampling methods in 2014, 2015, and 2016. These sentinel sites were selected for several reasons: (1) they hosted some of the largest populations of mardon skippers documented on federal lands in three of the four major areas from which this species is known; (2) there would likely be enough skippers to conduct distance sampling (which assumes a minimum of 30 observations per site - per year); and (3) they can serve as barometers of mardon skipper activity (including peak flight periods to inform the best time to conduct detection/no detection surveys at other smaller mardon population sites nearby) and inform population trends for each region. These three years of surveys provide the first robust population estimates of known mardon skipper populations in three of the four major geographical areas from which this species is known. For similar efforts in the southern Puget Sound region, see Potter and Olson (2012). We have now been monitoring these meadows for three years and have preliminary population estimates for each of these four sentinel sites. The estimates and overall analysis can be found in the Trends and Analysis section below. It should also be noted that while these sites may be used as barometers for regional population trends, additional satellite sites with smaller populations should be monitored to determine if these remain extant. As far as we are aware, it has now been 5-6 years since many of these smaller populations have been revisited.

METHODS

In 2014, Xerces staff established permanent distance sampling transects at four mardon skipper sites, based on the Mardon Skipper Rangewide Monitoring Protocol (Hatfield et al. 2013a). Some of these were adjusted during the 2014 and 2015 field seasons based on surveyor feedback. Endpoints for each transect were established with the program Distance (Thomas et al. 2010), and located in the field using GPS. Each transect was delineated in the field with pin flags, rebar, or wooden stakes (see Appendix for transect coordinates). Additional pin flags or tall PVC pipes with flags were placed along the transect route to facilitate surveys.

In 2016, warm spring weather resulted in an early start to the mardon flight season on the Conboy Lake NWR, which began on May 13 (McFall 2016 pers. comm.). This alerted surveyors to an earlier than usual survey period. Surveys subsequently took place at the four sentinel mardon skipper sites from May through July in 2016. Each site was visited five to seven times over the course of the 2016 field season (see visitation tables for each site in the Site Results and Discussion section below). Surveyors followed the general survey conditions and time of day recommendations provided by Seitz et al. (2007) and modified by Hatfield (2013):

- Weather conditions and time of day affect the activity and resulting visibility of butterflies. Weather parameters for butterfly surveying have been established by Pollard and Yates and are explained in their book *Monitoring Butterflies for Ecology and Conservation* (1994). Mardon skippers can be encountered outside of these conditions, but the survey would not meet protocol guidelines. Windy and/or cloudy conditions outside of the parameters stated below may occur during a survey. Be prepared to wait out conditions that are too cloudy and/or windy, and resume the survey when they pass.

- Conduct surveys only when ambient air temperature (air temperature in the shade) is greater than 55 degrees F (13 degrees C). Warmer temperatures above 60 degrees F (16 degrees C) are preferable.

- Survey between 1000 and 1600 hours.

- Survey only when sunshine is sufficient to cast a distinct shadow. Do not survey during rainy weather.
- Wind should be on average below 10 miles per hour or at or below Beaufort Scale 3 (leaves and small twigs constantly moving, light flags extended). Local wind conditions can vary considerably depending on habitat and exposure.

Surveyors followed the sampling protocol for distance sampling mardon skippers in Hatfield (2013). Upon each visit the surveyor walked the length of each transect and counted the number of skippers encountered, estimating the perpendicular distance to the transect line in ½ meter increments. At the end of the field season, Xerces staff used Distance 6.2 Release 1 (Thomas et al. 2010) to estimate the mardon skipper abundance and density of each site.

DATA INTERPRETATION

For each site, we report several statistics. At the most basic level, we report each site's individual one-day skipper count for each day that the meadow was visited. These are somewhat similar to the one-day counts that have taken place in the past. However, the methodology for distance sampling is different than the modified Pollard walks used in the past, and the two counts would be difficult to compare or interpret because of this. Additionally, we report the population estimates reported by the program Distance 6.2 Release 1 (Thomas et al. 2010). The statistics include the estimated density (N/ha) and total population (N), as well as the Coefficient of Variation (%CV) and the 95% Confidence Intervals (95% CI). The Coefficient of Variation is a unit-less measure of error about a statistic, and thus allows a comparison of the amount of error between sites with different means (here reported as population estimates). Loosely interpreted, the 95% CI contains the mean population size (N), with 95% confidence. With similar means, a population with a larger %CV will have a broader 95% CI. Generally speaking, to detect trends in meadows with statistical significance ($p<0.05$), it would be necessary to have two means (N) with 95% CI that did not overlap. This means that detecting population trends in meadows with higher %CV, and thus larger 95% CI will be challenging.

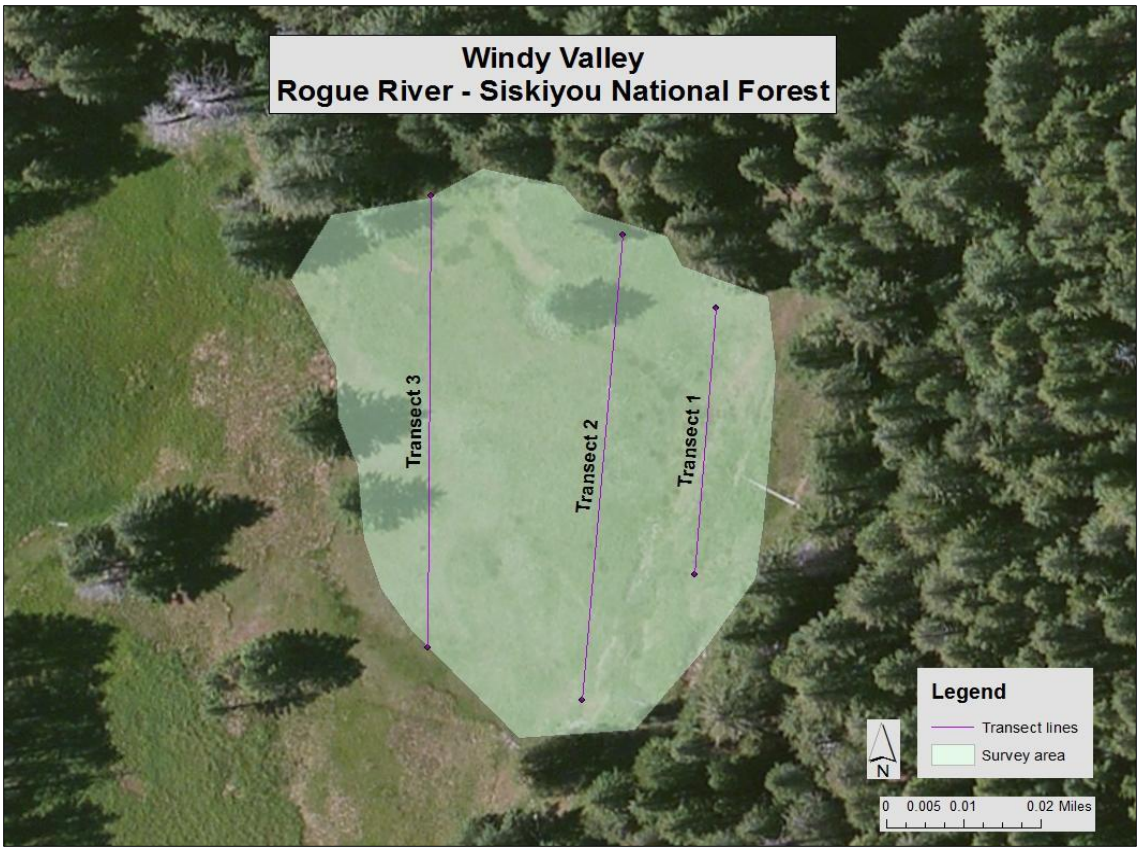
It is important to note that the population estimates reported here are a pooled sum of the individual daily estimates of butterfly abundance. Daily population estimates are not reported here for simplicity, but those data are available from Xerces upon request. The estimates provided are the best estimates of mardon skipper populations to date, and as long as the sampling protocol is followed in future monitoring efforts, the numbers reported here will be comparable to future surveys. The estimates could be improved if there were accurate measures of individual butterfly survivorship, which, to our knowledge, do not exist for this species.

SITE RESULTS AND DISCUSSION

WINDY VALLEY, ROGUE RIVER SISKIYOU NATIONAL FOREST, OR

Figure 1: Windy Valley survey site with surveyors. Photo by Rich Hatfield, the Xerces Society, 2016.

Windy Valley, in SW Oregon, is a small meadow surrounded by intact coniferous forests as well as remnants of the 2002 Biscuit Fire, which burned adjacent forests but not the meadow itself. The occupied area at this site is comprised of 0.89 hectares of bunch grasses and nectar sources at the northeast edge of a large seasonally wet sedge meadow (see Map 2). This site hosts the largest known mardon skipper population in the coastal Oregon region. Prior to this project's launch in 2014, the highest one-day count at this site was 226 mardon skippers on June 13, 2013. In 2016, Xerces staff and Forest Service biologists were on site June 1 to retrain Forest Service Biologists in the Distance Sampling protocol. Surveys began May 11 and ran through July 11, 2016 (see Table 2).



Map 2: Windy Valley distance sampling survey site

RESULTS

Throughout the season, 58 skippers were observed at the Windy Valley site. The peak count for 2016 was on June 2, with 31 individuals counted (Table 2). In the sampled occupied habitat, there is an estimated 333.47 mardon skippers per hectare (22.19 % CV), with a population estimate of 296 mardon skippers within the meadow (22.19 % CV, the habitat was 0.887 HA). For 95% Confidence Intervals, see Table 3.

Table 2: Number of skippers detected by date at Windy Valley.

Site	Area (HA)	# Transects	Total Distance of Transects (m)	5/11/2016	5/16/2016	5/25/2016	6/2/2016	6/21/2016	6/29/2016	7/11/2016	Total Observed*
Windy Valley	**0.887**	**3**	**262.33**	**0**	**2**	**19**	**31**	**4**	**2**	**0**	**58**

*Note: This includes all skippers detected during distance sampling (not just mardon skippers). It is possible that the same individuals were counted on multiple site visits.

Table 3: Windy Valley population estimates in 2014, 2015, and 2016.

		2014				2015				2016			
Site	**Estimate**	**Pop. size**	**% CV**	**95% CI**		**Pop. size**	**% CV**	**95% CI**		**Pop. size**	**% CV**	**95% CI**	
Windy Valley	Density (N/HA)	2,070.6	14.07	1,566.1	2,070.6	3,314	14.10	2,441	4,499	333.47	22.19	208.88	532.37
	Population (N)	1,837.0	14.07	1,390.0	1,837.0	2,940	14.10	2,166	3,992	296	22.19	185	472

DISCUSSION

Counts this year were significantly down from either of the past two years (see Table 3). While at first glance this would appear to be concerning, closer inspection of the survey data indicates that the peak of the flight season may have been missed. The first visit and maximum count for this year occurred on June 2, 2016 (31 butterflies). Following the first visit additional survey attempts were made on June 9th and June 16th, but the weather on those days was not within protocol limits (low ambient temperatures, and high degrees of cloud cover) to complete surveys. Because of this, there was a long break in surveys, which likely led to missing a significant portion of the flight season, and perhaps the true peak. As such, the low counts from this year should be tempered until additional years of survey data are collected. The remote location of this site, long travel times, and unpredictable spring weather make planning survey dates difficult; this will continue to pose a challenge in future survey years.

On June 1, we also discovered mardon skippers in an adjacent meadow to the main Windy Valley site. This site is to the northeast of the existing site and is separated by a stream and a thick band of trees (see figure 2). We believe that this site has some existing mardon skipper habitat, and that active management is needed to restore the site to maintain a population. This would require a new site specific management plan, or adaptation of the existing site management plan for Windy Valley.

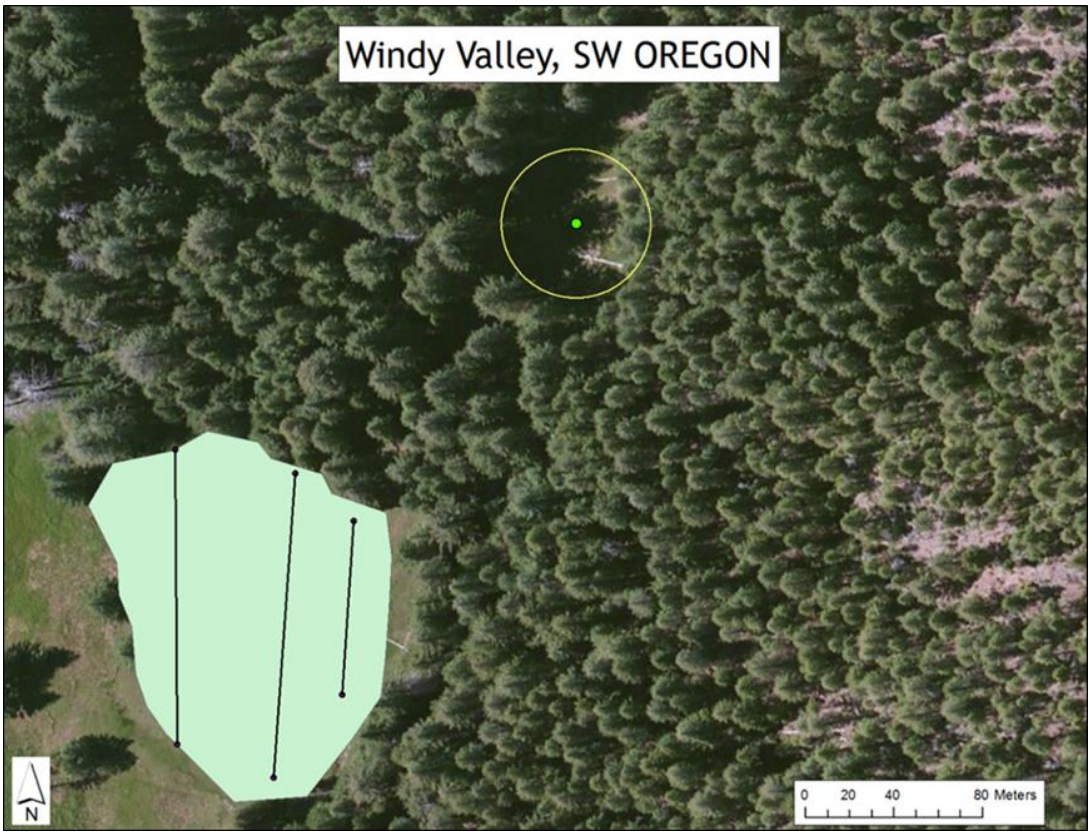


Figure 2: Existing Windy Valley site, and distance sampling transects. The new site is marked in green and circled in yellow to the NE of the existing site.

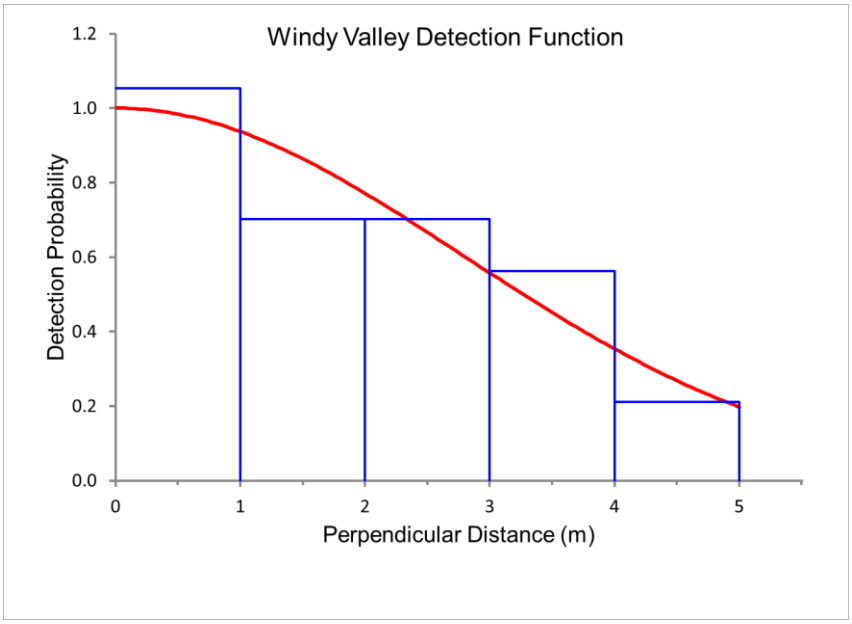


Figure 3: Windy Valley detection function

HOWARD PRAIRIE SITE COMPLEX, OR

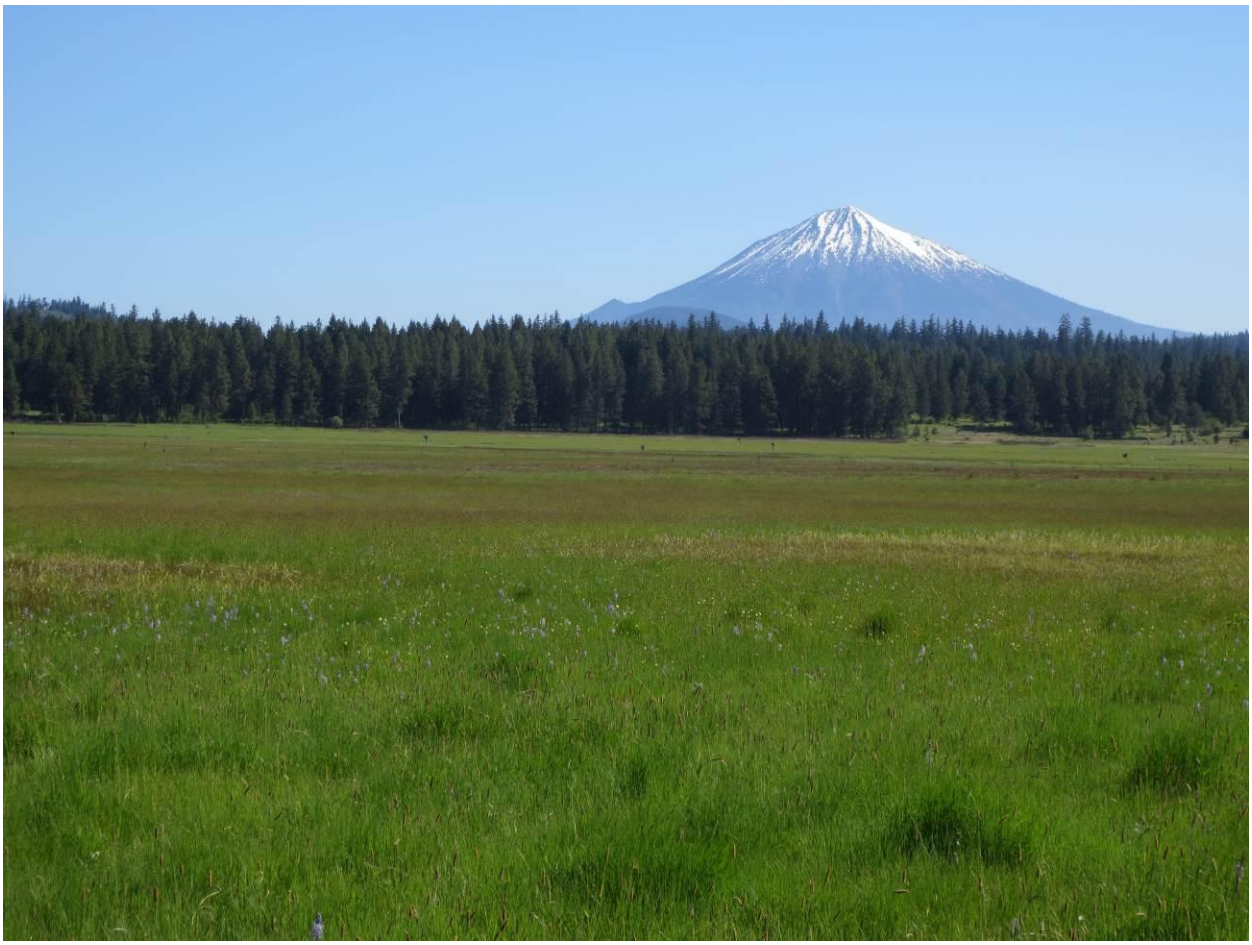
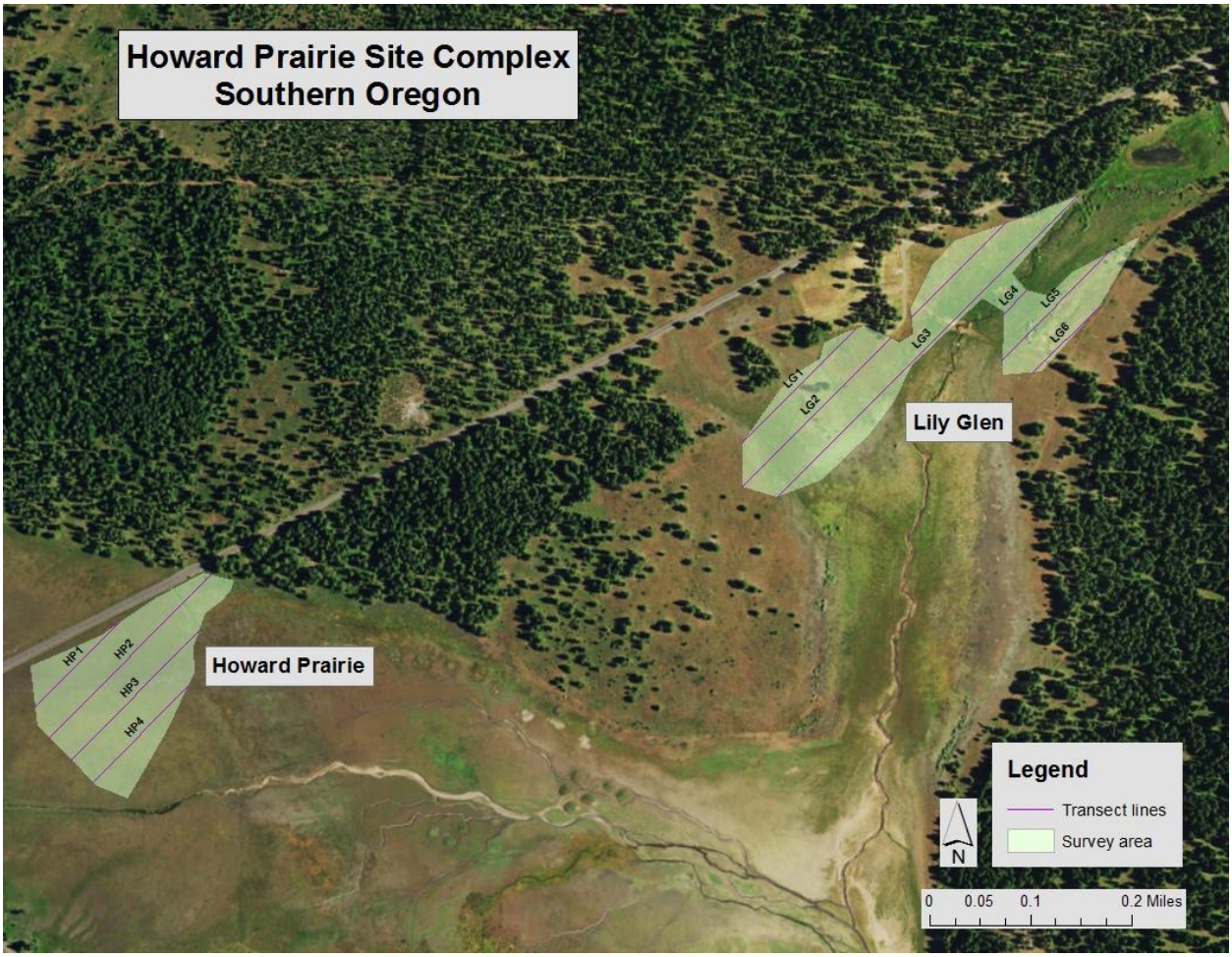


Figure 4: Mt. McLoughlin over the Howard Prairie survey site. Photo by Candace Fallon, the Xerces Society, 2014.

The Howard Prairie Site Complex is composed of its namesake prairie and the adjacent Lily Glen Park site. The Lily Glen Park is managed by the Jackson County Parks Department, and the remainder of both sites is managed by the Bureau of Reclamation. The Medford BLM District also manages the grazing allotment on the site. Howard Prairie is a large open meadow with two large trenches that carry water through the site. The site appears to dry out earlier than most other sites in the region and as a result may have a slightly earlier flight season. It does not appear to provide many sources of nectar during the adult flight period, although there is an abundance of host plants to support mardon skippers. Lily Glen is another large meadow with a permanent stream that bisects the site from NE to SW. There is a vernal pool habitat on the east side of the stream which supports abundant *Plectritis congesta* (a known nectar plant) and sporadic mardon skippers. Most of the remainder of the meadow is a mix of fescue, forbs, and bare ground.

Xerces monitored mardon skippers for the first time at the complex in 2012, conducting minimum population estimates (one-day counts) on two separate days that were believed to be near the peak of the flight period. These estimates suggested that the population within the complex was quite large, and possibly the largest population in the southern Oregon Cascades. During these one-day counts the peak count at Howard Prairie was 116 and the peak count at Lily Glen was 221.

In 2016, BLM biologists and two contractors were on site May 24 to place transects (see Map 3) and check for mardon skipper activity. Weather conditions were not conducive to butterfly activity (temperature and cloud cover exceeded protocol limits); no mardon skippers were seen during a walk through suitable habitat, though one juba skipper was spotted. Surveys were carried out for mardon skippers at Howard Prairie from May 28, 2016 through July 1, 2016 and at the Lily Glen site from May 26 through June 28, 2016 (see Table 4).



Map 3: Howard Prairie Site Complex distance sampling survey sites

RESULTS

Throughout the season, 19 skippers were observed at the Howard Prairie site, and 42 skippers were observed at the Lily Glen site. The peak count for the 2016 season was on 6/7/2016 at the Lily Glen site, and on 6/4/2016 at the Howard Prairie site (see Table 4). Because less than 100% of the butterflies captured at the end of the sampling period were mardon skippers we adjusted the final population estimates based on those observations (see Table 6). In the sampled occupied habitat, there is a pooled estimate of 46.15 mardon skippers per hectare (17.69% CV), with a population pooled estimate of 669 mardon skippers at both sites (17.69% CV, the habitat was 14.24 HA). For 95% Confidence Intervals, see Table 5. Howard Prairie has a higher density of mardon skippers (147.9/HA) than Lily Glen (35.81/HA). The population estimate for Howard Prairie is 855 mardon skippers (431.8% CV), and Lily Glen is 312 mardon skippers (26.61% CV). Note the very high coefficient of variation at the Howard Prairie site; this estimate should be considered unreliable.

Table 4: Number of skippers detected by site and date at the Howard Prairie complex.

Site	Area (HA)	# Transects	Total Distance of Transects (m)	Visit 1 (5/26/2016 – 5/28/2016)	Visit 2 (5/31/2016 – 6/4/2016)	Visit 3 (6/7/2016 – 6/11/2016)	Visit 4 (6/13/2016 – 6/19/2016)	Visit 5 (6/20/2016 – 6/25/2016)	Visit 6 (6/28/2016 – 7/1/2016)	Total Observed*
Howard Prairie	5.78	4	1084.5	2	13	4	0	0	0	19
Lily Glen	8.71	6	1887.0	4	7	19	8	3	1	42
Pooled	14.49	10	2,971.5	6	20	23	8	3	1	61

*Note: This includes all skippers detected during distance sampling (not just mardon skippers). It is possible that the same individuals were counted on multiple site visits.

Table 5: Howard Prairie and Lily Glen population estimates in 2014, 2015, and 2016.

		2014				2015				2016			
Site	Estimate	Pop. size	% CV	95% CI		Pop. size	% CV	95% CI		Pop. size	% CV	95% CI	
Howard Prairie	Density (N/HA)	137.5	34.7	49.9	137.5	170.65	18.65	106.53	273.36	***147.9***	***431.8***	***4.61***	***4,741***
	Population (N)	794.0	34.7	288.0	794.0	986	18.65	616	1,580	***855***	***431.8***	***27***	***27,403***
Lily Glen	Density (N/HA)	52.4	28.7	27.2	52.4	51.87	181.3	4.20	641.18	35.81	26.61	19.68	66.16
	Population (N)	443.0	28.7	230.0	443.0	452	181.3	37	5,585	312	26.61	171	568
Pooled Estimates	Density (N/HA)	189.8	26.4	92.6	389.1	115.35	26.93	66.91	198.85	46.15	17.69	32.45	65.64
	Population (N)	1,097.0	26.4	535.0	2,249.0	1,671**	26.93	696	2,881	669	17.69	470	951

**Note: This includes all skippers detected during distance sampling (not just mardon skippers). It is possible that the same individuals were counted on multiple site visits. See Table 6 for daily adjusted population estimates.

Table 6: Howard Prairie and Lily Glen adjusted population estimates based on observed daily mardon skipper percentages

Howard Prairie/Lily Glen	Pooled Daily Estimate	Pooled 95% Confidence Intervals (Unadjusted)		% Mardon (Pooled)	Adjusted Daily Estimate***
Visit: 1	50	24	105	55%	28
Visit: 2	137	48	391	68.5%	94
Visit: 3	223	143	347	87.5%	195
Visit: 4	173	85	351	71.5%	124
Visit: 5	72	29	179	90%	65
Visit: 6	14	3	59	0%	0
Pooled (Sum)					506***

***Note: The reported adjusted estimates do not include their associated %CV or 95% CI.

DISCUSSION

Howard Prairie

Population numbers at Howard Prairie were lower in 2016 than they had been in 2015 (Table 5). The Coefficient of Variation(% CV) at Howard Prairie is incredibly high (431.8%), and would make detections of butterfly population trends nearly impossible – the 95% confidence intervals span three orders of magnitude (Table 5). This high % CV may be due to the lower density of butterflies in this habitat, compounded with the length of the transects and the size of the habitat. There were also fewer than 30 butterflies detected over the course of the flight period this year, which is below the recommended minimum number of detections. In this case, the pooled data should be considered for future comparisons, and not the data at Howard Prairie. It should be emphasized that surveyors need to focus on the transect line while conducting surveys, as one of the assumptions of Distance Sampling is that detectability is 100% at zero, with detections falling off with distance away from the transect. Because the detection probability for Howard Prairie is less than 1 at zero (Fig. 5), it does not appear to meet this assumption.

The plant community at this site is relatively short and sparse. Because of this, detectability is expected to be higher at this site than at Lily Glen, though this year detection functions were lower in Howard Prairie compared with Lily Glen (Figs. 5 and 6). Pooled detection functions for both Howard Prairie and Lily Glen are provided in Fig. 7; note that this combines detection curves for two different surveyors. A low number of total detections led to an irregular detection function and a very high coefficient of variation for Howard Prairie. These irregularities disappear when the data are pooled across sites (see tables 5 and 6, and figure 7).

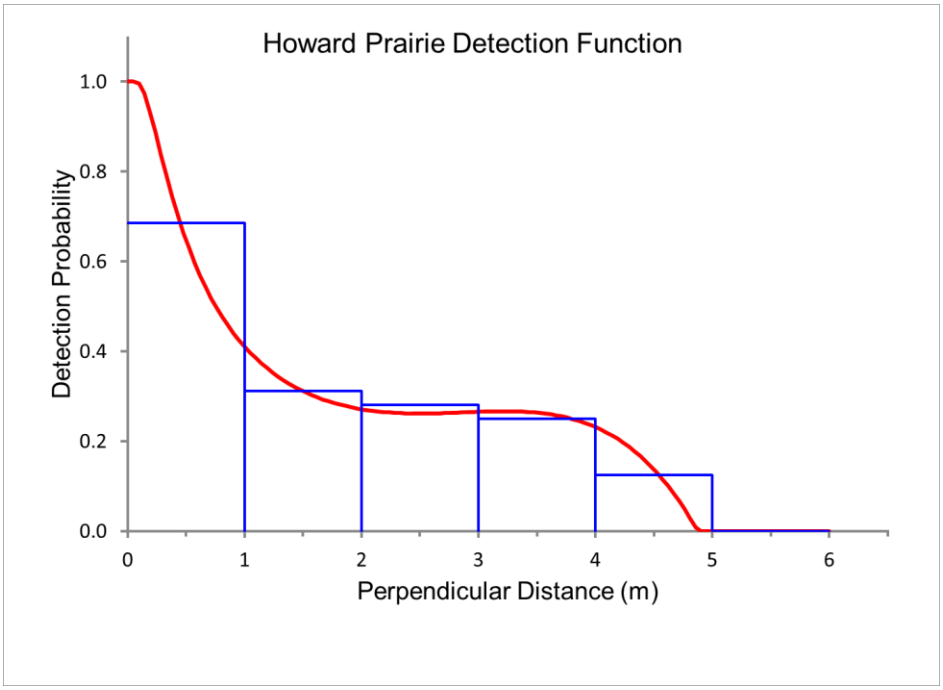


Figure 5: Howard Prairie detection function

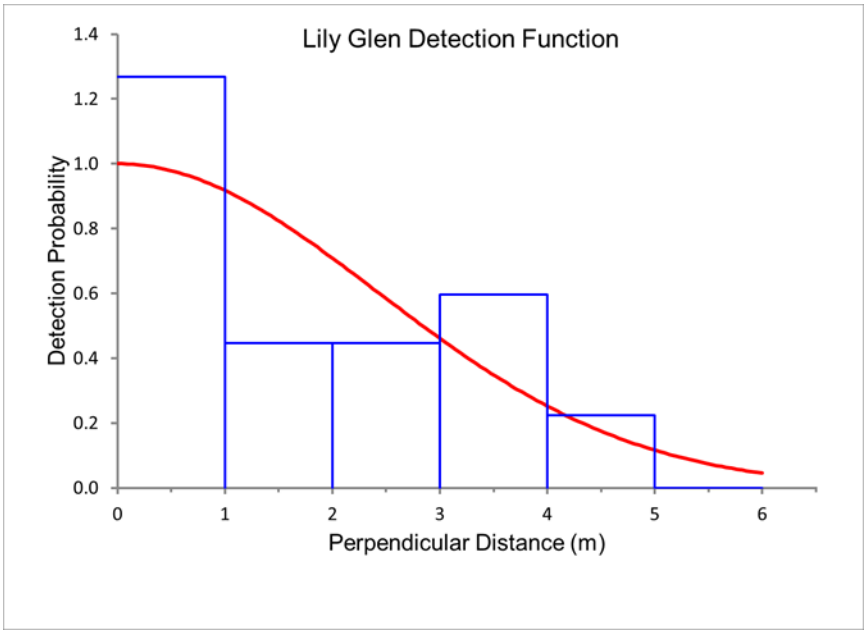


Figure 6: Lily Glen detection function

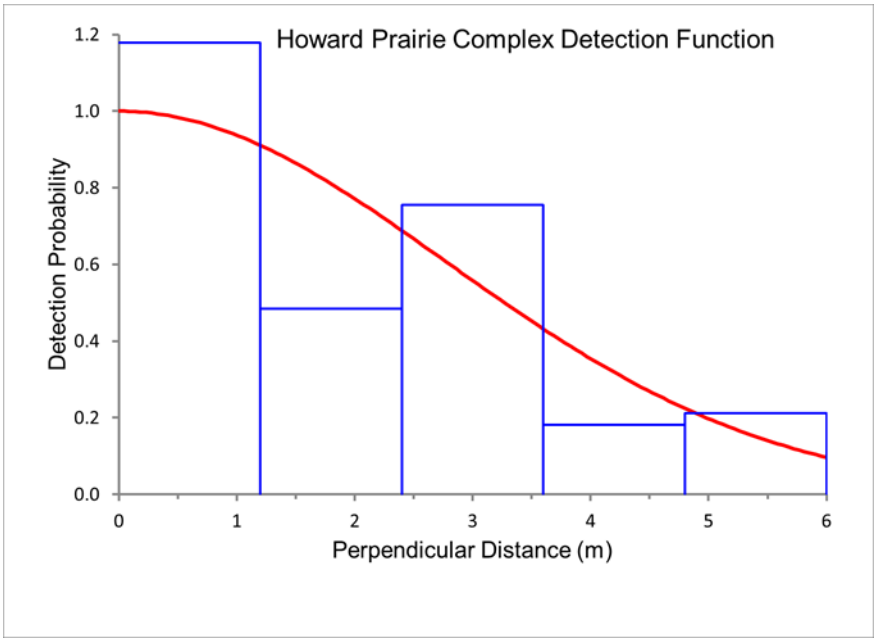


Figure 7: Howard Prairie Complex detection function

Lily Glen

Population estimates are much lower in 2016 than they were in previous years, but the Coefficient of Variation is much lower for this year, at this site, than in years past – indicating that this may be a more accurate population estimate. The population estimate for this year is well within the 95% Confidence Intervals from previous years' surveys.

The tall grass community at this site can impact skipper detectability; by June 7, grasses in the prairie were shoulder high (Barrett 2016, pers. obs.). On June 4 and 7, the site near the east restroom (east end of transect 2) was extremely active, which has always been a reliable netting site (Barrett 2016, pers. obs.). The area around the west restroom was also very active (8 or more individuals in a small area); this site has never had any mardon skippers during surveys (Barrett 2016, pers. obs.). At the other extreme, the west end of transects 1-3, that was very active the last two years was observed to have only checkered skippers this year (Barrett 2016, pers. obs.). Additional species seen in 2016 during netting surveys included: juba skippers and western branded skippers (*Hesperia* sp.). Checkered skipper numbers have increased substantially (at least 30 seen) and appear to emerge and increase in numbers on the same schedule as mardon skippers (Barrett 2016, pers. obs.). Additionally, *Hesperia* spp. seem to be dominant on the south side of the creek while mardon skippers dominate the north side of the creek (Barrett 2016, pers. obs.). By June 28, 2016, nectar sources were starting to decline as well as butterfly numbers; a few areas still had an estimated 10-20% of plants still blooming and while butterfly numbers were low, species diversity was high (Barrett 2016, pers. obs.). By this date, sea blush (*Plectritis congesta*) finished flowering in most areas and *Wyethia* sp. blossoms were totally gone and had brittle leaves. Yarrow (*Achillea millefolium*) continued to bloom but was observed to get little butterfly use (Barrett 2016, pers. obs.).

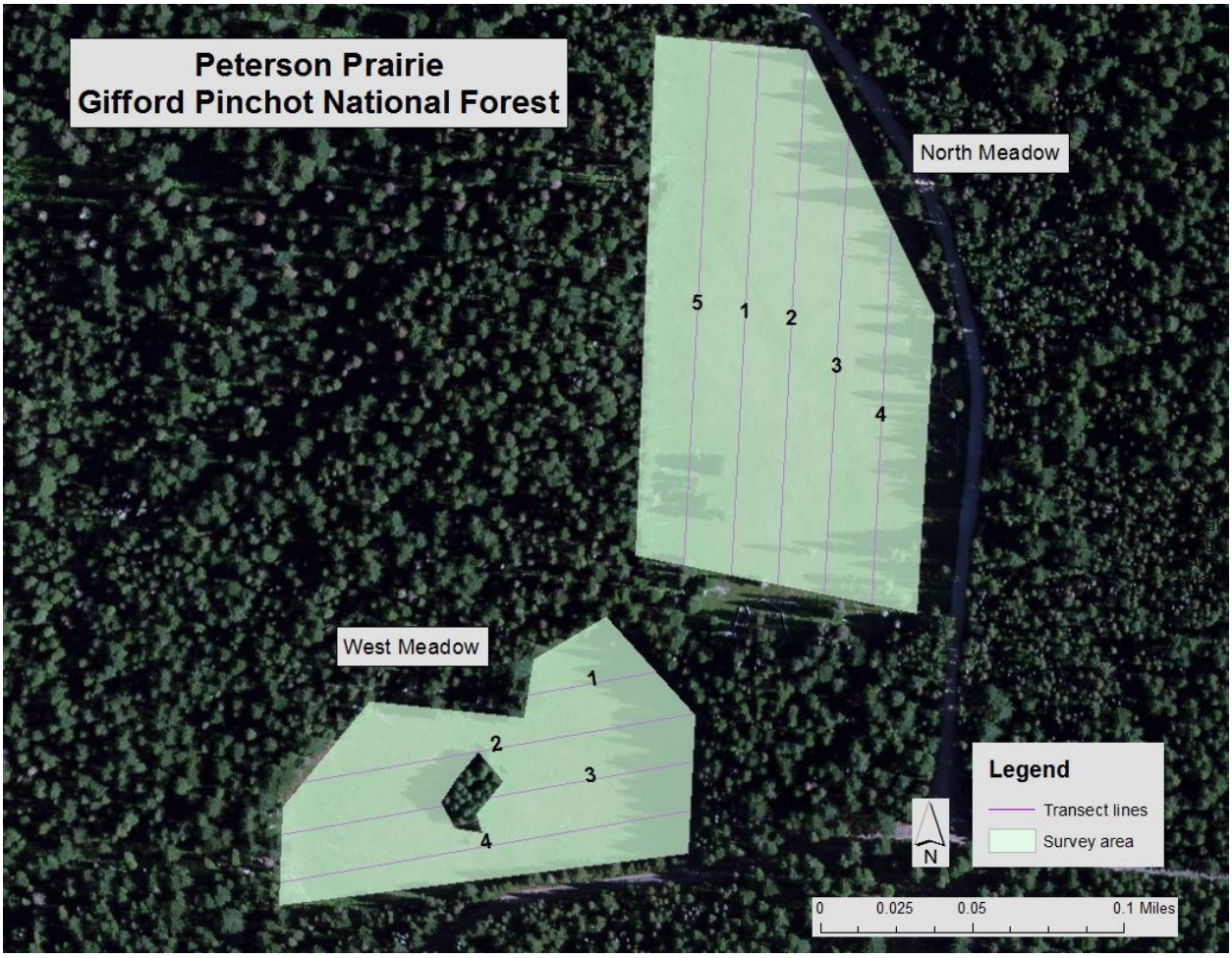
This park has active campsites, several of which are adjacent to the distance sampling transects, posing a potential problem if they are in use during the survey season. This could be especially disruptive if future surveys occur during Memorial Day weekend or the July 4th holiday weekend. The last survey date in 2014 was on July 2, and by July 3 the campground was filled with campers, horses and trailers, with additional campers expanding into the meadows. In 2015, several sites had campers who remained past Memorial Day weekend, but because the last survey date was just shy of the July 4th holiday weekend, there were no observations of camping impacts at the end of the season (Barrett 2016, pers. obs.). Unfortunately, in 2015 this area was impacted by Jackson County Parks personnel mowing the campground on June 16 to reduce fire danger, resulting in a 20 foot portion of Transect 1 getting mowed (Fallon & Hatfield 2015). This level of park activity (in terms of both recreation and mowing) is of potential concern to the maintenance of high quality mardon skipper habitat within the meadow. This year, no campers were observed over the Memorial Day weekend and surveys ended before the July 4th holiday (Barrett 2016, pers. obs.).

PETERSON PRAIRIE, GIFFORD PINCHOT NATIONAL FOREST, WA

Figure 8: Peterson Prairie North Meadow. Photo by Michele Blackburn, the Xerces Society, 2016.

Peterson Prairie is comprised of two natural grass and forb meadows, with the North meadow measuring 3.84 hectares, and the West meadow measuring 2.1 hectares (see Map 4). The elevation of the site is approximately 3,000 feet. These are xeric meadows, without a permanent water source, but there is a low swale which runs diagonally from NW to SE through the North meadow which retains moisture later into the summer. A Region 6 sensitive species, *Sisyrinchium sarmentosum* (pale blue-eyed grass) is found in and near this swale. There is a small aspen (*Populus tremuloides*) grove in the center of the West meadow.

The highest one-day count for mardon skippers at this site was in 2001 when 180 were counted in the north meadow and 49 in the west meadow (Wainwright 2012). Xerces staff set up transects on May 16, 2016, (see Map 4) and conducted all of the monitoring site visits for the remainder of the adult flight period, which ran from May 31 through June 12, 2016 (see Table 7).



Map 4: Peterson Prairie distance sampling survey sites

RESULTS

Throughout the season, 16 skippers were observed at the West Meadow site, and 62 skippers were observed in the North Meadow. The peak count for the 2016 season for both meadows occurred on 5/31/2016 (see Table 7). In the sampled occupied habitat, there is a pooled estimate of 18.97 mardon skippers per hectare (20.92% CV), with a population estimate of 563 skippers within the two meadows (20.92%CV, the habitat was 5.9 HA). For 95% Confidence Intervals, see Table 8. The north meadow has a higher density of butterflies (124.85/HA than the western meadow (44.19/HA). The population estimate for the northern meadow is 479 butterflies (25.76% CV), and the western meadow has 93 butterflies (49.83% CV). This is higher than estimates made in 2015 yet significantly lower than the estimates made in 2014 (Table 8). There were fewer than 30 butterflies detected over the course of the flight period this year in the West Meadow, which is below the minimum recommended number of detections. In this case, the pooled data should be considered for future comparisons and not the data at the West Meadow alone.

The numbers reported in tables 7 and 8 may be higher than the actual number of mardon skippers in the meadow. During post survey counts skippers that were not mardon skippers were netted. However, it was difficult to net enough post-survey butterflies to get reliable estimates to correct the surveys throughout the flight period. Juba skippers were the only other species of skipper observed during surveys.

Table 7: Number of skippers detected by site and date at Peterson Prairie.

Site	Area (HA)	# Transects	Total Distance of Transects (m)	5/16/2016	5/31/2016	6/3/2016	6/7/2016	6/12/2016	Total Observed*
West Meadow	2.1	4	697.58	0	12	1	2	1	16
North Meadow	3.84	5	1209.74	1	31	22	7	1	62
Pooled	5.94	9	1907.32	1	43	23	9	2	78

*Note: This includes all skippers detected during distance sampling (not just mardon skippers). It is possible that the same individuals were counted on multiple site visits.

Table 8: Peterson Prairie population estimates in 2014, 2015, and 2016.

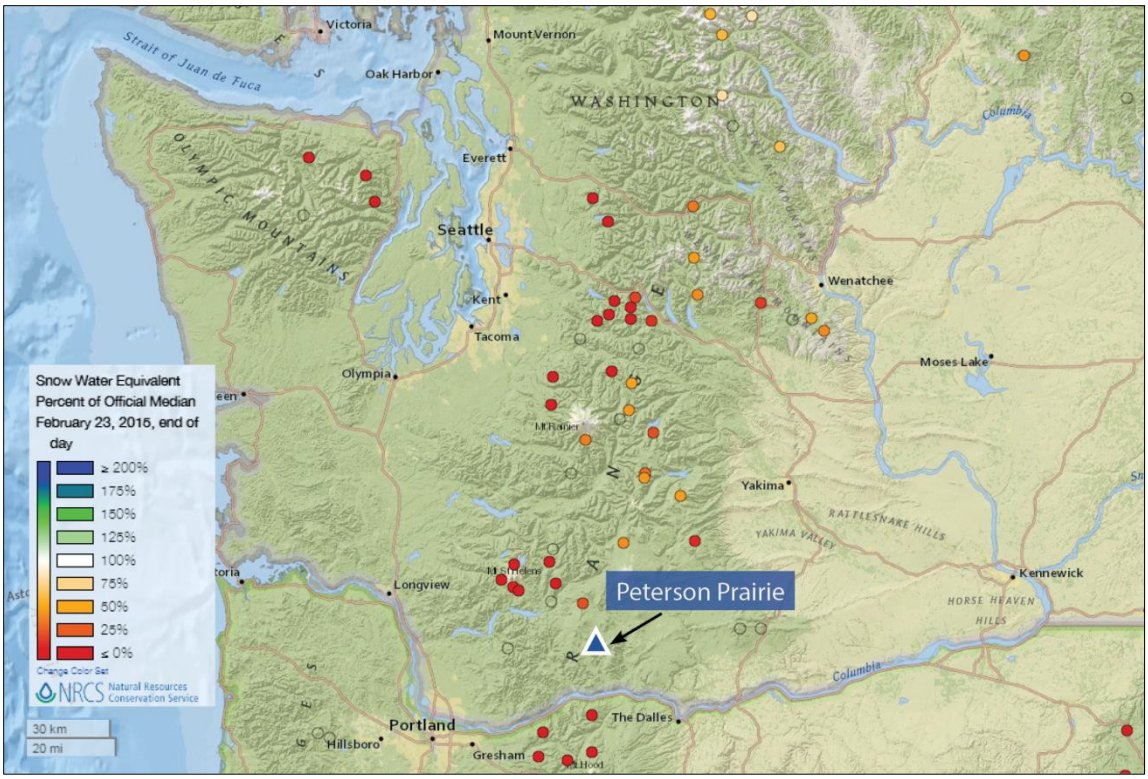
		2014				2015				2016			
Site	Estimate	Pop. size	% CV	95% CI		Pop. size	% CV	95% CI		Pop. size	% CV	95% CI	
Peterson Prairie North Meadow	Density (N/HA)	633.5	21.8	367.8	633.5	71.25	30.63	21.66	71.25	124.85	25.74	66.05	236.0
	Population (N)	2,433.0	21.8	1,412.0	2,433.0	151	30.63	83	274	479	25.76	254	906
Peterson Prairie West Meadow	Density (N/HA)	121.2	18.3	82.8	121.2	6.79	49.87	2.58	17.85	44.19	49.83	12.733	153.37
	Population (N)	255.0	18.3	174.0	255.0	14	49.87	5	37	93	49.83	27	322
Pooled Estimate	Density (N/HA)	452.4	19.8	276.3	740.7	25.53	26.96	15.13	43.08	18.97	20.92	12.4	29.0
	Population (N)	2,687.0	19.8	1,641.0	4,400.0	152	26.96	90	256	563	20.92	368	861

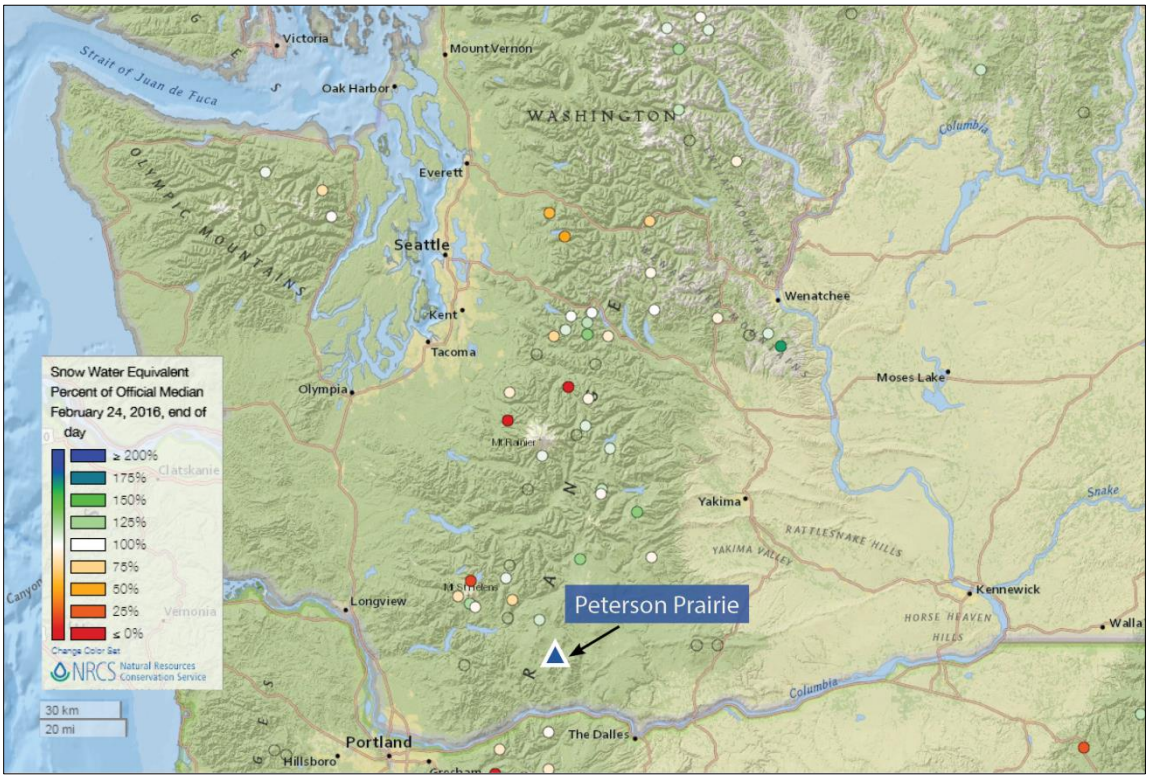
DISCUSSION

Peterson Prairie is a very dry site with limited nectar sources during the adult mardon skipper flight season. The most abundant nectar sources in 2016 were camas (*Camassia quamash*) and purple violets (*Viola* spp.). Other blooming plants found during the survey season included dusky horkelia (*Horkelia fusca*), cinquefoil (*Potentilla* sp.), yarrow (*Achillea millefolium*), and spreading phlox (*Phlox diffusa*). Other than mardon skippers, butterflies noted during surveys included western ochre ringlets (*Coenonympha tullia*), pale tiger swallowtails (*Papilio eurymedon*), blue butterflies (*Plebejus* spp.), chalcedona checkerspots (*Euphydryas chalcedona*), greater fritillaries (*Speyeria* spp.), and satyr anglewings (*Polygonia satyrus*).

Population estimates for Peterson Prairie in 2016 were higher than those made in 2015, though both years experienced significantly lower population numbers compared with 2014 (see Table 8). In Fallon & Hatfield (2015), we noted that site conditions were notably drier in 2015 than in 2014 and population numbers significantly lower. In 2016 snow remained in shaded parts of the west meadow in late May, perhaps indicating more normal water conditions. Insect populations undergo natural fluctuations from year to year; however, the multiple and likely compounding effects of drought on an already dry site like this could lead to local population declines that were seen in 2015. Low elevation snowpack throughout the Washington Cascades was less than 50% of the 1981-2010

median for winter 2014 (Fig. 9a), but snowpack rebounded in winter 2015/2016 in some areas of the cascades near Peterson Prairie; measuring above the 1981-2001 median (Fig. 9b). The favorable weather conditions this year may have influenced the moderate increase in mardon population numbers for Peterson Prairie.





Figures 9a & 9b: Snow Water Equivalent map depicting snowpack levels as of February 23, 2015 (NRCS 2015), and snowpack as of end of February 2016 (NRCS 2016).

Detection of mardon skippers fell below 60% after just one meter from the transect in the north meadow but less drastically in the west meadow (Figs. 10 and 11). A pooled detection curve for the two meadows is shown in Figure 12. It is important to note that there were many more detections in the north meadow (see Tables 7-8), so its detection curve may be a more realistic representation of this species' detection function, at least in this habitat.

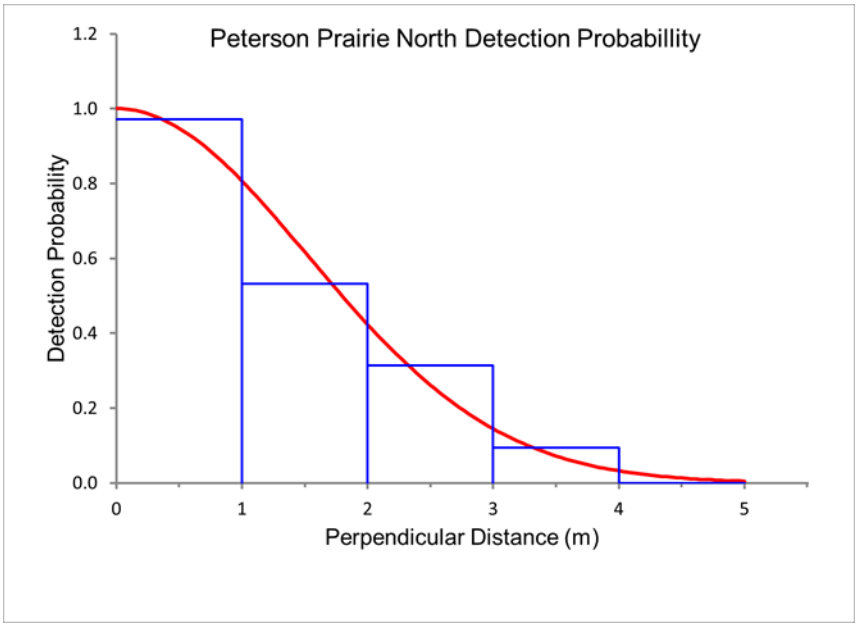


Figure 10: Peterson Prairie North detection function

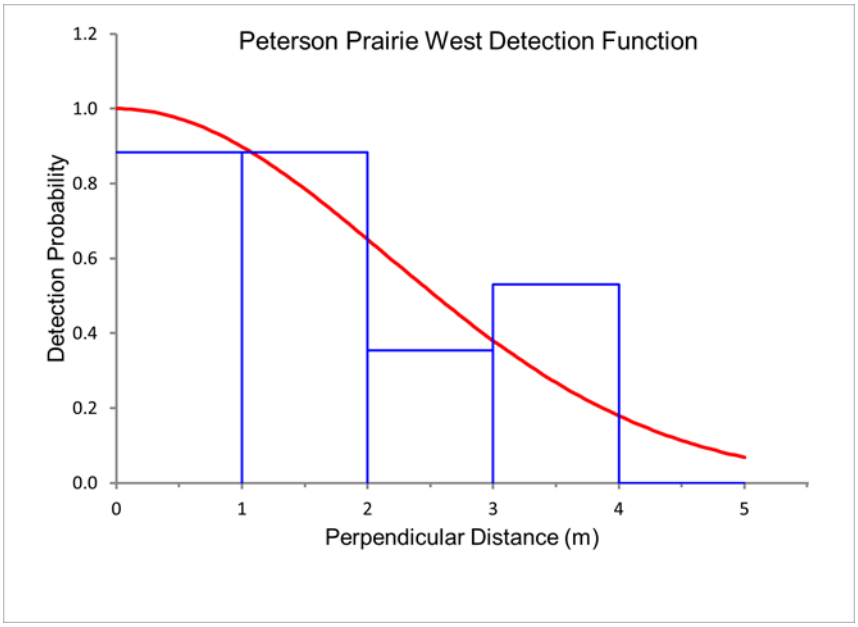


Figure 11: Peterson Prairie West detection function

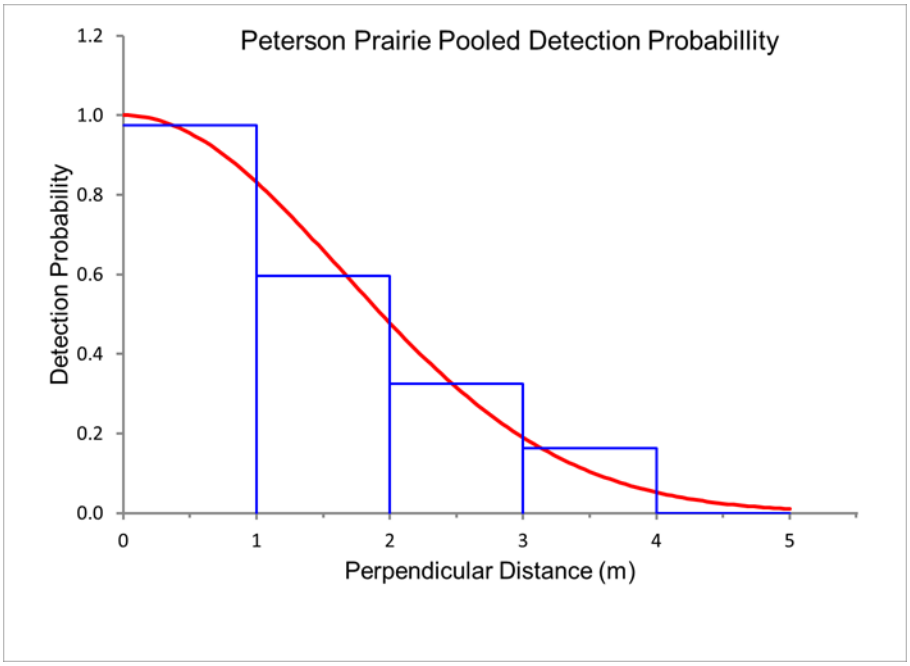


Figure 12: Peterson Prairie Complex detection function

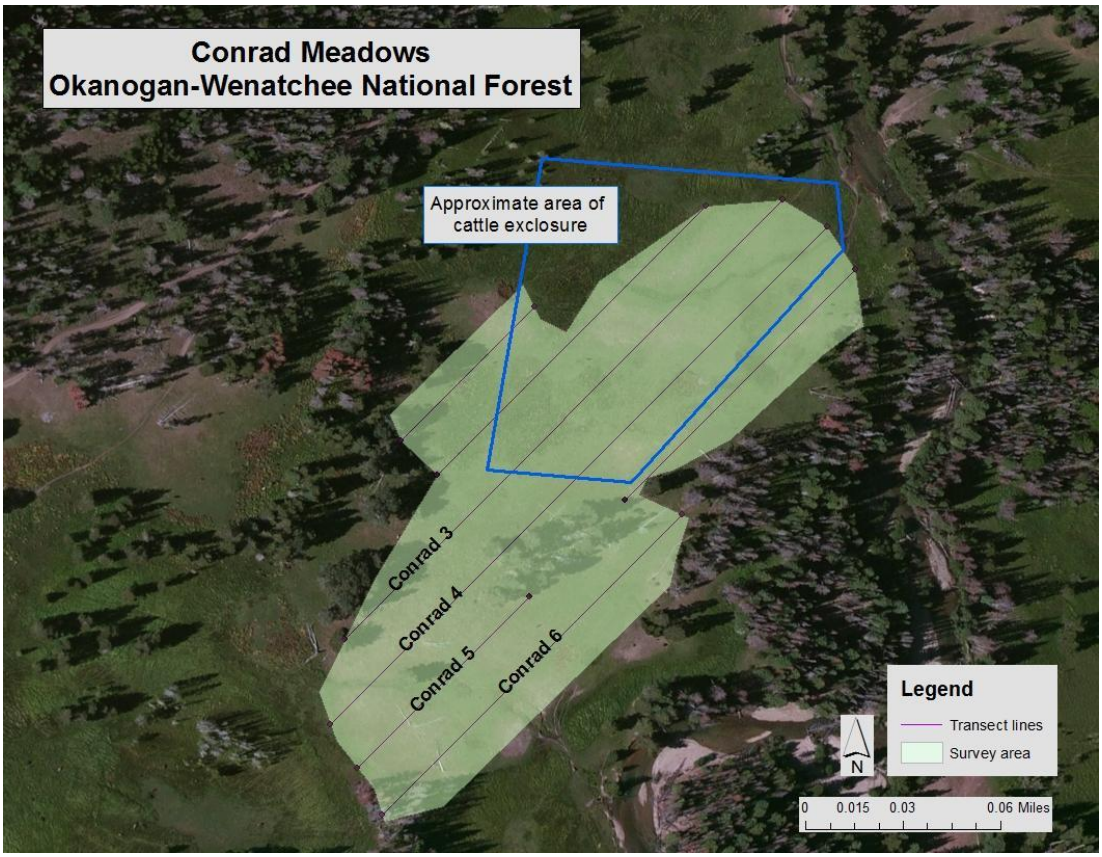
CONRAD MEADOWS, OKANOGAN-WENATCHEE NATIONAL FOREST, WA

Figure 13: Conrad Meadows survey site. Photo by Candace Fallon, the Xerces Society, 2015.

The Conrad Meadows site is part of a large complex of grass meadows near the edge of the Goat Rocks Wilderness. Mardon-inhabited areas are dominated by native onespike oatgrass (*Danthonia unispicata*). Various *Poa* and *Carex* spp. are also scattered throughout the meadow. Blooming nectar plants included camas (*Camassia*

quamash), slender cinquefoil (*Potentilla gracilis*), aster, clover, and delphinium (*Delphinium* sp.) (St. Hilaire 2016, pers. obs.) This site has been monitored since 2007 (although no surveys occurred in 2013), with the largest one-day population estimate occurring in 2009 with 931 mardon skippers (St. Hilaire 2012).

Forest Service staff reset the permanent distance sampling transects in this meadow using tall PVC pipes and flagging (see Map 5) on May 30. These tall pipes made seeing the transects much easier for the surveyor, particularly since pin flags cannot be used at this site due to elk activity. Weather conditions were within protocol limits during the first visit on May 30th, though no mardon skippers were detected in an informal survey; survey transects were not walked. Formal surveys began on June 6. Similar to the 2014 and 2015 seasons, when the first visits were the highest recorded population estimates for the adult flight season, the beginning of the mardon skipper flight season was missed in 2016 (see Table 9).



Map 5: Conrad Meadows distance sampling survey site

RESULTS

Throughout the 2016 season, 578 skippers were observed in Conrad Meadows. The peak count occurred on the first day of surveys (6/6/2016) (see Table 9). In the sampled occupied habitat, there is an estimated density of 712.14 mardon skippers per hectare (13.76% CV), and a population estimate of 2,742 mardon skippers (13.76% CV). For 95% confidence intervals, see Table 10.

Table 9: Number of skippers detected by date at Conrad Meadows.

Site	Area (HA)	# Transects	Total Distance of Transects (m)	6/6/2016	6/21/2016	6/28/2016	7/3/2016	7/11/2016	Total Observed*
Conrad Meadows	3.85	6	1435.39	168	162	166	73	9	578

*Note: This includes all skippers detected during distance sampling (not just mardon skippers). It is possible that the same individuals were counted on multiple site visits.

Table 10: Conrad Meadows population estimates in 2014, 2015, and 2016.

		2014				2015				2016			
Site	Estimate	Pop. size	% CV	95% CI		Pop. size	% CV	95% CI		Pop. size	% CV	95% CI	
Conrad Meadows	Density (N/HA)	1,593.1	15.84	1,060.0	2,316.7	2,291	10.56	1,858	2,824	712.14	13.76	537.3	943.9
	Population (N)	6,135.0	15.84	4,081.0	8,919.0	9,875	10.56	7,999	12,189	2,742	13.76	2,069	3,635

DISCUSSION

It is notable that these estimates are possibly lower than the actual butterfly population in the meadow; the first day that butterflies were detected was also the highest daily count of the 2016 season (see Table 9). While a fair numbers of mardon skippers were seen on the first survey date (June 6, 2016), the cool weather conditions in the days leading up to this visit likely indicate that the peak of the population did not occur before June 6th. Incidental observations made by a biologist (OKW Range Conservationist) on June 10th indicated that mardon skipper numbers were very high and mating was occurring (Pers. Com to J. St. Hilaire 2016). The very warm weather (90-100F) following June 6th may have resulted in increased activity, with the peak occurring before the second visit on June 21st; unfortunately this survey period was missed. Additionally, there were freezing temperatures between June 13th and June 21st generating unsuitable weather conditions for surveys, and potentially lethal conditions for adult and larval butterflies. This weather may also have affected the flight period resulting in lower numbers of mardon skippers (St. Hilaire, pers. com. 2016). While the lower counts observed this year may be a factor of the weather, they may also reflect inconsistent sampling effort. We understand that spring weather can create difficult survey conditions at this site, and likely contributed to this uncertainty.

In most years, this site is grazed by both wild elk and domestic cattle throughout the adult flight period. Conrad Meadow may be highly productive for mardon skippers due to the high complexity of the meadow (several different plant communities), variety of moisture from dry to wet (with moist areas present even during drought conditions), variety of grass heights (short to tall), and grazing intensities (from heavy to light) (Fallon & Hatfield 2015).

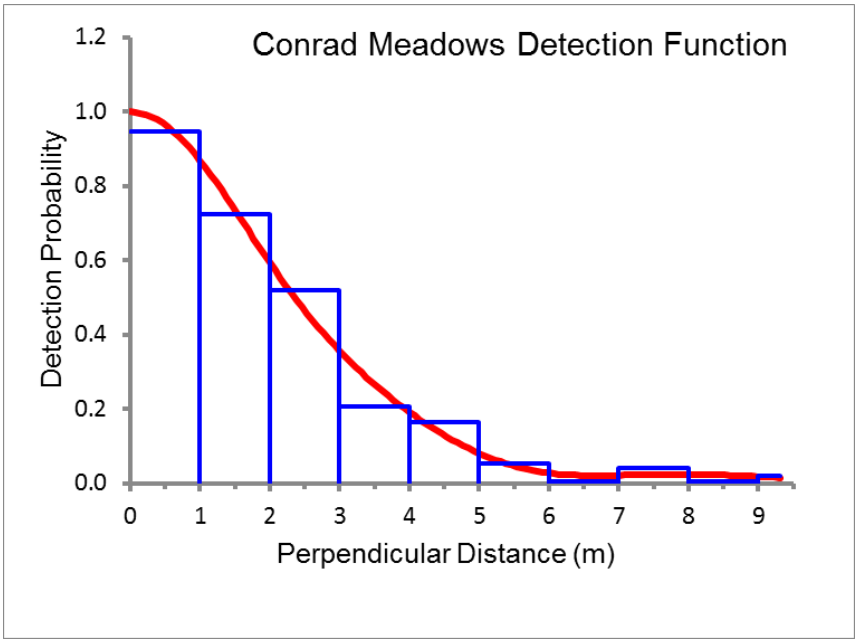


Figure 14: Conrad Meadows detection function

TRENDS AND ANALYSIS

While three years is probably insufficient to look at trends and population averages, we include this information here as a way to compare the results of the last three years (see Figures 15-18). It is important to note that these comparisons and trend analyses are only as good as the data collected. As such, there have been noted omissions in data collection at Windy Valley and at Conrad Meadows (see above and Fallon & Hatfield 2014, 2015). In each of the three years of surveys at Conrad Meadows the beginning of the flight season has not been surveyed. At Windy Valley, much of the flight season was missed in 2014 and 2016. These discrepancies make comparisons between years difficult as the entire population was not surveyed in those years.

Each year's population estimate at the Howard Prairie complex are within the 95% Confidence Intervals, although the population in 2016 does appear to be quite a bit lower than the previous years' estimates, despite similar effort (Fig. 15). Nevertheless, insect populations are notoriously stochastic and this amount of variation is not unexpected. However, it will be important to continue monitoring this site because of the high level of recreational activity.

The Peterson Prairie data are a bit harder to read. Population estimates were highest in 2014, with a significant drop in 2015 – but followed by a more moderate, yet significant increase in 2016 (Fig. 16). It is possible that the population in 2015 was small because of the low snow levels that we noted last year, and this year saw a bit of a recovery as conditions were more favorable. While this is pure speculation, we believe it further emphasizes the need to monitor surrounding populations as the danger of repeated stochastic weather events could potentially cause local extirpations. Without satellite populations nearby, natural repopulation of extirpated meadows would be extremely difficult.

Population estimates for both Conrad Meadows and Windy Valley were their lowest in 2016 (Figs 17 and 18). However, because of inconsistent monitoring efforts, it is unclear if these estimates are accurate reflections of the population, or sampling errors. For Conrad Meadows we suspect that it may be some of each as anecdotal reports from that site this year suggest that the number of butterflies was fewer than it had been in years past (St. Hilaire 2016, pers. comm.). We do not have similar reports from Windy Valley. However, the maximum count for that site

for 2016 (N=31) was significantly lower than the maximum counts in 2014 and 2015 (N=113 and 89, respectively). Unfortunately, it is unclear if the peak count on June 2, 2016 was the true peak, or if the true peak occurred in the 18 days that went by without further surveys. It is worth noting that the peak counts for 2014 and 2015 were after June 2.

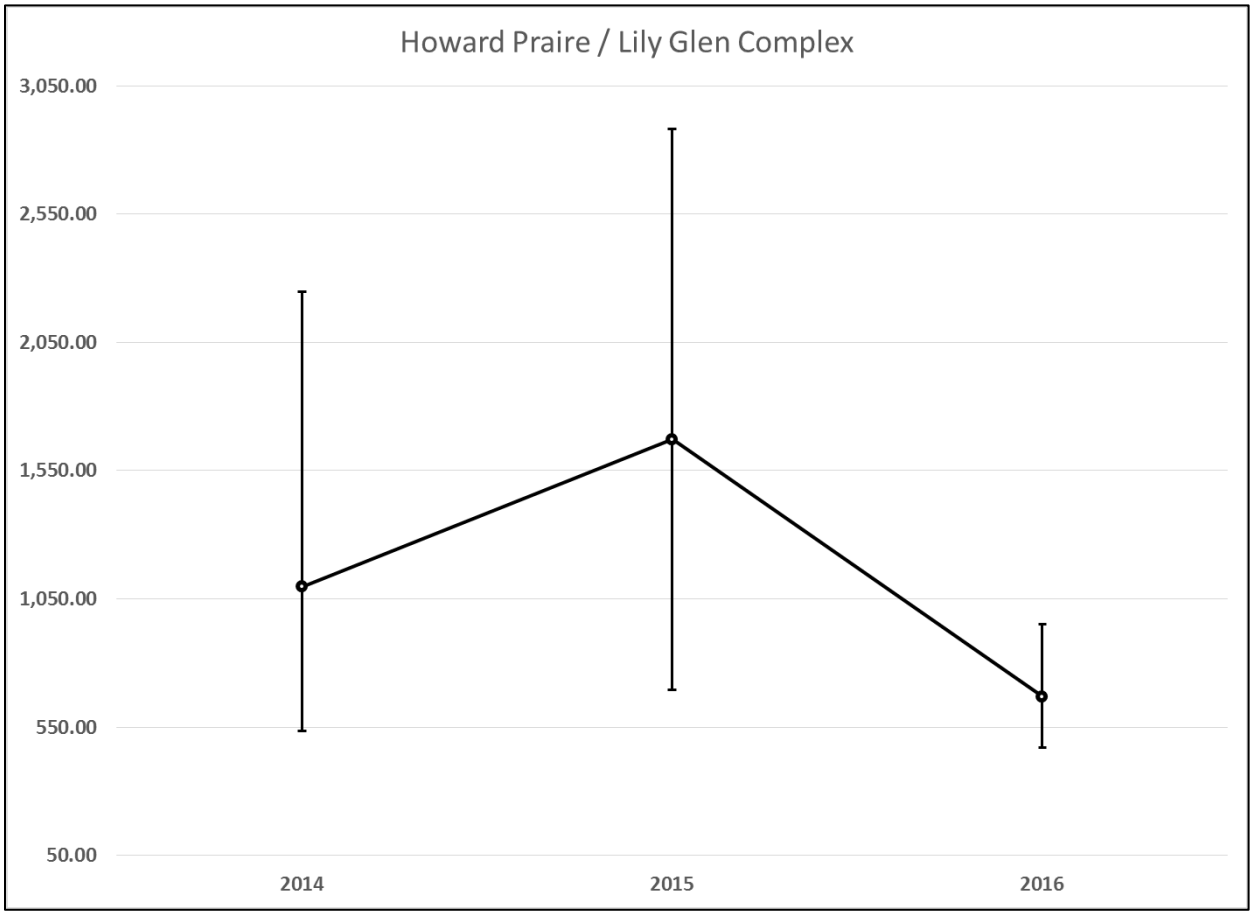


Figure 15: Howard Prairie complex population estimates (dots) and 95% confidence intervals (error bars).

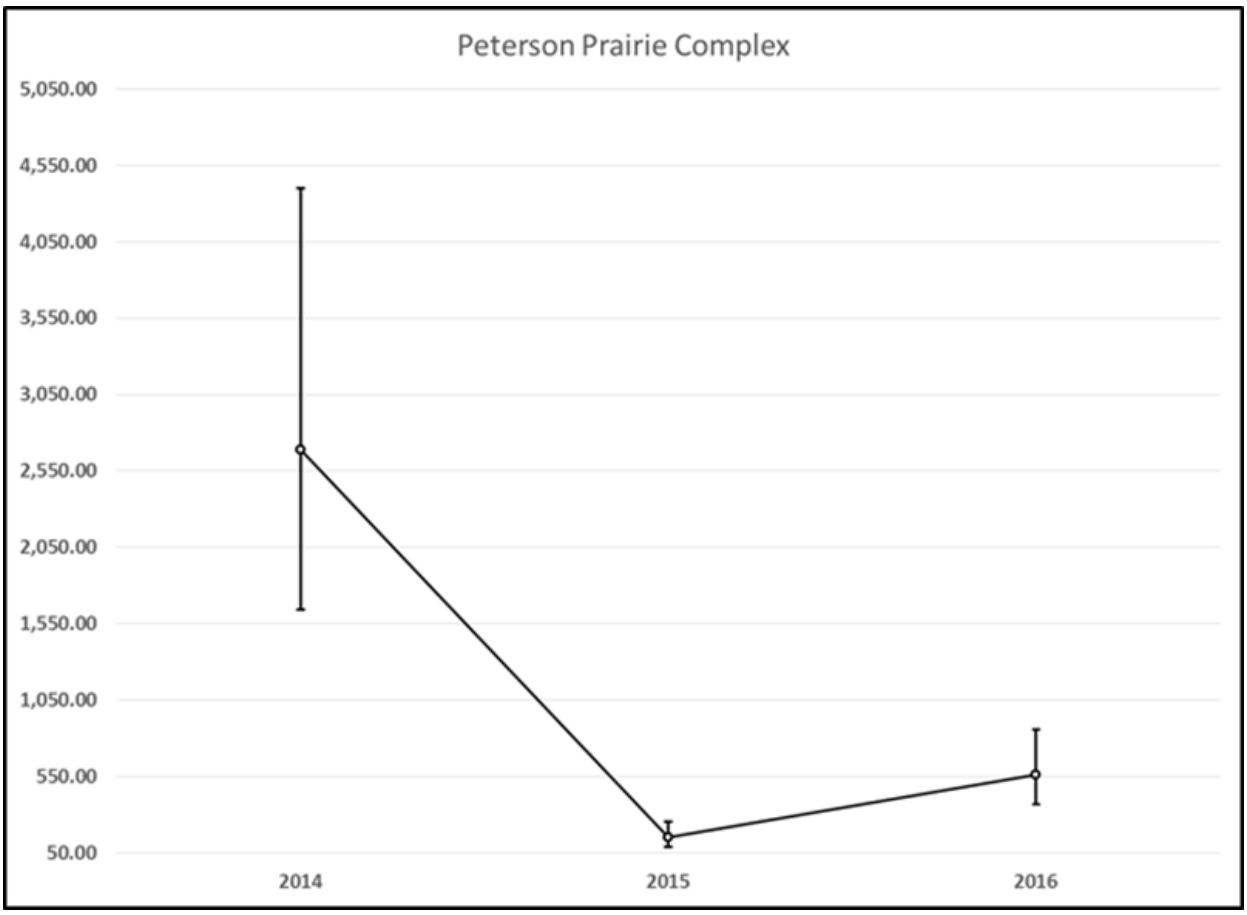


Figure 16: Peterson Prairie complex population estimates (dots) and 95% confidence intervals (error bars).

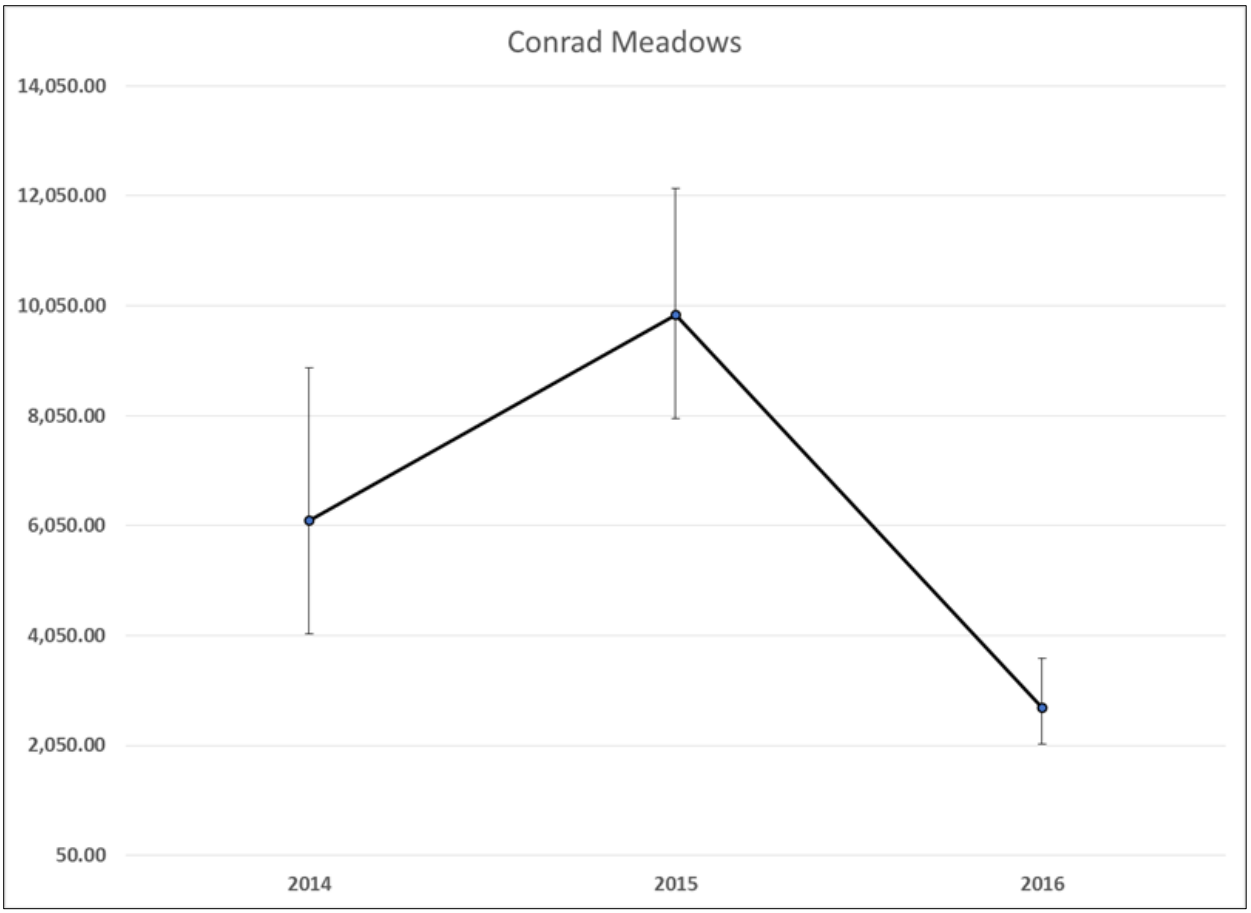


Figure 17: Conrad Meadows population estimates (dots) and 95% confidence intervals (error bars).

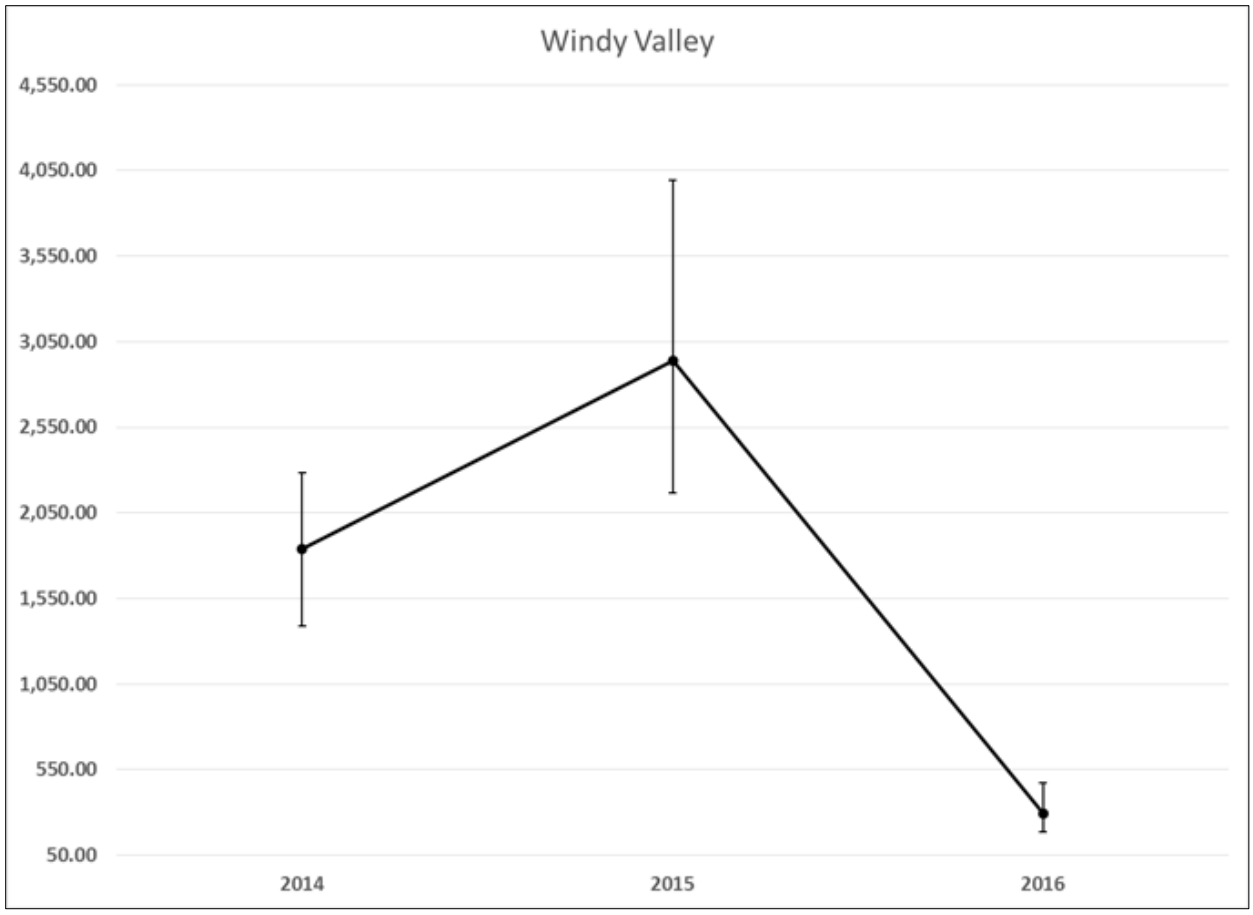


Figure 18: Windy Valley population estimates (dots) and 95% confidence intervals (error bars).

GENERAL RECOMMENDATIONS FOR MONITORING AND MANAGEMENT

FUTURE SURVEYS

We recommend continuing to monitor each of these sites using distance sampling surveys (ideally with 5-7 visits to each site within the adult flight period) to better understand the size of the population at each site and the distribution within each of the sites. It may take several more years to determine if there are any trends in those population estimates. We recommend that surveyors review the Distance Sampling protocol (Hatfield 2013) each year to review the assumptions of Distance Sampling, and to ensure that future surveys meet those assumptions. We particularly urge surveyors to focus on 100% detection on the survey transect, and to monitor the population throughout the flight period of the butterfly.

It is important to note how quickly detection of the mardon skipper drops off in almost all of the environments surveyed. At some sites, in just over one meter, the probability of detection drops to 50% or less (see detection probability functions in results section for each site). This solidifies the importance of using a sampling method that accounts for detectability when sampling for the mardon skipper. It is also notable that each meadow/habitat has vastly different detection functions, and that no two habitats are the same. Whether this is due to habitat differences, differences in butterfly behavior between locations, or observer differences is beyond the scope of

this investigation, but worthy of consideration. If the differences are biological in nature (and not due to observer differences/error), they could be indicative of differences in mardon skipper ecology between the contrasting portions of the species' range.

We also recommend instituting detection/no-detection surveys as outlined in Hatfield et al. (2013a) in a subset of historically occupied meadows. It has been several years since many of those sites have been visited, and it would be good to reconfirm the species' presence throughout its range. This is particularly relevant as weather patterns over the last few years have induced extremely early flight seasons, and the area has experienced prolonged drought conditions, which has the potential to affect small populations.

THREATS & GENERAL MANAGEMENT RECOMMENDATIONS

Throughout its range the mardon skipper is threatened by many different factors, including conifer encroachment, invasive grasses and forbs, grazing by domestic livestock, off-road vehicle (ORV) use, prescribed and natural fire, recreation (including camping), applications of Btk, climate change, and issues related to small population size and stochastic events. On a landscape scale, climate change is a longer term threat. Of these threats, conifer encroachment, ORV use in the meadows, grazing by livestock, land management (mowing), and recreational use are the primary threats to mardon skipper populations at the meadows covered in this report. Below we discuss these threats and some general recommendations for management.

INVASIVE WEEDS AND CONIFER AND SHRUB ENCROACHMENT

Sites affected: All to some degree, but especially Lily Glen, Howard Prairie, and Peterson Prairie West

Conifer encroachment and invasive grasses and forbs are among the two most pervasive threats to mardon skipper habitat, yet control of these threats is attainable through active and adaptive management. Conifer encroachment and invasive species are threats because they have the ability to alter micro and macro-habitats within the meadow boundaries. Butterfly populations are constrained by temperature (Crozier 2003, 2004) and are restricted to especially warm macro- and microhabitats in temperate climates (Thomas et al. 2001). The small tufts of vegetation and open habitat structure selected by ovipositing females are likely to correspond to the warmest locations in the prairie or meadow (Forsberg 1987). The recent meta-analysis by Thomas et al. (2011) indicates that host plant condition is positively correlated with butterfly population health in the majority of well-studied taxa in temperate regions. Moreover, there is field evidence that populations that occupy high quality larval habitat are more persistent and more likely to serve as a source in a metapopulation (Thomas et al. 2011). Thus, for the mardon skipper, any process that has the potential to alter host plant conditions will also likely negatively affect mardon skipper populations; maintaining open meadow conditions should be a priority for this species.

In 2014, Xerces staff observed several areas at Lily Glen and Peterson Prairie that were in the early stages of conifer or shrub encroachment (see Figure 19). Here and in areas where this is occurring, small trees and problematic shrubs should be removed as soon as possible, before they grow larger and reproduce. A plan should be developed and implemented that removes trees using methods that incorporate sensitivity to the butterflies' life history. We provide general recommendations for conifer encroachment and invasive species removal below, but also stress the need to consult with a butterfly habitat restoration specialist to develop site specific management plans.

Figure 19: Example of tree and shrub encroachment in mardon skipper meadow at Lily Glen, OR. Photo by Candace Fallon, the Xerces Society, 2014.

Ideally, a conifer removal plan would include the following:

- Remove all small trees under 4 inches Diameter at Breast Height (DBH) from the open meadow area of the site.
- Wherever possible, cut by hand with chainsaws or handsaws.
- Remove all downed wood and branches from the meadow area.
- Take care to avoid actions that could degrade habitat and kill individual skippers as a result of heavy equipment use, people trampling meadows, scattering or piling of trees or branches in meadows, or burning of piles in or adjacent to the occupied area of the site.
- Maintain a buffer of large trees at the edges of meadow since they may play an important role in maintaining the microclimate and hydrology of the local habitat. If thinning is needed for fuels and/or ecosystem needs only remove small diameter trees. If additional tree removal is needed consult with someone familiar with the effects of habitat restoration, mardon skipper biology, and their distribution within the meadow.

Used indiscriminately, herbicides can reduce the quality of habitat by removing floral resources and host plants, and may be directly toxic to some pollinators. However, herbicides are a cost-effective vegetation management tool and are the only tools available to control some noxious weeds. Judicious herbicide use can suppress undesired vegetation while maintaining diverse habitat. We stress the need to consult with a butterfly habitat restoration specialist to develop site specific management plans that are specific to the life history requirements of the mardon skipper. Ideally, if herbicides are used:

- Use the most targeted active ingredient and formulation possible, applying during the life stages when weeds are most vulnerable.
- Conduct spot treatment of individual invasive or noxious weeds or woody plants with a backpack sprayer, weed wiper, or similar appropriate technology.
- If possible, apply herbicide treatments in fall when mardon skippers are not active.

RECREATION

Sites affected: All (to varying degrees)

Recreation in the form of camping, hiking, horseback riding, or off road vehicle (ORV) use can potentially harm mardon skippers and their habitat. These activities can directly affect mardon skippers by crushing eggs, larvae, pupae, or adults. In addition, the quality of mardon skipper habitat may be impacted by soil disturbance, introduction of non-native invasive weeds, and damage to nectar and host plant resources. The primary recreation uses at these four sites are camping, hiking, and horseback riding.

Windy Valley is subjected to the least recreational pressure due to being more difficult to access (the meadow is reached by hiking a 1.5 mile trail), although a small campsite is available adjacent to the meadow.

Peterson Prairie is easily accessible off a Forest Service road and there is evidence of off road vehicle (ORV) use in the larger north meadow (surveyors found vehicle parts and a piece of a helmet in the meadow). Additionally, water to stock Peterson Prairie Campground at the beginning of the season is obtained by trucks which access the north meadow from a gate at the southwest end. This creates disturbance through several sampling transects and damage to breeding habitat in the preferred wet areas of the meadow (see Fig. 20).

Figure 20: Areas needing management attention, Peterson Prairie, WA. Photo by Michele Blackburn, the Xerces Society, 2016.

Conrad Meadows is accessible via a gated and locked private road or a hiking and equestrian trail. As the trail through the meadow is an access point for the Goat Rocks Wilderness, horses and riders frequently ride across the mardon skipper occupied habitat.

Howard Prairie and Lily Glen are both accessible via good paved roads, although Howard Prairie appears to get fewer visitations. Lily Glen provides camping and recreation opportunities and functions as a County Park. This site probably gets the most recreation use out of all the mardon skipper sites covered in this report. Specific recommendations for Lily Glen include the following (note that all of these recommendations were also provided in the site-specific management plan developed in 2013. For more detailed recommendations, see Hatfield et al. [2013b]):

- Do not allow camping in the mardon skipper occupied areas
- Install a hard crossing in the creek bottom for horses to stabilize stream channel and install a sign to direct horse traffic to one crossing (see horse damage along creek margins, Fig. 21)
- Repair the pedestrian bridge and install a sign to direct pedestrians to the bridge (see Fig. 21)
- Ensure that only Certified Weed Free Hay is used on site


Figure 21: Areas needing management attention, Lily Glen, OR. Photos by Candace Fallon, the Xerces Society, 2014.

LIVESTOCK GRAZING

Sites affected: Lily Glen, Howard Prairie, and Conrad Meadows

Livestock grazing may cause adverse impacts to butterfly populations by trampling all butterfly life stages, removing larval and adult food sources, and disturbing the soil and allowing weeds to invade (Warren 1993). Tall-grass and mixed-grass prairies appear to be very susceptible to the effects of overgrazing (Royer and Marrone 1992; McCabe and Post 1997; Royer and Royer 1998, cited in COSEWIC 2003), which can reduce or eliminate critical adult nectar sources and larval host plants. In a study on the Dakota skipper (*Hesperia dacotae*), Dana (1997) found that grazing cattle reduced skipper numbers in direct proportion to grazing intensity. However, grazing is not always detrimental; some light or rotational grazing created mixed grass vegetation structure that was actually preferred by the Dakota skipper (Dana 1991). In the absence of fire and other natural disturbances, cattle grazing may play a role in maintaining the disturbance necessary to maintain open meadow habitats essential for mardon skippers. However, if the disturbance from grazing is too intense, it can have detrimental effects on butterflies and other plant and animal populations (Bilotta et al. 2007; Hatfield & LeBuhn 2007; Wallis De Vries et al. 2007; Dumont et al. 2009; Kimoto 2011).

The Lily Glen, Howard Prairie, and Conrad Meadow mardon skipper sites all occur within active grazing allotments, which are grazed at different times of year at different densities. Lily Glen and Howard Prairie are usually grazed in October and November, after the adult flight period has ended (Hatfield et al. 2013b). At Conrad Meadows, cattle are often present during the adult flight period in July but are excluded from part of the mardon skipper occupied habitat by a temporary fence (St. Hilaire 2014, pers. comm.). Further investigation into the effects of livestock grazing on mardon skipper populations is recommended at each of these sites. This should include site-specific research to determine the most appropriate combination of timing, intensity, and duration. Below we provide some general recommendations for livestock grazing; for more detailed recommendations and management plans for these sites, see St. Hilaire (2012) and Hatfield et al. (2013b).

General recommendations:

- At the most severely impacted sites cattle should be excluded from the area to allow the habitat time to recover.
- Grazing should never be allowed during the flight period of the adult mardon skipper.
- Optimally, cattle should not be allowed to enter a site when mardon skipper larvae are active, although more research is needed to determine the impact of cattle on mardon skipper larvae at various times of the year.
- Use low stocking rates.
- Keep grazing periods short, with recovery periods for the habitat relatively long.

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APPENDIX: ENDPOINTS FOR DISTANCE SAMPLING TRANSECTS

Coordinates are NAD 1983, Zone 10. Note that the Howard Prairie endpoints are different than those used in 2014.

Site	Points	UTM E (X)	UTM N (Y)
Windy Valley		**Transect**	**1**
	Start	405329.4	4687206.3
	End	405334.0	4687264.1
		Transect	**2**
	Start	405306.1	4687179.0
	End	405314.6	4687280.0
		Transect	**3**
	Start	405285.1	4687186.2
	End	405253.7	4687284.4
Howard Prairie		**Transect**	**1**
	Start	545512.4	4679411.2
	End	545653.7	4679552.5
		Transect	**2**
	Start	545534.7	4679362.8
	End	545796.2	4679624.3
		Transect	**3**
	Start	545569.7	4679327.1
	End	545778.3	4679535.7
		Transect	**4**
	Start	545604.7	4679291.3
	End	545760.2	4679446.8
Lily Glen		**Transect**	**1a**
	Start	546641.5	4679833.1
	End	546824.6	4680016.3
		Transect	**1b**
	Start	546641.7	4679762.6
	End	546879.8	4680000.8
		Transect	**2a**
	Start	546641.7	4679762.6
	End	546879.8	4680000.8
		Transect	**2b**
	Start	546910.6	4680031.6
	End	547064.7	4680185.8

Site	Points	UTM E (X)	UTM N (Y)
Lily Glen continued		**Transect**	**3**
	Start	546696.1	4679746.3
	End	547178.5	4680228.8
		Transect	**4**
	Start	547057.6	4680037.2
	End	547097.6	4680077.2
		Transect	**5**
	Start	547055.5	4679964.4
	End	547230.5	4680139.4
		Transect	**6**
	Start	547105.0	4679943.1
	End	547213.7	4680051.7
Peterson Prairie North		**Transect**	**1**
	Start	603607.9	5091704.6
	End	603622.5	5091984.8
		Transect	**2**
	Start	603632.6	5091699.4
	End	603647.4	5091982.2
		Transect	**3**
	Start	603657.4	5091694.3
	End	603670.1	5091937.0
		Transect	**4**
	Start	603682.2	5091689.2
	End	603692.7	5091890.4
		Transect	**5**
	Start	603583.1	5091709.7
	End	603597.6	5091987.3
Peterson Prairie West		**Transect**	**1**
	Start	603500.1	5091641.5
	End	603568.3	5091653.6
		Transect	**2**
	Start	603380.4	5091595.0
	End	603588.0	5091631.7

Site	Points	UTM E (X)	UTM N (Y)
Peterson Prairie West continued		**Transect**	**3a**
	Start	603369.6	5091567.8
	End	603455.4	5091582.9
		Transect	**3b**
	Start	603479.7	5091587.2
	End	603587.6	5091606.2
		Transect	**4**
	Start	603368.9	5091542.3
	End	603586.4	5091580.6
Conrad Meadows		**Transect**	**1**
	Start	631231.9	5151253.8
	End	631298.6	5151320.5
		Transect	**2**
	Start	631250.4	5151237.0
	End	631384.0	5151370.5
		Transect	**3**
	Start	631204.0	5151155.2
	End	631422.2	5151373.3
		Transect	**4**
	Start	631197.1	5151112.9
	End	631444.3	5151360.1
		Transect	**5a**
	Start	631210.7	5151091.1
	End	631296.2	5151176.6
		Transect	**5b**
	Start	631343.7	5151224.2
	End	631458.3	5151338.7
		Transect	**6**
	Start	631222.9	5151068.0
	End	631372.2	5151217.2