REPORT FROM THE FIELD
DEC '21

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With
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It turns out that everyone, even me in my role as primary author of the quarterly "Report From The Field" website postings, has a boss. The September edition of the article was posted incomplete because my editor told me the article was both exceeding the soft page limit and, more importantly, I had reached the firm deadline for when the article needed to be posted on the website before the PR/MDIA newsletter reached its readers. That article primarily discussed the observed impact of Global warming on the Poppy Reserve's temperature patterns over the last twenty plus years and then started to discuss the Reserve's rainfall patterns. The article concluded that there is no clearly discernible trend in the Reserve's temperature patterns but there is a clear decreasing trend in the Reserve's rainfall. Due to the imposed deadline, that article's rainfall discussion was limited to how much the overall seasonal rainfall has decreased since 1997. Any discussion on the observed trends in the equally important detailed rainfall patterns had to be left for a future article. This article provides that concluding discussion.

For completeness, and to refresh our memories, the same plot showing the observed trend in the Reserve's total seasonal rainfall is shown in Figure 1.

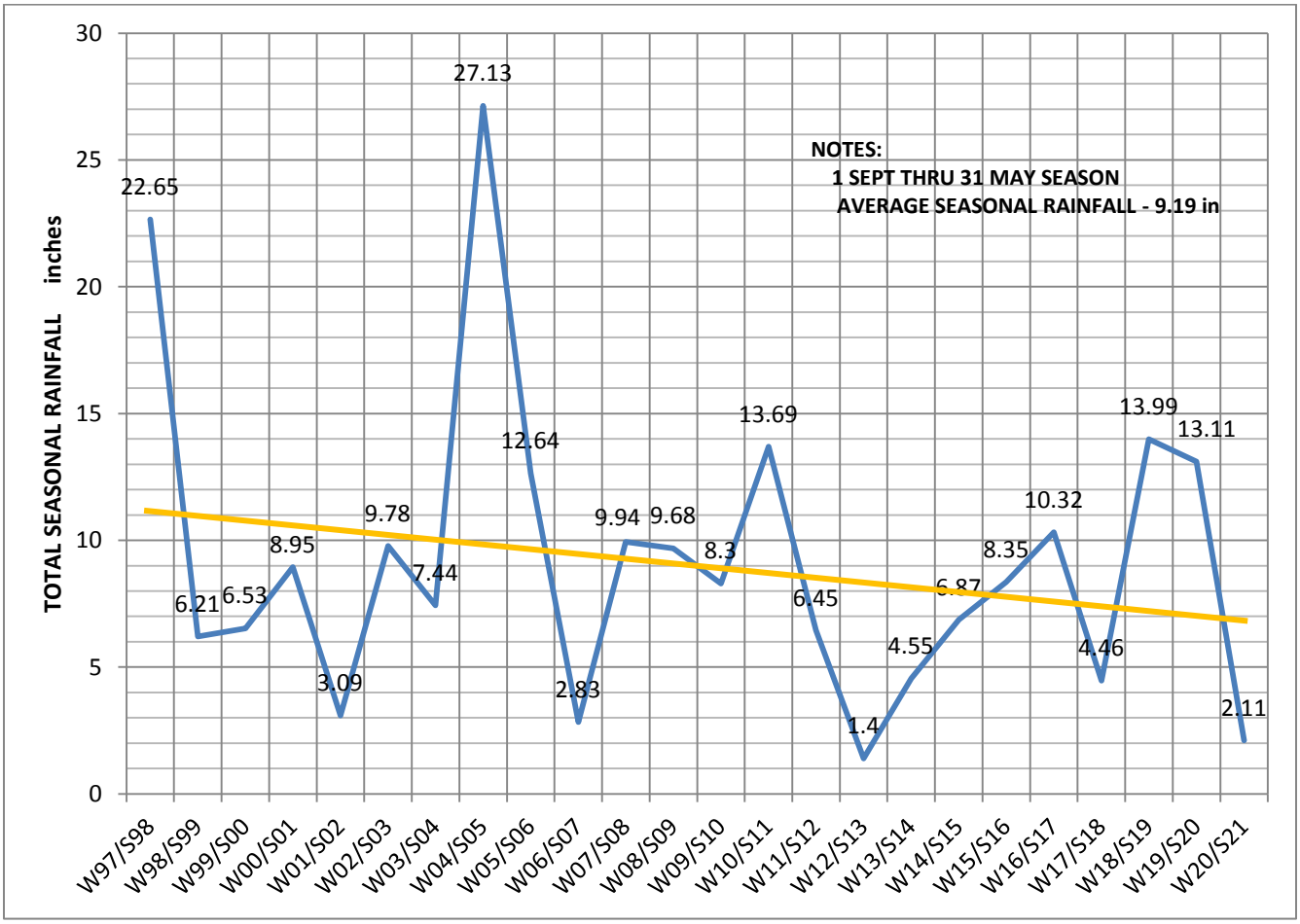
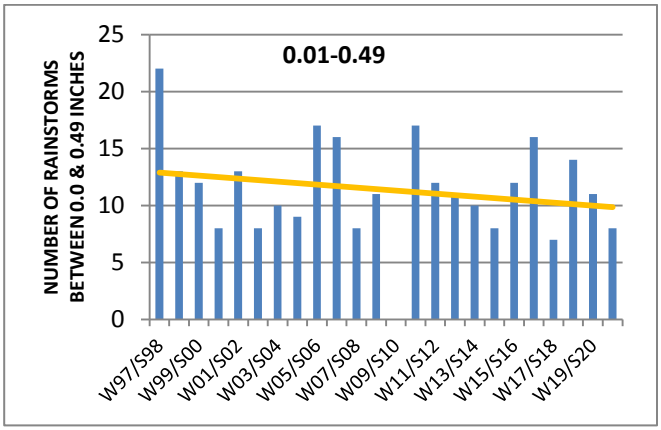


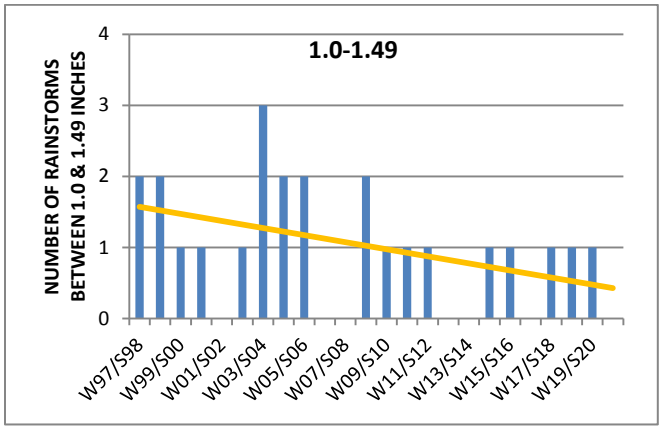
FIGURE 1: POPPY RESERVE SEASONAL RAINFALL

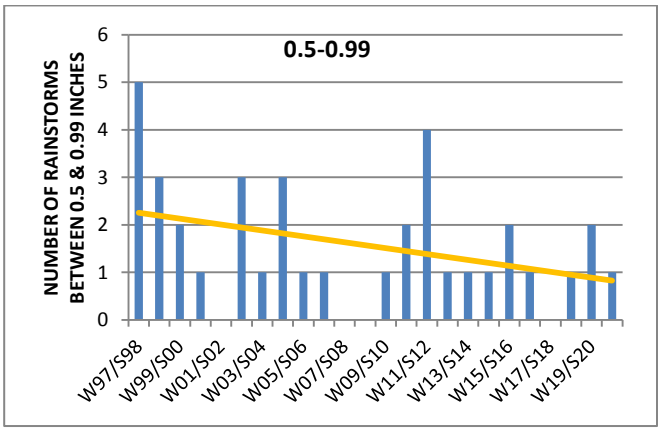
As discussed in the September posting, each seasonal rainfall can be considered a combination of an average rainfall amount and a random variable component superimposed, plus and minus, on the average value. The linear gold line in Figure 1 is the long term trend line which represents the average component of the rainfall. This trend line's decreasing slope shows the average rainfall has decreased from eleven inches to only seven inches over the intervening years since 1997 when the Reserve's rainfall was first started to be measured and recorded. The September article speculated that this level of decrease is likely to be enough to result in fewer storms of sufficient strength to trigger large quantities of poppy seed germination thereby seasons with outstanding poppy displays could become less frequent. In addition, the decreasing seasonal rainfall reduces the amount of moisture available to be stored in the soil potentially resulting in shorter poppy seasons.

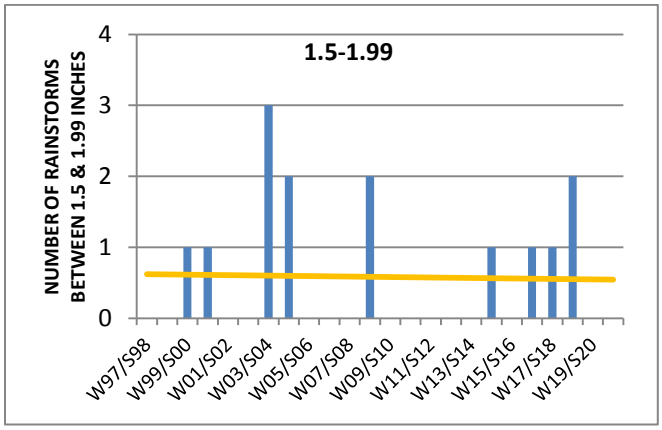
Figure 2 shows how the detail rainfall patterns have changed over the same intervening years. Each of the Figure's plots shows the number of rainstorms each year's winter/spring rainy season had in increments of increasing half inch of rainfall. Not being sure I'm explaining this clearly, here is, hopefully, a clarifying example. During the winter/spring of 1997/1998, there were 22 separate rainstorms that deposited between 0.01 and 0.49 inches of rainfall. During that same winter/spring there were an additional five rainstorms that deposited between 0.5 to 0.99 inches of rainfall, an additional two rainstorms that deposited between 1.00 and 1.49 inches of rain, and etc. all the way to three storms depositing three inches of rain and higher for a total number of rainstorms of 33, if I added them up correctly. It should be noted that there were no rainstorms that deposited between 1.5 and 2.5 inches of rain that winter/spring.

Similarly to the seasonal rainfall showed in Figure 1, the gold lines in the Figure 2 plots are the long term trend lines generated with a statistical linear regression analysis and they are predicting a potentially dark future for the Reserve's poppy displays.









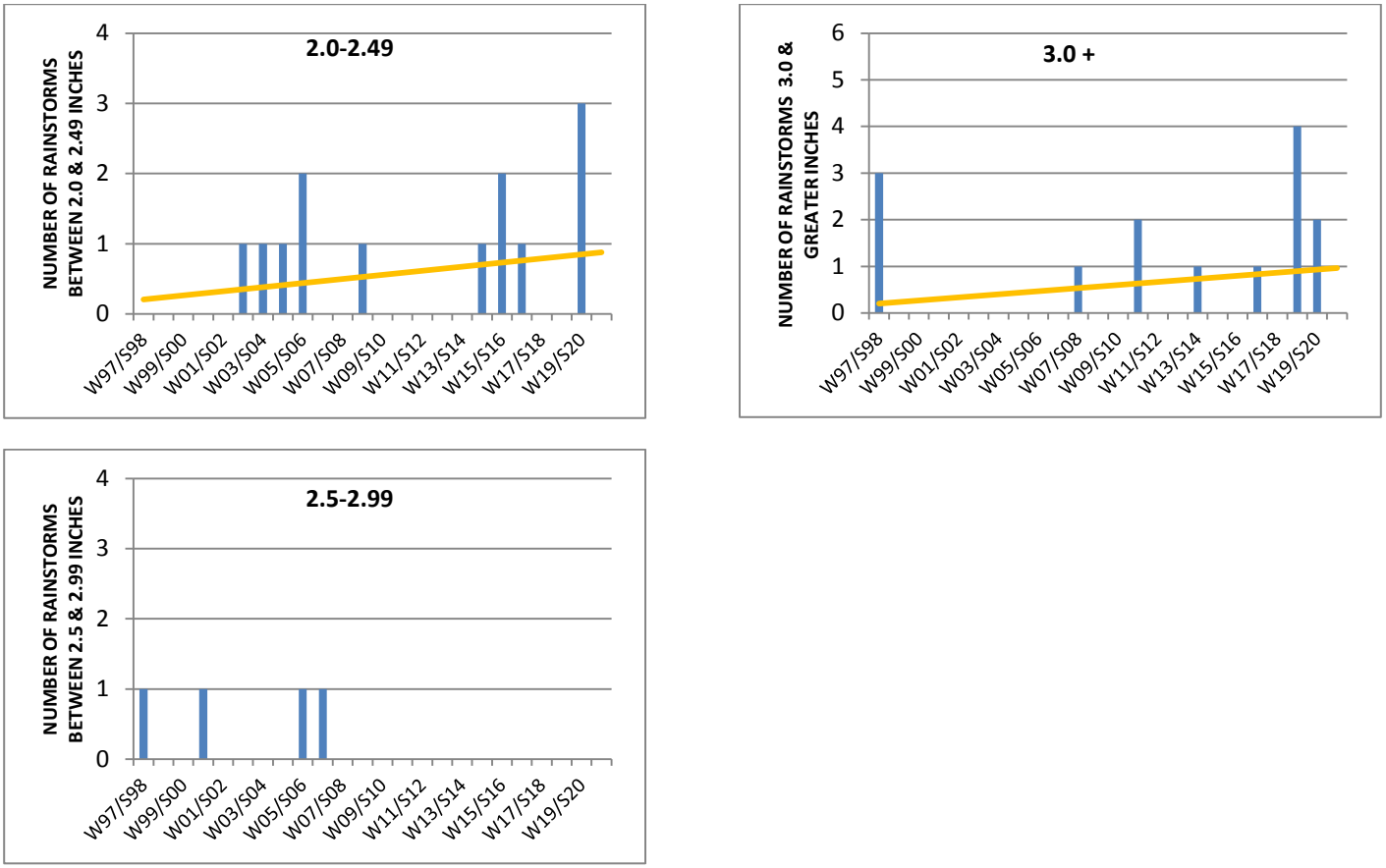


FIGURE 2: POPPY RESERVE INDIVIDUAL RAINSTORM PATTERNS

As can be seen in the Figure 2's plots, a large majority of the Reserve's rainstorms are weak; depositing ½ inch or less of rain. Even though these storms are the most numerous, they are not that significant for two reasons. First, because many of these weak storms deposit only a few thousandths of an inch of rain, their total rainfall is only a fraction of the season's total; except for unusual drought years. Secondly and more importantly, these weak rainstorms don't deposit enough rain to moisture the soil adequately to trigger any poppy seed germination. They might add marginally to the soil's moisture reservoir but they don't produce any poppy plants. Over many years of field observations, the volunteer researchers only find appreciable poppy seed germination following rainstorms that deposit more than ½ inch of rainfall. The maximum amount of poppy seed germination seems to occur after rainstorms depositing one to one and a half inches of rainfall.

When you review the plot for this optimum rainfall range, the plot is seemingly telling a very disturbing story. Of all the ranges of rainfall plotted, this plot has the steepest decreasing trend line. During the late 1990's, every winter/spring rainy season would have, on average, more than one rainstorm whose depositing rainfall amount resulted in maximum poppy seed germination. Now, twenty some years later, the Poppy Reserve is only having one of these rainstorms once every two years, on average. This plot is telling us that we can now expect poppy seed germination needed for outstanding poppy displays to occur only once every two years, on average, and, unless the long term rain pattern changes, it is going to get drastically worst in the coming years. Having two spring seasons with outstanding displays back to back will become increasingly rare; similar to winning the lottery.

Even though a single rainstorm triggering the maximum poppy seed germination results in enough poppy plants for outstanding poppy displays, having even one, or more, of these rainstorms each winter does not guarantee outstanding poppy seasons every spring. Seed germination is only the first step in a train of

events that eventually determine the quality of the poppy displays. Clearly, if the seeds don't germinate to start off the train of events, the displays will be poor but, even with large numbers of seed germination, events can subsequently happen that will degrade the potentially outstanding displays. Some of these events include too long a spacing between rainstorms, limited number of subsequent rainstorms, freezing temperatures, and, even, unseasonably hot temperatures. Any one of these events can end, and have ended, a promising start to the poppy season.

Having a single rainstorm that results in the maximum amount of seed germination is not necessarily required for outstanding poppy displays. Having a series of winter's storms providing moderate to high seed germination can still additively result in the total amount of poppy plants needed for outstanding poppy color. Unfortunately, the plot showing the number of rainstorms depositing between 0.5 and 0.99 inches of rainfall also shows a substantial decreasing trend line from more than two a season to less than one a season. Therefore, the probability of having the needed multiple of these seasonal storms has become much less; these storms will not compensate for the lessening number of optimum rainstorms.

The trend line for storms depositing between 1.5 and 1.99 inches of rainfall has not decreased like the slightly weaker storms but they have always been relatively infrequent, only once every two years on average, so they also will not compensate for the lack of optimum rainstorms. Only once in the last ten years has there been more than one of these rainstorms during the winter/spring rainy season making it clear that these storms can't be counted on.

The observed increasing frequency of rainstorms depositing two and more inches of rainfall does not compensate for the fewer number of the weaker rainstorms because the researchers typically observe lesser amount of poppy seed germination resulting from these stronger rainstorms. Surprisingly, no poppy seed germinations have been observed following the few rainstorms that deposited three inches or more rainfall.

Even though the observed changes in the Reserve's rainfall patterns point to far fewer outstanding poppy seasons being likely, it is still not inevitable if the researcher's interpretation of the seed germination patterns is correct. It appears that the Reserve's wild poppy population has a built in mechanism that allows the poppies to adapt to changes in the rainfall pattern. As previously mentioned, it appears that dispersed seeds of wild, native poppy populations will germinate over a wide range of soil moisture conditions. This is because a varying proportion of the dispersed seeds will germinate under different soil conditions; i.e. a small portion of seeds will germinate under drier soil conditions, a larger portion of the seeds will germinate under moderate soil moisture conditions and a different portion of the seeds will germinate under wetter soil conditions. The number of seeds in each varying portions is evolutionarily determined to maximize the survival of the population for the specific rainfall pattern of its location. If the rainfall patterns change, the number of seeds in each portion selectively adjusts to maintain maximum population survival. The open question is "can the Reserve's poppy population adapt quick enough to keep up with the rapid changes in the rainfall patterns?".

With the observed changes in the rainfall patterns, I expect a larger portion of future seeds will germinate under both drier soil conditions and wetter soil conditions and a smaller portion of future seeds will germinate after the now fewer rainstorms that result in moderate soil moisture conditions. Only time will tell if even the future outstanding displays will be the same quality as in the past. It all depends on how adaptable the poppies are. Even with the population changing to maintain maximum survival, it doesn't mean that the probability of survival remains constant. It is certainly possible that future poppy displays will be degraded from what we currently look forward to and value. In the worst case, poppies might not even be able to continue to grow on the Reserve.

The September "Report From The Field" article's discussion on the Reserve's summer temperature trends included discussing if the timing of the peak summer temperatures had shifted over time and concluded there has been no discernible long term trend in the timing of the peak temperatures. Because the timing

of when the first seed germinate event occurs can impact the spring's poppy season, this article's analysis of the Reserve's rainfall trends includes a similar discussion on the timing of the winter storms.

Table 1 provides the date for the first rainstorm expected to trigger poppy seed germination for every year starting with the winter of 1997. Based on current field observation data this is the first storm of each winter/spring season that deposits a half inch of rainfall or more. These dates are based on the rainfall recorded by the "official" weather station located within the Reserve's maintenance yard. Knowing some areas of the Reserve commonly have slightly higher rainfalls than the maintenance yard, Table 1 also lists the date for the first rainstorm depositing 0.45 inches of rainfall at the maintenance yard if this storm occurred before a storm that deposited the normally selected 0.5 inches of rainfall. The blank in the table's ≥0.5 inches column for the W01/S02 season indicates no rainstorms deposited ½ inch of rain during that drought year.

SEASON	≥0.45 INCHES	≥ 0.5 INCHES
W97/S98		25-Sep
W98/S99		4-Sep
W99/S00		10-Feb
W00/S01		10-Jan
W01/S02	27-Jan	
W02/S03	7-Nov	16-Dec
W03/S04		31-Oct
W04/S05		19-Oct
W05/S06		20-Sep
W06/S07	9-Dec	19-Feb
W07/S08		4-Jan
W08/S09		1-Nov
W09/S10		13-Oct
W10/S11		19-Oct
W11/S12		14-Sep
W12/S13		24-Jan
W13/S14		21-Nov
W14/S15		31-Oct
W15/S16		15-Oct
W16/S17		21-Dec
W17/S18		8-Jan
W18/S19	28-Nov	6-Dec
W19/S20		27-Nov
W20/S21	27-Dec	28-Jan
W21/S22		25-Oct

TABLE 1: DATE OF FIRST SEASONAL RAINSTORM TO TRIGGER POPPY SEED GERMINATION

Table 1 is also color coded to highlight the years with unusually low seasonal rainfall, orange, and unusually high seasonal rainfall, green, as determined by the seasonal rainfalls shown in this article's Figure 1. The highlighting shows that the first poppy seed germination date is not strongly correlated with the eventual total seasonal rainfall amount. Over the last twenty five years, the first seed germination event has occurred as early as early September and as late as mid-February (quite a range) with the season's first germination event occurring most commonly in October.

To determine if there has been any shifting in the first germination event, the dates in Table 1 were converted to the number of days from 1 September, the beginning of the season, and plotted against the season's years and then the linear trend line fitted to the dates. Figure 3 shows the plotted data for the assumption that at least a half inch of rainfall is needed to trigger poppy seed germination.

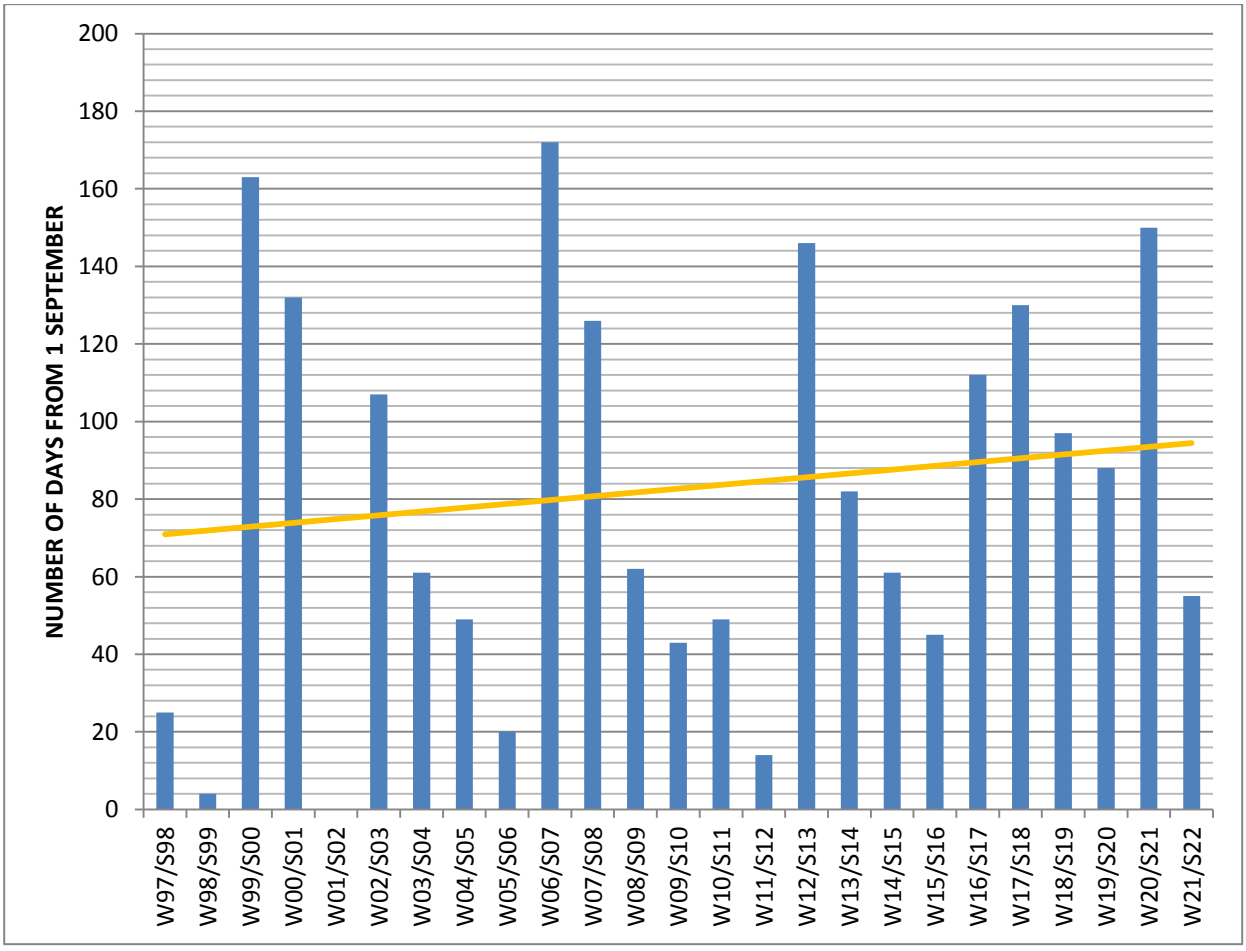


FIGURE 3: DATE OF POPPY RESERVE FIRST POPPY SEED GERMINATION EVENT

As can be seen, the season's first germination event date now occurs, on average, three weeks later into the season compared to the late 1990's. This shift to a later beginning date gives the young poppy plants less time to grow and mature before the late spring temperatures begin to rise.

For the case that 0.45 inches of rainfall is adequate to trigger seed germination, the dates in that Table 1 column were also similarly plotted. That plot also showed a definite shift to later first germination events since the late 1990's but the shift was only two weeks compared to the three weeks shown in Figure 3.

In contrast to no clearly discernible changes in the Poppy Reserve's temperature patterns as discussed in the Sept.'21 website article, there has been marked observable changes in the Reserve's rainfall patterns. To summarize this article's analyses, the observed changes in the rainfall patterns are most likely putting multiple stresses on the Reserve's poppy population from fewer seed germinating rainstorms, later seed germination and less soil moisture. The recent back to back seasons of outstanding poppy displays are clear evidence indicating that the genetic diversity within the poppy population has been largely adequate for the population to adapt to the climate changes that have already occurred; or we were extraordinarily lucky. Time will tell if the population will be able to equally adapt to continuing changes in the Reserve's future rainfall patterns.

I'll end this discussion on the Reserve's shifting rainfall patterns with two stories about the adaptability of poppies. In some ways, this first story is pure speculation, it is a mental experiment, because I have no data to explain the observations. My conclusions seem to me to be the most reasonable explanation. The story started with me seeing packets of commercial poppy seeds stating the commercial grower guaranteed 95% poppy seed germination. This high germination yield was in contrast with poppy researchers' reports that I had read stating that the typical germination yield for wild poppy seeds are typically only 10 to 20%; only one out of five to one out of ten native seeds they tested in the laboratory actually germinated. This low percentage was surprising. To me, Mother Nature is all about efficiency. Why put so much energy into growing four to nine out every ten seeds that won't germinate.

This is my speculation how the germination yield goes from, maybe, 10% to a guaranteed 95%. First, I believe the 10% is not the full story. The researcher goes out and collects some wild poppy seeds and brings them back to the laboratory to conduct the germination tests. She/he puts the seeds on some wetted substrate (I have used a stack of wetted paper towels for my seed germination testing and this worked fine). That wetted substrate determines the equivalent moisture level and only that portion of the collected seeds that are genetically adapted to germinate under that specific moisture level germinated. That doesn't mean the other seeds won't germinate; they just need a different moisture level. Simply reporting a 10% germination yield is misleading. So what does the commercial grower do?

Maybe, he/she also goes out and collects wild poppy seeds, brings them back and sows them in his/her field. Then the grower starts to water the field under some selected watering pattern that the grower believes will result in the maximum number of collectable seeds that can be sold for a profit. Maybe, they water once a week or every two weeks or once a month. More importantly, each watering is for "X" minutes at "Y" gallons per minute. That again determines the soil moisture level and, again, only the wild seeds that are adapted to that moisture level germinate; again, maybe only 10 to 20% of the total seeds. When the germinated plants mature and put out fruit, the grower collects the seeds and re-sows them. A higher percentage of those collected seeds now carry the gene that tells the seed to germinate under the grower's selected watering pattern. This collecting and re-sowing cycle goes on for a few years. Because they simply don't germinate, each year's cycle eliminates any seeds that need a different soil moisture level to germinate. After a few years, all of the seeds are adapted to the grower's specific watering pattern and the grower can claim 95% germination yield which seems more expected for Mother Nature's true germination yield. Everything is fine except …. When a packet of seeds is sold to a home gardener, they have to use the same watering pattern as the commercial grower to get the quoted high germination yield. If they use a radically different watering cycle, they might get zero germination but, if that happens, the gardener likely chalks it up to old seeds, the guarantee is simply a grower's marketing ploy, or that they have a black thumb.

The use of commercial seeds can carry more serious consequences. After many wild fires, there is a concerted effort to reseed the burnt area to help stabilize the soil to prevent erosion. Up until a few years ago, seeds of non-native plant species were typically used for these post-fire reseeding efforts. These plant species were selected for their root patterns and because they were fast growing. Recognizing the problem of non-native plant proliferation, the Federal government announced that they would use only seeds of native plant species in the future for their post-fire replanting efforts. That sounds like progress but,

needing very large quantities of seeds for these re-seeding efforts, it seemed likely that the Federal government agencies would still purchase the needed seeds from commercial growers who grow native plant species for harvesting their seeds. As pointed out in the above story, these commercial seeds will only germinate under a single soil moisture condition. If the first post-fire rainstorm doesn't give the seeds' needed moisture conditions, little or no critically needed seed germination will occur and the slopes are left bare to erode. This author pointed out this limitation of commercial seeds of even native plant species and advocated using a mixture of three or four commercial seeds each grown under different soil moisture conditions to more closely simulate a native seed population. This more likely ensures that the needed seed germination will happen under a wider range of soil moisture levels that normally occur during natural rainstorms.

This article will conclude with a short update on what has been happening at the Poppy Reserve this autumn. As of late November, the Poppy Reserve has seen only one rainstorm this autumn, on 25 October. This storm was strong enough to moisten the soil adequately to trigger moderate levels of poppy seed germination, at least in some areas of the Reserve. On the western side of the Reserve, rainfall varied from 0.6 to 0.8 inches. Unfortunately, there is no rainfall data for the east side of the Reserve because the one active rain gauge on the Reserve's east ridge was compromised so its collected rainfall amount is suspect and, therefore, was disregarded.

At the time of writing this article, the almost one month since that single rainstorm is becoming worrisome. During past winters, the researchers have observed the start of mortality of the just germinated, young poppy plants after periods of four to five weeks with no further rainfall. Hopefully, the Reserve will soon see another rainstorm. If the storm timing is frequent enough, very high survival rates for poppy plants have been observed. Up to 95% of the just germinated poppy plants have survived to the blooming phase of their life cycle if the subsequent rainstorms have the necessary timing.

Two of the four current permanent monitoring plots have been inventoried to document the quantitative amount of poppy seed germination. In the plot closest to the Visitor Center only three young poppy plants were located. The plot inventorying was conducted ten days after the 25 October rainstorm. Normally, young poppy plants begin to emerge from the soil in seven to ten days after their seed germination and the last emergence is, maybe, fourteen days so it is possible that additional poppy plants emerged after the inventorying. With ten days from the storm being only a few days after the first plant emergence, the emerged poppy cotyledons are still small and relatively easy to miss so there could still be a few more poppy plants in the plot that were simply missed. Besides, in most years, this monitoring plot generally has relatively few poppy plants. A quick survey of the downhill side of the sidewalk across from the plot found more poppy plants so it appears possible that the monitoring plot results are not completely reflective of that general area.

The inventorying of the second monitoring plot found approximately thirty poppy plants. Based on past seasons' observations, this amount of seed germination is higher than typically expected for the 0.6 inches of rainfall measured by the adjacent rain gauge. Even if all of the thirty or so plants survived to maturity and blossomed, this number of plants is probably not sufficient to result in outstanding poppy displays but it is certainly a good first step to those displays.

The first step in inventorying a plot is to locate each individual poppy plant within the plot and mark each located plant with a plastic toothpick. This step alone can take up to several hours of labor at each monitoring plot, depending on the amount of competing vegetation, with the researchers down on their knees systematically scanning each area of the plot looking for the telltale gray green, double forked cotyledons unique to poppy plants. To accomplish a valid inventory, it is important to accomplish this step within ten to fourteen days after each rainstorm that is expected to trigger seed germination. This timing is important because it gives adequate time for poppy cotyledon emergence while allowing size differences to distinguish between cotyledons from the immediate past rainstorm and any cotyledons that had germinated after any previous rainstorms. This timing is also short enough that it is very unlikely that any germinated cotyledons will have died already.

The second step of the inventorying effort is to add a numbered flag to each plastic toothpick. It is at this step that a definitive count is obtained for the emerged cotyledons. With the marking of each located plant in the first step having already occurred, the timing of this step is of lesser importance. At this point, a form is also filled out listing each numbered poppy plant.

The third, and final, step is to periodically revisit the monitoring plot to annotate on the created form the then current status of each marked plant. This periodic status updating allows that season's plant mortality to be calculated, and determine when it occurred, as well as document each poppy plant's life cycle unfoldment i.e. plant growth, first blooming, first fruiting, seed dispersal etc.

Due to time limitation, only the first step of the inventorying process was accomplished during the researchers' Nov. 5 visit to the Reserve. We look forward to future visits where the inventorying effort can continue to collect data.

As always, I encourage everyone to continue to visit the Reserve throughout the year. During many years, you can see plant species blooming almost year around. Those blooming in the summer and autumn months are different plant species that you don't find during the spring season so you can add to your personal plant list. With the Reserve's limited rainfall last winter, there are, unfortunately, far fewer blossoms to observe this year. On the other hand, in compensation for the lack of blossoms, the relatively early seed germination event provides the Reserve visitors an opportunity to follow the development of next spring's wildflower season from an early stage.

If you have any questions, comments, corrections, want to add a year to the best poppy display year competition, or simply just want to say "hi", you can contact me at mfpowell@verizon.net. I always enjoy hearing from any readers. May all stay safe and healthy.