DECADES OF DECLINE: Survey data for Poweshiek Skipperling (*Oarisma poweshiek*) during 1988-1997 in Iowa, Minnesota, and North Dakota

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SUMMARY. A considerable proportion of the Poweshiek Skipperling (*Oarisma poweshiek*) sites we surveyed in 1988-97 in Iowa, Minnesota, and eastern North Dakota had none found (already classifiable as subdetectable), or unreliable detection, or detection only in small numbers. Additional sites of likely habitat in core range have no Poweshiek record, to our knowledge. Even when analyzing only sites with any Poweshiek recorded during our butterfly surveys, most unit surveys during main Poweshiek flight period had 0 individuals recorded. Poweshiek had an uneven distribution of abundance within site (even in high-quality undegraded prairie), peaked in upland prairie in sites also containing lowland grassland, and had relatively low abundance in wetland and wet to mesic prairie even if it was undegraded and in sites with upland prairie. Long-term idling and unintensive haying were more consistently associated with higher Poweshiek numbers and population persistence than fire management. The mean Poweshiek abundance in fire-managed sites skewed high relative to the median abundance and to the % surveys recorded as zero, because 5-10% of unit surveys showed rapid recovery, or super-recovery. However, the median and % zero is more representative of what happened more frequently, where higher numbers skewed consistently toward the longest times since last fire studied. Poweshiek showed an extremely negative immediate response to rotational fire, the primary management in most of these sites: no detection at all in >70% of surveys in the first growing season after a fire, indicating particularly slow re-colonization into burned vegetation following Poweshiek mortality during the fire. Poweshieks were remarkably volatile in abundance--both in annual fluctuations and in response to management. Even though most instances of year 0 after fire had zero or extremely low numbers, we observed a few instances of surprisingly high numbers even then. Conversely, in years 1-3 after fire, when the average abundance was higher and a few "super-recoveries" occurred, we also had examples of stalled or incomplete "recovery" (better termed "non-recovery"). **<u>Poweshiek decline has not been sudden. It has been ongoing for decades.</u>** It is only through a constant focus on avoiding the worst-case scenario that the rare best-case scenario of long-term population persistence is possible for extremely specialized and fragile butterfly populations like Poweshiek.

INTRODUCTION. The Poweshiek Skipperling (*Oarisma poweshiek*) is a habitat-specialist butterfly with a relatively small range centered on northern tallgrass prairie. Because of the vast destruction of tallgrass prairie, this skipper has been of conservation concern for decades (e.g., Coffin and Pfannmuller 1988, Selby 1990, Royer and Marrone 1992, WDNR 1999, Schlicht et al. 2007). We surveyed Poweshiek Skipperling sites in Iowa, Minnesota, and North Dakota during 1988-1997 (Swengel 1996, 1998; Swengel and Swengel 1997, 1999; Schlicht et al. 2009, Swengel et al. 2011). This study area was the core range for Poweshiek, which has since become subdetectable here in recent surveys (Selby 2005, 2010; Dupont 2011). Please see the unpublished Swengel research reports for 1990, 1991, 1992, and 1993, as listed in the reference sections of the USFWS status survey update (Selby 2010), for details of the surveys we conducted in Iowa and Minnesota during 1988-1993. The purpose of this report is to supplement those reports and published papers with our 1994-1997 data and with more analyses to search for patterns useful for guiding Poweshiek conservation. We are emphasizing the smaller populations here, in the context of all Poweshiek sites we surveyed, since the larger populations still extant during this study period have already received more attention elsewhere.

FLIGHT PERIOD. Gerald Selby and Dennis Schlicht conducted surveys in Minnesota during 1988-1990 and 1993-97, respectively, Mike Saunders in Iowa in 1993-94, and Tim Orwig in North Dakota in 1995-97. We greatly appreciate that these teams have shared their unpublished reports with us, as well as many being posted on the Internet (links listed in Schlicht et al. 2009 and Swengel et al. 2011; Orwig 1995, 1996, 1997). All of these other teams had a longer survey period per year during Poweshiek flight period than we did (Table 1). We found Poweshiek in all ten of our survey years, and did well at surveying during main flight period in 8/10 years (Table 1). We were not targeting only Poweshiek in these surveys. We counted all butterflies seen, so that all our survey periods were useful for some purpose. Although we received grant funding in 2 of these years (see Acknowledgements), we were volunteers in all years of these surveys and had (and have) severe constraints on scheduling and time, as is typical for volunteer experts (Pyle 1998).

WEATHER and TIME OF DAY. Swengel and Swengel (1999) reported that in the range of survey conditions we experienced, Poweshiek abundance significantly and positively correlated with increasing temperature, and significantly and negatively correlated with wind speed, with no statistical relationship to percent cloud cover or percent sunshine. However, Poweshiek was detectable in the full range of temperatures (14°-32°C, or 57-90°F) and wind speeds (0-48 km/hr, or 0-30 mph) and cloud conditions (0-100% clouds) we conducted surveys in Poweshiek flight period at Poweshiek sites. We did not survey when butterflies were undetectable.

Due to time constraints, we opted to survey in subpar conditions rather than obtain no data at all in those periods. Because of that, we obtained our record highest observation rate ever: 100 Poweshiek individuals in 0.508 hr and 0.25 miles (248.56/km) at Prairie Coteau on 7 July 1992 with 80-100% clouds, only 10% sunshine, wind to 15 mph (24 km/hr), and temperature of 75° to 74°F (24-23.3°C). Immediately after that, we found an additional 41 in the next unit, with 0% sunshine and 73°F (22.8°C). Honorable mentions for outstanding numbers in subpar conditions include 50 in 0.496 hr and 0.5 miles (62.14 per km) at Prairie Coteau the day before in 0% sunshine, 65°F (18°C), and wind to 10 mph (16 km/hr), and 72 in 0.217 hr and 0.25 mi (178.96/km) at Hole-in-the-Mountain on 5 July 1994 in 74°F (23°C), 20% sunshine, and wind to 10 mph (16 km/hr). Although wind statistically held down Poweshiek activity (or detection) more than cloudiness, we did still find good numbers on a survey at Staffanson on 8 Jul 92 in 20-25 mph (32-40 km/hr) wind: 47 individuals in 0.446 hr and 0.35 miles (83.44/km) in 80°F (27°C) and 97% sunshine; 27 in a previous unit there in 0.408 hr and 0.3 miles (55.93/km) in 77-79°F (25-26°C) and 100% sunshine and the same wind.

We also found Poweshiek active in the full range of time of day that we surveyed: 0733-1855 hr CDT (this is a slight correction to the 1745 CST as printed in Swengel and Swengel 1999) out of 0733-1855 hr CDT surveyed in Poweshiek sites. Poweshiek abundance did not show a statistical relationship to time of day (as a linear variable from earlier to later in the day) or to "crepuscularity" (amount of time away from noon, either way).

Our record worst conditions with a Poweshiek detection was 57°F (14°C) with 5% sunshine and wind up to 15 mph (24 km/hr) at about 0740 hr CDT. Our record worst conditions for active Poweshiek in good numbers occurred when we recorded 17 individuals in 0.3 miles (35.2/km) in 63-64°F (17-18°C), 2% sunshine, and wind to 15 mph (24 km/hr).

Nonetheless, weather combined with climatic conditions can be important. In our decades of butterfly surveying, it has appeared that in extreme drought conditions, butterflies appear to be more moisture limited than weather limited in detectability. That is, butterflies may be more active in cooler, relatively more humid conditions, even in overcast conditions relatively early in the morning, compared to the typical expectation that butterflies will be more active when it is warmer and sunnier. In these unusual circumstances, it appears that desiccation is a more critical limiting factor than increased energy expenditures required to be active in cooler conditions.

META-ANALYSIS VALIDATION. In Minnesota, Schlicht and we had a sufficient numbers of sites that we happened to survey on similar dates in the same years to test how well the two teams obtained similar results. Schlicht et al. (2009) reported a very strong significant covariance of Schlicht and Swengel data, both generally and for Poweshiek specifically, when matched to similar date especially at the site scale but also by subsite. There was less overlap in site and date between Saunders' and Swengels' surveys so the validation test was necessarily weaker (Swengel et al. 2011). However, these comparisons also indicated a positive relationship between teams' datasets, or at least did not question this correlation. These analyses validate a meta-analysis approach for assembling multiple survey datasets together to examine Poweshiek population patterns.

In Schlicht et al. (2009), it was possible to calculate a calibration constant to adjust Swengels' surveys (unlimited width transects by two surveyors on parallel routes) to be comparable to Schlicht's fixed-width single-observer surveys. That constant is 2.4; in other words, divide our observation rates by 2.4 to be comparable to his observation rates. In all cases where we statistically analyze the meta-analysis dataset (multiple teams joined together), our observation rates are calibrated thus to the other teams'. However, everywhere else in this report, where we report analyses only of our data, or report raw survey results, no calibration was done.

There was no overlap in sites between Selby and Swengels within year, and little between Orwig and Swengels, so it is possible to compare flight period data (Table 1) but not covariance of survey results between these pairs of teams.

SITE TIME SERIES. The survey results by site in Iowa and Minnesota (Table 2) focus on the many sites surveyed in the 1990s where only zero or low numbers of Poweshieks were found. That is because the relatively few sites that were well known and studied, and had larger populations then, are already relatively well covered elsewhere.

More sites, especially in Minnesota, have a Poweshiek record at some time in their conservation history over the last five or so decades (Coffin and Pfannmuller 1988: about 45 plots in the range map) compared to other prairie-specialist skippers such as Ottoe Skipper (*Hesperia ottoe*). But to put this in perspective, consider the Regal Fritillary (*Speyeria idalia*), the most famous prairie-specialist butterfly and a conservation concern in much of its range. Since it has had no legal status in Minnesota, it is not mapped in Coffin and Pfannmuller (1988). Thus, we assume it had more known populations than Poweshiek. In our formal survey work in Iowa, Minnesota, and North Dakota, we found Poweshiek at 20 sites (Swengel and Swengel 1999) of 37 surveyed during the species' flight period. We found Regal Fritillary at 33 sites (as analyzed in Swengel and Swengel 1997), but the Regal's longer flight period made it possible for us to have more survey dates (including August visits) covering Regal's flight period than Poweshiek's. Limited only to surveys during Poweshiek flight period, with some years' survey periods very early in Regal flight, we still recorded the Regal at 27 sites.

Furthermore, many of these Poweshiek sites (Table 2) had low or sporadic Poweshiek observations during main flight period for this species. In Iowa and Minnesota, there is very strong concordance in the repeat survey visits to a site within year at these sites, both within and among teams (Table 2). For the Minnesota sites, of the 28 instances in this table with 2-4 counts at a site in a year, none of the repeat visits got a count more different than 1 Poweshiek from the others and >90% got the same count as other counts. There were no repeat visits at the Iowa sites covered here. Since our North Dakota study area has received less analysis than Minnesota and Iowa sites, we are including a wider range of North Dakota sites here (Table 3), some of which still had good Poweshiek numbers and, as a result, wider variation in numbers by date within year.

Three of our Minnesota sites have no Poweshiek records in our data nor in anyone else's that we know of, even though they are plausible habitat in range. Many other Minnesota sites were unreliable for finding Poweshiek Skipperling after 1989, defined here as having more zeroes than positive records, and positive records being low numbers when found. Examples include Audubon, Bicentennial, Blazing Star, Foxhome, Frenchman's Bluff, Town Hall, and Zimmerman. Most notable are Bicentennial and Blazing Star, which were known to have good numbers of Poweshiek prior to that (McCabe and Post 1977; our visits in 1988). Three other sites were relatively more reliable for positive detection per survey, but only produced low numbers per site: Lundblad, Twin Valley, and Western Prairie North.

Of the 2403 Poweshiek individuals recorded in our formal surveys, nearly half were from one site (Table 4). Five sites disproportionately produced most (87%) of our Poweshiek sample. Three other sites also produced good numbers, although fewer than expected based on survey effort. The remaining 12 sites produced only 2% of individuals in 46% of the survey effort. Some of these poor results could be vagaries of timing and weather on our surveys, but this is not likely to be the primary explanation given the concordance between survey teams in Tables 2-3 and the meta-analyses (Schlicht et al. 2009, Swengel et al. 2011). The five top sites had a tendency to be more recently preserved, an even stronger tendency to contain long-unburned or never-fire-managed habitat occupied by Poweshiek throughout our study, and all had standing water in or next to them. Our analysis in Wisconsin of the benefit of a permanent non-fire refugium in core habitat for specialist butterflies is consistent with this (Swengel and Swengel 2007).

Thus, Poweshiek was not secure in Iowa and Minnesota in the 1980s and 1990s because data do not exist to indicate that many sites had large populations. In other words, only a relatively small number of sites apparently produced any large numbers on surveys in recent decades. Furthermore, Poweshiek decline has not been sudden but has been ongoing for decades. Many populations were subdetectable already, or becoming subdetectable, during our study period in this region 1988-97.

VEGETATIVE ASSOCIATIONS. In Swengel and Swengel (1999), we found that Poweshiek peaked in undegraded (high-quality never tilled) prairie vegetation that was upland (dry-mesic or dry prairie; but not including harshly dry sand prairie) in non-small sites (>30 ha or 74 ac) that had topographic diversity (i.e., containing both wetter than mesic and drier than mesic grassland, which we affectionately call "up-low") (Table 5). Our analysis did not detect a distinction between intermediate and large sites. Small sites also did not show significantly lower Poweshiek numbers but this sample was small, so that it looks as if a biologically meaningful difference with lower numbers in small sites might have been occurring. In this analysis, low prairie (wet and wet-mesic vegetation) and mesic prairie had similarly low numbers, as did sites with relatively uniform topography (sites with all wetter than mesic prairie; we found no Poweshiek in uniformly drier than mesic sites). We also found low numbers in wetland (sedge meadow) but we did too few surveys in that vegetation type to test statistically. When we limited the sample only to topographically diverse sites or high-quality units (Table 5), or to high-quality units in non-small sites (Table 6), the influence of the other variables remains similar.

The importance of up-low indicates that even though wetland and lowland prairie registered relatively low numbers, these areas are still important for the long-term persistence of Poweshiek populations. Since larval success is the overwhelming limiting factor in the global experience of successful rare butterfly maintenance (Thomas 2011), we hypothesize that "up-low" confers benefit to a Poweshiek population because the low places produce better larval survival in drought and up places help survival in floods.

MANAGEMENT TYPE. Management type is analyzed in Table 7. Long-term idling (non-management) of prairie had significantly high numbers--that is, when the vegetation persists as open uncanopied prairie as in this sample, then long-term idling is a relatively good strategy. Haying also gave a clear signal of being significantly high in a relatively consistent manner. The mean Poweshiek abundance was higher in idling but the median higher in haying. Grazing came out significantly low, but this came from a small sample from Sheyenne National Grassland, which has a dustbowl heritage and, at least in some places, more protracted periods of more intensive grazing during our survey period than we think preserve managers would do. While our results are representative for this site, they are not representative of what conservation grazing could be for Poweshiek. For example, Dennis Schlicht's team found higher numbers of Poweshieks on some of his private agricultural study sites, some of which were likely grazed, in 1997.

FIRE. Rotational fire management (typically 3-6 year rotations) gave a very mixed signal (Table 6). It statistically placed both with low-abundance sites and high-abundance sites. While the mean Poweshiek abundance placed fire between idling and haying in the high category, the median placed fire squarely in the low category with the grazing we observed. That is, the standard deviation around the mean Poweshiek abundance in fire management was huge, much larger than the SD around the higher mean in idling. This is symptomatic of the extreme range of Poweshiek responses occurring in fire-managed sites: very low numbers in most cases but a few spikes where recovery, or super-recovery, occurred.

YEAR-BURN. The data are also broken by year-burn classes (year-burn 0 = first growing season after a fire in spring or previous fall) in Table 8. These are presented both for the entire sample and for the best-case scenario (limited to units with vegetative characteristics associated with peak Poweshiek numbers). The mean Poweshiek abundance is more skewed than the median by the relatively few outlier instances where above-average recovery, or super-recovery, occurred. The mean year-burn gives a more optimistic picture of rotational management than median and percent surveys with zero Poweshiek do. The latter two measures are more representative of the experience in most units, and give a clear indication that longer since fire is more favorable than more recent fire (within the range available to study: year-burns 0-6).

We arbitrarily defined super-recovery as 50 or more Poweshiek per km in our surveys (Table 9). Per Schlicht et al. 2009, convert that to be comparable to a one-surveyor limited-width survey by dividing by 2.4, or about 20 per km. Only about the top 6% of surveys (all sites) and top 10% (best-case scenario vegetation) with a known year-burn achieved that abundance, most frequently in year-burn 2, followed by year-burn 1. While these remarkably high densities are rare, they are memorable and affect the mean much more than the median. Unfortunately, the median rate and the percent of unit surveys with 0 Poweshiek are more representative of the typical experience in a fire-managed unit (Table 8). There is a strong skewing toward 0 Poweshiek in year-burns 0-1 and relatively more positive values in year-burns 4-6 (all units) or year-burns 5-6 (best-case scenario of vegetative characteristics), which are the longest periods since fire in our surveys. Even in the best-case scenario, looking at all year-burns, over 50% of the time 0 Poweshieks were recorded in the survey. When compared to our survey effort, these super-recoveries were non-randomly distributed, with the most over-representation in year-burn 2 and most under-representation in year-burn 0 (Table 9).

Nonetheless, super-recoveries did occur in year-burn 0 (Tables 9-10), which is remarkable for being so much of an outlier from the typical extremely low Poweshiek numbers in year-burn 0 (Table 8). Poweshiek incidence in year-burn 0, as well as super-recoveries, was strongly skewed toward incomplete combustion (Table 11). Nonetheless, the overwhelming result in year-burn 0 was 0 Poweshiek recorded, even in incompletely combusted units, as evidenced by the % unit surveys with 0 Poweshiek recorded (Table 11). Furthermore, it is not at all clear that partial combustion confers much benefit to Poweshiek population persistence, because it's unpredictable where and how much incomplete combustion will occur, plus such management may not be accomplishing much benefit in vegetative outcome for Poweshiek, possibly even leading to even more frequent burning. Most of these super-recoveries occurred in 1994 and 1996 even though we recorded incomplete burns in Poweshiek sites in four other years. It is too small a sample to analyze whether this is biologically meaningful--that is, whether annual fluctuation (climatic variation) contributed to this.

As a result, rotational fire is extremely risky for managing Poweshiek. It is like the lottery: it is unpredictable how it will work out, and in a few cases, an extremely positive outcome can occur, but in most cases the outcome is a low number usually zero. As a result, after enough iterations of rotational fire management cycles, the chance of permanent non-recovery by Poweshieks becomes highly likely. That's because a poorer than average recovery is bound to happen sometime (because of a series of poor fluctuations due to unfavorable or wildly varying climate) but most fire management is based on expecting average (or better than median) butterfly outcomes such as described in Table 7, as contrasted to the percent zero Poweshiek surveys. Also, by far most rotational fire management in the past has not considered the specific core areas and preferred habitats of Poweshiek in a given site when deciding location and size of a particular fire. This can also explain the extreme range of response to rotational fire in Tables

3-4: some fires occurred in areas of negligible significance to the Poweshiek population while others encompassed most or all core areas, while still burning only a portion of the site. These results strongly support, at a minimum, the implementation of a permanent non-fire refugium in core Poweshiek habitat, with very unintensive alternative management as needed, in each extant population.

NON-FIRE MANAGEMENT. By contrast, rotational haying and idling (which can include localized spot treatments of problem vegetation) are much less risky. There may not be as many super-recoveries but the extreme mortality bottleneck of fire is also avoided. From the long-term vantage of hindsight, it appears that avoiding risk is more useful than playing the lottery of rotational fire. Long-term idling (with localized treatment of problem plants if needed) and rotational haying do not subject Poweshiek to an extreme mortality bottleneck like fire does. These results, and numerous long-term declines in fire-managed sites, and the longer-term persistence of relatively many populations in unintensive agriculture prior to conservation, strongly support managing Poweshiek sites with unintensive techniques without any fire.

Idling and haying had the lowest percent of 0 Poweshieks on unit surveys in Poweshiek sites during Poweshiek flight period. However, idling still had 50% zero. From this point of view, unintensive haying looks safest (38% 0), although caution must still be exercised to avoid that 38%. On the other hand, haying in this study is primarily represented by how private farmers did it, rather than how conservation managers could do it when taking consideration of Poweshiek requirements. Thus, our work likely understates the benefit haying could have for Poweshieks when done solely for conservation purposes. Nonetheless, given how fragile extant Poweshiek populations are, extreme caution is advised in any management.

Unfortunately, we have too small a sample to make a comparison to idling and haying in the best-case scenario of vegetative characteristics, and we have too small a sample to examine abundance by year-hay.

ANNUAL FLUCTUATIONS. Table 12 shows some quantifications of the great annual fluctuations in Poweshiek observation rates. In the literature and in our analyses of long-term monitoring of numerous specialist butterfly species, every so often an extremely good or bad year occurs. It requires decades of long-term monitoring to capture that full range of variation in a dataset, and in short-term datasets, a string of good or bad years can run back to back, or can be mixed together. Furthermore, the fluctuation evident in the coming summer Poweshiek surveys are unknowable at the time most land uses and managements occur (e.g. burning, fall mowing). Since Poweshiek fluctuates greatly, it is difficult to distinguish a low fluctuation (a normal event in a stable population that is not a concern so long as great caution is used not to add additional stress to population numbers) from the beginning of a population decline (a concern). Conversely, Poweshiek was also capable of striking spikes of high abundance. Our record highest density was 248.56/km (196.85 per hr). But to compare our two-surveyor, unlimited width results to others' one-surveyor, limited width surveys, divide our rates by 2.4. As a result, Dennis Schlicht blew our record away, with 261.82/hr in a unit at Hole-in-the-Mountain in 1995. Saunders' peak survey was 121.2/hr at Haffner. It is only through large scale surveying over the long term that it is possible to distinguish fluctuations (both low and high) from trends.

FLUCTUATIONS AND FIRE. During our study, management units were placed about at random relative to Poweshiek occupancy of a site, and burning was applied in highly variable amounts per year. Combine that with great fluctuations in response to great climatic variation, and highly variable results in an individual management cycle of 2-5 years are bound to occur, as is evident in the results here. But over the long run, at some point randomly too much lethal burning will affect a Poweshiek population that has a randomly worse than average population fluctuation afterward. Population decline and loss is therefore inevitable under such fire regimes, independent of other adverse or mitigating factors. Responses of Poweshieks to fire were far more variable around the mean than for other managements studied. Greater variation and more frequent catastrophes (e.g. fire) are known to cause a greater risk of populations extirpation than populations of the same average size that have less variability (Lacy et al. 1992).

VARIABILITY AND STATISTICAL INSIGHT. The great variation (large standard deviation) around Poweshiek's patterns, and the existence of outliers (such as super-recovery from burning) do not mean their populations can't be understood. Instead, it means that much more margin for error is required in all conservation actions because the outcome may be at the worse end of the variation instead of the average response or (should you be so lucky) better than average. It also means that very large high-quality datasets (corrected for survey effort) from many sites for many years are necessary to obtain adequate confidence in understanding the species overall, joined with detailed individual site knowledge. This is exactly the same approach in the best human medical practice (humans are also very complex and highly variable!): detailed monitoring of individual people to tailor large scale, high-quality, detailed research specifically to the situation of that individual. Any anecdote can be found to "disprove" something by focusing on rare outlier examples. It's unreasonable to expect a biological pattern to occur 100% of the time, and clearly Poweshieks (and humans) do not present such simple black and white patterns. To identify the range of what is possible and what has higher probability of occurring requires large-scale high-quality datasets.

There are many ways to extirpate a Poweshiek population. Some risk factors are pervasive in the landscape: small patch size, isolation, degradation, afforestation. Some are specific to conservation activities: e.g., fighting exotic plants in ways that Poweshieks themselves do not tolerate. Many more risk factors are specific to the unconserved landscape: pesticides, intensified uses including temporary ones such as brief heavy grazing that may later on leave good enough looking prairie vegetation but not Poweshieks. Conservation agencies have been very effective at finding and targeting the best prairies to conserve first, including the best Poweshiek habitat (deliberately for Poweshieks or not). As a result, it is not surprising that it is hard to find "new" Poweshiek sites recently. What is available as unconserved or unmanaged or neglected prairie in the landscape today is more picked over than what was available to target for conservation in decades past. Poweshiek is not an infinite resource; at some point, there are no "new" sites still out there to bail out extirpations that have been occurring for decades at known sites.

Conversely, many factors must come together right, consistently year-round year after year, for Poweshiek populations to persist. Management happens to be one of the factors critical to Poweshiek that is most within human control. As a result, a focus on sympathetic management, not just for Poweshiek "habitat" (vegetation) but for Poweshieks themselves, can get the most conservation benefit, within the limits of available resources and what's possible to achieve. We should not assume that there must be more Poweshieks out there undiscovered, so we must be extremely careful with the ones still extant. But we also should not assume that Poweshieks do not still exist out there in or near sites with undetectable populations, so that immediate institution of extremely "sympathetic" management (in the British parlance) might make them detectable again.

POSITIVE BIAS. Human memory is anecdotal and positive biased. Outlier high counts in our surveys are vivid memories even decades later, but the many low and zero counts are just a blur. Even non-anecdotal database analysis is positive-biased. Means are skewed upward by the few outlier high counts but medians are often unhelpful because they are all zero even when there are statistically significant differences among groups (Table 5). Statistical testing is biased by results in good sites and good years, because that's where most of the sample sizes of individuals are, but most populations are small and survival of the bad years is the critical limiting factor that must be understood.

Conservation management is similarly positive-biased. In general the best sites are targeted for conservation first. Since fire is skewed toward conserved sites, it is occurring in better habitat (in terms of vegetative characteristics) than the other managements, which are biased negatively by being in poorer vegetative characteristics and/or by being done for agricultural purposes rather than conservation applications. After all, all the good populations had to survive 10-15 decades of being in agricultural management before conservation converted them to preserve (fire) management. Surveying is often biased to "new sites" (newly preserved sites) where fire management has an incomplete influence yet. As a result, declines at "old" sites are relatively poorly verified and documented while it is happening, as opposed to decades after the subdetectability began.

Eventually "the chickens come home to roost." The critical limiting factors evident in all those zeroes lurking in the dataset (as in Tables 5-8, 11) express themselves as population losses that are inescapable to notice. That, unfortunately, is well past when the most efficient, effective conservation intervention can occur. We can help reduce future biodiversity disaster globally by documenting the decades of Poweshiek decline as accurately and completely as possible, so that these painful lessons need not be re-invented elsewhere unnecessarily. This will also improve the chances that the very few fragile populations of Poweshiek still extant can be effectively conserved. If Poweshiek is to persist at all, we will have to counteract these positive biases effectively so that conservation planning is not too rosy in expectations about what Poweshiek populations can tolerate. It is only through a constant focus on avoiding the worst-case scenario that the rare best-case scenario of long-term population persistence is possible for extremely specialized and fragile butterfly populations like Poweshiek, so that conservation planning is not too rosy or optimistic in expectations about what Poweshiek populations can tolerate or need (Swengel 2011-2012).

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We hope these are useful to you. Sincerely, Scott and Ann Swengel

Table 1. Comparison of flight period data for Poweshiek Skipperling, by state and team: dates of zero recorded before flight period, first observation date, peak or good/main flight dates, last observation date, and dates of zero recorded after flight period.

	OTHER TEAM--					SWENGEL TEAM------------------------------------				
	ZERO	FIRST	PEAK	LAST	ZERO	ZERO	FIRST	GOOD/ MAIN	LAST	ZERO
IOWA										
	SAUNDERS					SWENGEL				
1989							1 Jul	1 Jul		
1991						28 Jun				
1993	27 Jun	2 Jul	13 Jul	25 Jul						
1994		22 Jun	22 Jun-4 Jul	11 Jul			4 Jul			
1995						2 Jul				
1996							8 Jul			
MINNESOTA										
	SELBY/SCHLICHT					SWENGEL				
1988		24 Jun	24-28 Jun	7 Jul			21 Jun	21-23 J	23 Jun	
1989		28 Jun	2-6 Jul	16 Jul			29 Jun	29-30 J	30 Jun	
1990	25 Jun-26 Jun	29 Jun	5 Jul	23 Jul		18 Jun, 25-26 Jun	16 Jul		18 Jul	19 Jul
1991							8 Jul			9-12 Jul
1992							6 Jul	6-8 Jul	10 Jul	11 Jul
1993	1,5 Jul	6 Jul	9-14 Jul	18 Jul			5 Jul	9-10 Jul	10 Jul	
1994		29 Jun	29 Jun-5 Jul	7 Jul			4 Jul	4-6 Jul	6 Jul	
1995	29 Jun	1 Jul	10 Jul	13 Jul			2 Jul	3-6 Jul	6 Jul	
1996		30 Jun	9-15 Jul	15 Jul			8 Jul	8-12 Jul	12 Jul	
1997		1 Jul	11-15 Jul	15 Jul			7 Jul	7-10 Jul	10 Jul	
NORTH DAKOTA										
	ORWIG					SWENGEL				
1995		28 Jun	4 Jul	4 Jul		3-4 Jul				
1996		1 Jul	7 Jul	10 Jul			9 Jul	10 Jul		10 Jul
1997	30 Jun-6 Jul	8 Jul	8 Jul	10 Jul			8 Jul			9 Jul

Table 2. N Poweshieks by site and date. Unitalicized = Swengel data. Italicized data come from Schlicht (Minnesota) and Saunders (Iowa). If more than one date in a year at a site, and if count differed among those dates, the different counts are presented in chronological order.

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
MINNESOTA SITES - any Poweshiek record known										
Agassiz Dunes						**0**				
						0714				
Audubon			**0**	**0**	**2**	**0**	**1**		**1**	**0**
			0625	0710	0709	0709	*0702*		0711	0710
			0718			*0713*				
Bicentennial	**13**		**0**	**0**	**1,0,0**	**0**		**0**	**0**	**1**
	0622		0626	0711	0709	0708		0706	*0703*	0710
			0719		0710	0709		*0709*	*0707*	
					0711	*0717*			0711	
									0713	
Bicentennial hay prairie					**0**	**0**		**0**	**0**	**0**
					0711	0708		*0704*	*0703*	0710
						0709		0706	*0707*	
						0717		*0709*	0711	
								0713	*0713*	
Bicentennial pasture								**0**	**0**	
								0709	*0703*	
								0713	*0707*	
									0713	
Blazing Star	**24**		**0**	**0**	**0**	**0**		**0,1**	**0**	**0**
	0622		0626	0711	0710	0708		*0709*	*0703*	0710
			0719			*0717*		*0713*	*0707*	
									0711	
									0713	
Foxhome				**0**	**0**	**0**	**0**			
				0710	0708	0707	0706			
						0712				
Frenchman's Bluff						**0**			**0**	**0**
						0708			0711	0710
Lundblad		**4**			**0**	**0**	**4**			
		0629			0706	0705	*0629*			
						0706				

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
***Strandness**							**2** 0706			
Town Hall	**0** 0622			**0** 0710	**0** 0708	**0** 0707	**0,1** 0706 *0702*			
Twin Valley			**0** 0626 0719	**0** 0711	**2** 0710	**4** 0708				
Western North				**0** 0710	**2** 0709	**2** 0709	**2** *0702*			
Zimmerman			**0** 0719			**0** 0708	**1** *0705*			
MINNESOTA SITES - no Poweshiek records known to us										
Kettledrummer				**0** 0710	**0** 0708	**0** *0712*	**0** *0702*			
Seven Sisters			**0** 0720	**0** 0709 0712	**0** 0708	**0** 0707	**0** 0706			
Western South						**0** 0707				
IOWA SITES										
Crossman		**1** 0701				**0** *0725*	**0** *0626*			
Hayden		**1** 0701				**1** *0725*				
Kalsow				**0** 0628		**0** *0721*				

Table 3. N Poweshieks by date in North Dakota. Unitalicized = Swengel data. Italicized data come from Tim Orwig's surveys. Count totals are in chronological order.

	1995	1996	1997
Aaser WPA	**0**	**0,2**	**0**
	0627	*0702*	*0709*
		0710	
Briggs/Berndt WPA			**11**
			0708
Hartleben	**1,18**	**1,73,39,31**	**0,15,6**
	0628	*0701*	*0630*
	0704	*0707*	0708
		0709	*0710*
		0710	
Krause WPA	**0**	**1,0**	**0**
	0627	*0704*	*0706*
		0709	
White Lake, Tewaukon NWR		**1**	**0**
		0709	*0706*
Sheyenne National Grassland (divided into sectors) (each number represents a unit survey)			
mid (3 units)	**0**	**0,0,0**	**0,0,0**
north (1 unit)	**0**	**0**	
north central (1 unit)		**0**	**0**
northeast (2 units)		**0,0**	**0,0**
southwest (5 units)	**0,0,0,0,0**	**0,0,0,0,0**	**0,0,0,0**
	0703	0710	0708
southwest (near National Grassland) (5 units)	**0,0**	**1,1,0,0,0**	**1,0,0,0**
	0,0	0710	0708
	both units surveyed on 0703 & 0704		
northwest (1 unit)	**0**	**0**	**0**
	0704	0710	0709
south (2 units)	**0,0**	**0,0**	**0,0**
	0703	0710	0708
southeast (5 units)	**0,0,0,0,0**	**1,0,0,0,0**	**0,0,0,0**
	0703	0709	0708

Table 4. N Poweshieks itemized by site, for sites where we found >50 individuals, with expected Poweshiek based on proportion of survey effort (hours) at each site out of all survey effort. For statistical testing, the sites are grouped into three categories. Observed vs. expected in those three groups is highly significantly non-random (P=0.0000). * Long-unburned or never-fire managed area of Poweshiek-occupied habitat in site throughout our surveys there.

Year preserved	Site	N Poweshiek	% Poweshiek	Survey hours	% effort	expected Poweshiek
1978, 1990	*Hole-in-the Mountain, MN	1057	44.0	30.30	18.5	444.5
1986	Prairie Coteau, MN	477	20.0	12.33	7.5	180.0
1972	Staffanson, MN	354	15.0	9.93	6.0	144.0
	*Prairie Marshes, MN	146	6.0	5.15	3.0	72.0
	*Hartleben	54	2.0	2.01	1.0	24.0
1975	Bluestem	113	5.5	12.15	7.0	168.0
1971	Chippewa	89	4.0	8.55	5.0	120.0
1970s	Ordway	62	2.5	9.44	6.0	144.0
five best sites (overrepresented Poweshiek)		2088	87.0	59.72	36.0	865.0
three good sites (underrepresented Poweshiek)		264	11.0	30.13	18.0	432.5
remaining 12 sites (very underrepresented Poweshiek)		51	2.0	75.65	46.0	1105.5
Total		2403		163.50		

Table 5. Mean ± SD and median Poweshiek relative abundance (individuals per km per unit survey) for Poweshiek Skipperling in Iowa, Minnesota, and North Dakota 1988-1997. % zero means percentage of unit surveys that had 0 Poweshiek recorded. Data reported are only from unit surveys during the species' flight period in each year at sites where the species was ever recorded during this study's surveys. Within each vegetative characteristic, variates sharing any of the same letters are not statistically different by the Mann-Whitney U test (two-tailed P < 0.05). The initial table using all data was published in Swengel and Swengel (1999) except for the medians and % zero.

Variable	N	mean	SD	median	% zero	statistical grouping
Prairie type						
wetland	4	1.04	2.07	0	75.0	--
wet prairie	129	2.99	10.09	0	79.1	B
mesic prairie	55	3.33	9.80	0	74.5	B
dry prairie	291	13.93	2.62	0	52.9	A
sand prairie	6	0.00	0.00	0	100.0	--
Prairie quality[1]						
degraded	28	0.81	3.30	0	92.9	C
semi-degraded	120	4.82	12.96	0	68.3	B
undegraded	337	11.94	30.57	0	58.8	A
Site diversity ("up-low")[2]						
uniform	118	2.76	8.61	0	74.6	B
diverse	367	11.72	29.81	0	59.4	A
Size size[3]						
small	11	1.18	2.26	0	72.7	A
medium	220	11.25	27.78	0	60.5	A
large	254	8.41	25.94	0	65.0	A
Limited to diverse sites ("up-low")[2] (unpublished)						
Prairie type						
wetland	3	1.38	2.39	0	66.7	--
wet prairie	52	3.41	11.29	0	84.6	B
mesic prairie	15	4.38	14.71	0	80.0	AB
dry prairie	291	13.93	32.62	0	57.9	A
sand prairie	6	0.00	0.00	0	100.0	--
Prairie quality[1]						
degraded	27	0.84	3.36	0	92.6	B
semi-degraded	75	6.08	15.35	0	62.7	A
undegraded	265	14.42	33.71	0	55.1	A
Size size[3]						
small	11	1.18	2.26	0	72.7	A
medium	173	13.56	30.44	0	56.1	A
large	183	10.61	30.33	0	61.7	A

Variable	N	mean	SD	median	% zero	statistical grouping
Limited to high-quality units (unpublished)						
Prairie type						
wetland	4	1.04	2.07	0	75.0	--
wet prairie	70	2.68	9.63	0	78.6	B
mesic prairie	20	0.87	1.94	0	70.0	B
dry prairie	243	15.70	34.92	0	51.9	A
Site diversity ("up-low")[2]						
uniform	72	2.83	9.51	0	72.2	B
diverse	265	14.42	33.71	0	55.1	A
Size size[3]						
small	10	1.30	2.35	0	70.0	A
medium	159	13.84	31.38	0	54.1	A
large	168	10.78	30.60	0	62.5	A

[1] based on native prairie floristic diversity and extent of brush and non-native plants

[2] uniform = only lowland or only upland grassland in the site
diverse = both lowland and upland grassland in the site

[3] small (<20 ha or 50 ac)
medium (>30 and <130 ha, or >74 and <321 ac)
large (>140 ha or 345 ac)

Table 6. Mean ± SD and median Poweshiek relative abundance (individuals per km per unit survey) for Poweshiek Skipperling in Iowa, Minnesota, and North Dakota 1988-1997, in dataset as in prior table but limited to high-quality units in non-small sites. % zero means percentage of unit surveys that had 0 Poweshiek recorded.

	uniform				diverse			
	N	mean	med	% zero	N	mean	med	% zero
wetland	1	0.00			3	1.38	0.00	66.7
wet, wet-mesic	53	3.54	0.00	71.7	14	0.00	0.00	100.0
mesic	18	0.89	0.00	72.7	2	0.78	0.78	50.0
dry-mesic, dry	no site had Poweshiek in study				236	16.12	0.00	51.7
very dry sand	no site had Poweshiek in study				no such site in sample			

Table 7. Mean ± SD and median Poweshiek relative abundance (individuals per km per unit survey) for Poweshiek Skipperling in Iowa, Minnesota, and North Dakota 1988-1997. % zero means percentage of unit surveys that had 0 Poweshiek recorded. Data reported are only from unit surveys during the species' flight period in each year at sites where the species was ever recorded during this study's surveys. Management types sharing any of the same letters are not statistically different by the Mann-Whitney U test (two-tailed P < 0.05). All of this was published in Swengel and Swengel (1999) except for the medians and % zero.

Management	N	mean	SD	median	% zero	statistical grouping
Idle	24	11.02	22.96	0.62	50%	A
Grazed	10	0.21	0.66	0.00	90%	B
Hayed	21	7.59	15.97	1.55	38%	A
Burn+mow/hay	2	0.00	0.00	0.00	100%	-- (untestable)
Burned	428	9.81	27.49	0.00	64%	AB

Table 8. Data for burned in prior table broken by year-burn, presented as N unit surveys, mean and median relative abundance, and percent units with an abundance of 0. The sample is smaller because some sites were known to be in fire management but we did know when the last burn occurred in the unit we were surveying. The data are presented both for all fire-managed units and for the best-case scenario from the point of view of Poweshiek Skipper: high-quality upland prairie (dry-mesic or dry) in up-low sites, where Poweshiek numbers peaked.

	All fire-managed units				Best case scenario			
Burn year class	N	mean	median	% zero	N	mean	median	% zero
Year-burn 0	112	2.65	0.00	79.5	62	2.73	0.00	74.2
Year-burn 1	79	10.31	0.00	58.2	46	15.81	2.62	43.5
Year-burn 2	51	20.60	1.13	49.0	28	35.55	7.77	39.3
Year-burn 3	33	6.16	0.00	57.6	21	8.39	0.00	52.4
Year-burn 4	15	14.15	5.33	40.0	11	16.52	5.33	36.4
Year-burn 5-6	10	13.74	3.15	30.0	7	18.78	22.37	28.6
All years	299	9.08	0.00	63.1	175	13.61	0.00	51.9

Note: the sample for idle and hay in the best-case scenario is too small for comparison here.

Table 9. Distribution among year-burns of units surveys exhibiting super-recovery from fire (defined as 50+ Poweshiek per km, representing the top 6% of unit surveys in the entire survey sample and the top 10% of unit surveys in the best-case scenario (see Table 8). Limited to sites primarily managed with fire only (no broadcast mowing or haying in addition). Expected values are calculated proportional to amount of distance surveyed in each category during Poweshiek flight period at sites recording any Poweshieks in this dataset. Chi-square goodness of fit test Chi = 11.35 and P=0.0449 for entire sample and Chi = 15.41 and P = 0.0088 for best-case scenario. Values most deviating from random distribution are boldfaced and underlined.

	Entire survey sample				Best-case scenario			
	N units of super-recovery	total miles surveyed	% of survey effort	N units ex-pected	N units of super-recovery	total miles surveyed	% of survey effort	N units ex-pected
Year-burn 0	**<u>2</u>**	32.600	35.2	**<u>6.3</u>**	**<u>1</u>**	18.625	36.27	**<u>6.2</u>**
Year-burn 1	5	25.450	27.5	5.0	5	14.225	26.92	4.6
Year-burn 2	**<u>8</u>**	16.100	17.4	**<u>3.1</u>**	**<u>8</u>**	8.275	16.11	**<u>2.7</u>**
Year-burn 3	2	11.150	12.0	2.2	2	5.875	11.44	1.9
Year-burn 4	1	4.375	4.7	0.8	1	2.900	5.66	1.0
Year-burn 5-6	0	2.925	3.2	0.6	0	4.250	3.60	0.6
Total	18	92.600	100.0	18.0	17	54.150	100.0	17

Table 10. Distribution of Poweshiek individuals observed in year-burn 0 compared to later year-burns. Expected values are calculated proportional to amount of distance surveyed in each category during Poweshiek flight period at sites recording any Poweshieks in this dataset. Chi-square goodness of fit test Chi-square = 315.91 and P=0.0000.

	N Poweshiek observed	miles of surveying	% of survey effort	N Poweshiek expected	observed / expected ratio
year-burn 0	154	32.60	35.2%	462	0.333
year-burn 1-6	1158	60.00	64.8%	850	1.362
total	1312	92.60	100.0%	1312	

Table 11. Distribution of Poweshiek individuals observed in year-burn 0, by how completely the burn combusted dead plant litter and standing dead herbaceous cover. Expected values are calculated proportional to amount of distance surveyed in each category during Poweshiek flight period at sites recording any Poweshieks in this dataset. Chi-square goodness of fit test P=0.0000 for both a three-way test and two-way test (complete vs. partial and very incomplete combined), Chi-square = 80.6 and 57.7 respectively.

Degree of combustion	miles surveyed	% of survey effort	N Poweshiek observed	N Poweshiek expected	% zero Poweshiek on surveys	N unit surveys
complete	25.925	79.5	82	122	81.9	83
partial in places	4.350	13.4	36	21	70.0	20
very incomplete	2.325	7.1	36	11	77.8	9
Total	32.600	100.0	154	154	79.5	112

Note:
0 total Poweshieks in 79.5% of year-burn 0 unit surveys
25 total Poweshieks in 14.3% of year-burn 0 unit surveys
129 total Poweshieks in 6.2% of year-burn 0: all of these had partial burn for some or all of burn

Table 12. Annual fluctuations in observation rates (individuals per hr) of Poweshiek Skipper in Minnesota. Site abundance indices are from the meta-analysis dataset used in Schlicht et al. (2009). Only reliably detectable populations during this period are included; as a result, Bicentennial and Blazing Star are excluded from this analysis. Sites are: Chippewa, Glacial Lakes (4 years only), Hole-in-the-Mountain (new and old as separate sites), and Prairie Coteau.

	5 sites for 4 years		4 sites for 6 years	
	mean	median	mean	median
1992			18.56	16.63
1993	1.53	1.32	1.70	1.65
1994	31.00	43.00	38.29	46.18
1995	40.53	19.83	45.70	19.39
1996	27.43	22.73	28.78	25.33
1997			3.72	2.36