Interpretation of the Observations of Romspert and Burk (1979) on the Demography of *Astragalus magdalenae* var. *peirsonii* (ASMAP) and Reconciliation with the Findings of Willoughby (2001), Phillips et al. (2001), and Phillips and Kennedy (2002)

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Under contract to the Bureau of Land Management (BLM), Desert Planning Staff, Romspert and Burk (1979) studied the following seven Algodones Dunes plant species, all of which were considered by BLM at the time to be sensitive species: *Ammobroma sonorae*, *Astragalus lentiginosus* var. *borreganus*, *Astragalus magdalenae* var. *peirsonii* (ASMAP), *Croton wigginsii*, *Eriogonum deserticola*, *Helianthus niveus* ssp. *tephrodes*, and *Palafoxia arida* var. *gigantea*. Two study sites were established, apparently subjectively, south of Interstate 8 at the south end of the Algodones Dunes, one on the west side of the dunes and one on the east side of the dunes. ASMAP occurred only in the western study site. For that reason, only the results from the western site are discussed below.

Phenological condition was recorded for each of the sensitive plants each month (except November) from June 1978 to April 1979. The report (page 6) states that "the species were observed on the study sites, and when conditions allowed, elsewhere in the dunal system." It is impossible to tell from the report whether observations on the phonological condition of ASMAP come only from the belt transect used for the study (see below) or from the belt transect and elsewhere in the dunes.

The report (page 9) states:

> Mortality and growth rates of the sensitive plant seedlings were determined from a … one by twenty-five meter transect established at the west site. The transect was monitored from June, 1978 to April, 1979, with seedling density and height data collected. [Although not explicitly stated in this section of the report, Figure 10 makes it clear that no observations were made for the month of November 1978.]

Results and Interpretation

Phenology

On page 15 of the report Romspert and Burk report that:

> On the west study site, *Astragalus magdalenae peirsonii* had already produced seed, as most of the plants were in a vegetative state by June, 1978. A few of the

> plants still had dried pods attached, and many pods were scattered about in the surrounding area. In July, this species had already dropped many of its leaflets and some entire leaves. This drought deciduous vegetative state existed from July until October, and then, in December, plants entered a reproductive phase. Individuals were observed with reproductive buds and a few had developed inflorescences. Seedlings were present in December, although not in great numbers. Some adult plants had set fruit by January. Some of the seedlings that had germinated in November or December had reached the flowering or even the fruiting stage by March.

Romspert and Burk tracked the number and height of seedlings of ASMAP in the 1 m x 25 m belt transect at the west study site between June 1978 and April 1979. They do not define how they distinguished seedlings from older plants, but size and probably absence of flowers were likely criteria they employed. Figure 10 of the report shows the number and, apparently, cumulative height of the seedlings (the y-axis is labeled "Total Height of Seedlings") and drops from about 300 mm (the report does not give the units of measurement but it is logical that the "300" indicated on the y-axis would represent mm) in July 1978 to about 175 mm in August 1978 to 0 mm in September 1978. The number of seedlings went from a high of 20 in June 1978 to 18 in July 1978 to 13 in August 1978 to 0 in September 1978.

The report gives no indication of the month the 20 seedlings tracked between June and September 1978 likely germinated. Given the precipitation data for Yuma, Arizona, shown in Figure 5 of the report, it seems likely that these seedlings may have germinated as the result of rain in February 1978 that totaled about 1.5 inches (39 mm) for the month, although they could also have germinated from rains in March 1978, which Figure 5 shows as totaling about 0.40 inches (10 mm). [1]

The report gives no information on the number of plants older than the seedling age class that were present in the belt transect. Nor does the report indicate that any measurements were made on either seedling or adult plants to determine reproductive output (e.g., number of flowers, fruits, or seeds). Despite this, the report reaches conclusions on the importance of older plants compared to seedlings in regards to their respective contributions to the seed pool (page 19):

> (Page 19): *Astragalus magdelane peirsonii* contributed the second greatest cover[2] in the transect after *Croton wigginsii* during the summer of 1978 (Figure 10). By September, seedlings had disappeared completely from the transect. December saw the reestablishment of seedlings in the transect and by March five of the remaining seven individuals were in a reproductive state. Again the variation in

[1] Although the report states that the monthly precipitation data for 1978 are from Yuma, Arizona, there are three weather stations with "Yuma" in their name: Yuma WSO AP, Yuma Citrus Station, and Yuma Proving Ground. None of the monthly totals for any of these stations matches exactly the monthly totals given in Figure 5 of the report, although the values from Yuma Proving Ground appear to come closest (based on data housed at the Western Regional Climate Center (www.wrcc.dri.edu).

[2] The report makes reference to "cover" of seedlings but the attribute actually measured was the height of seedlings. Presumably the "cover" referred to here is the cumulative height of seedlings.

> number of individuals of this species from December to April is probably an artifact of the sampling technique. The individuals in the transect that reproduced did not contribute a significant number of seeds to the seed pool; that contribution was made by the older plants.
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> (Page 28): The small size at reproduction and the ability of this species of *Astragalus* [ASMAP] to become reproductive in a single season (4 months; December-March) is not unique to the milk vetches alone. Plants that become reproductive the first season, as in *Astragalus lentiginosus borreganus*, do not contribute a great deal to the gene pool.

These conclusions concerning the contribution of young plants to the seed pool appear to be unsupported by any actual measurements of reproduction. The comparison to *Astragalus lentiginosus borreganus* is also problematic, since the latter species is known to be an annual that only occasionally perennates (Hickman 1993; Felger 2000; Calfora 2002). [3] Based on the discussion below, it seems very possible that many of the "older plants" referred to by Romspert and Burk are less than one year old. The 1978-1979 cohort tracked by the authors consisted of 7 seedlings, 5 of which became reproductive between December and April. (It's quite possible that some of these seedlings may have germinated following a large rainfall event in January 1979—see Figure 2 below—rather than in December 1978. That would account for the discrepancy in seedling numbers noted by the authors and obvious in Figure 10 of the report: 6 seedlings were counted in December, 5 in January, and then 7 in each of February, March, and April. If 2 seedlings germinated in the plot between the January and February observation dates this would explain the discrepancy between the number of seedlings counted between December and February and would also account for the fact that 2 of the 7 species were not yet flowering: those 2 were younger than the other 5.) One wonders what the authors would have concluded had they continued their observations into May and June 1979. If this cohort lived into May, plants may well have grown much larger and had many more flowers (note from Figures 1 and 2 that—whereas both April and May of 1978 were dry—only April of 1979 was dry). Indeed, by that point the authors may have considered these to be "older plants."

I think it is quite possible that many of the "older plants" referred to by Romspert and Burk may in fact have been less than one year old. As Figure 1 shows, there was a very large precipitation event in August 1977, followed by smaller events in December 1977 and January, February, and March 1978. It is quite possible that ASMAP seedlings germinated following each of these events. Thus, many, even most, of the "older plants" observed by the authors may in fact have been from two or more of these cohorts (e.g., August 1977, December 1978, and possibly even January and February 1979), whereas

[3] Perhaps tellingly, Romspert and Burk (page 15) draw the same conclusion for *Astragalus lentiginosus* var. *borreganus* as they do for ASMAP: "Some of these plants set seed the first season, however these plants contributed very few seeds to the population as most of the seed production was from older plants." This lend further credence to the interpretation that "older plants," both for *Astragalus lentiginosus* var. *borreganus* and for ASMAP, are plants that are less than a year old. For *Astragalus lentiginosus* var. *borreganus* the authors go on to report that "many of these adult plants died and their seeds had dispersed by April, 1979." This is what would be expected of an annual.

the seedlings they began tracking in June 1978 may have been from a later cohort (e.g., February and/or March 1978). Because they did not begin their study until June 1978, this is impossible to know with certainty.

The conclusion that many, if not most, of the "older plants" recognized by Romspert and Burk are less than one year old makes their findings consistent with the findings and observations of Willoughby (2001), Phillips et al. (2001) and Phillips and Kennedy (2002). Willoughby (2001) reported on the monitoring conducted by BLM in 1998, 1999, and 2000, following growing seasons of rainfall that averaged 199%, 49%, and 37%, respectively, of the long-term mean. A total of 5,064 ASMAP individuals (5,013 adult plants and 51 seedlings) were tallied along 34 transects in spring and summer of 1998, 942 individuals (all adults) were tallied in spring 1999, and 86 individuals (all adults) were tallied in spring 2000. These tallies correspond with what one would expect from a plant behaving primarily as an annual. Further evidence of the predominantly annual nature of the species is also provided in Willoughby (2001), who showed that the r^2 value of a regression of ASMAP abundance class values on average precipitation for the years 1977, 1998, 1999, and 2000 is 0.91, indicating that 91% of the variability in ASMAP abundance class values is explained by growing season precipitation. The low number of seedlings tallied for ASMAP during this study, even for the high precipitation year of 1998, is a result of the timing of the monitoring: monitors began traversing the transects in April of each year, by which time most of the individuals had already begun flowering.

Phillips and Kennedy (2002) reports that of 71,000 individuals counted as part of a study conducted by Phillips et al. (2001), only 5 were older than the current season. The low carryover of plants older than a year observed by Phillips in 2001 is not at all surprising given the two prior years of poor to very poor rainfall discussed above. Indeed, the fact that BLM tallied only 86 ASMAP individuals in 2000 indicates that most of the 1998 cohort of ASMAP had already died. Sampling by Phillips and Kennedy (2002) in winter 2001-2002 indicated that 26% of the 2000-2001 cohort had survived, a figure they considered to be very high and a result of sufficient precipitation in spring and summer.

Weather

Figure 5 in Romspert and Burk shows total precipitation for each month of 1978 and the average monthly precipitation from 1951 through 1970. Interestingly, the report does not show monthly precipitation for the period of July-December, 1977, or for January-April, 1979, despite the fact that precipitation during these two periods undoubtedly affected subsequent counts and measurements. The following two figures show monthly growing season precipitation at 7 weather stations in the vicinity of the dunes (locations of these stations are shown in Willoughby (2001; Map 4). Figure 1 shows the period from July 1977 to June 1978. Figure 2 shows the period from July 1978 to June 1979.

Conclusion

The 10-month study of Romspert and Burk (1979) does not provide sufficient information on the demography of ASMAP to make interpretations on the differential

contribution of plants of various age classes to the seed pool. There are several reasons for this: (1) Individual plants were not marked and followed over time. Instead, plants were counted every month in a belt transect. Because of this a plant that was an adult at the end of the study could either have been an adult at the beginning of the study or a younger plant at the beginning of the study. (2) The length of the study was insufficient to determine the age of the plants in the quadrat. As pointed out above, it is very possible that many of the "older plants" observed in the study were less than one year old. (3) No measurements of reproductive output were made on plants of any age class. (4) No counts were made of plants that were not considered seedlings. A related problem is that no stated criterion was given to distinguish between seedlings and older plants. (5) The sample size was too small to make inferences to a larger population. It is not possible to determine what the sample size of adult plants was because no counts of adult plants are given. Seedling counts varied from a high of 20 plants at the beginning of the study to 7 plants at the end. The area covered by the study ($25m^2$) was also too small.

In defense of the authors it should be noted that their counts of ASMAP seedlings and observations on phenology were just a small part of a much larger study that measured soil properties, seed germination, water potentials, and photosynthetic rates, among other things.

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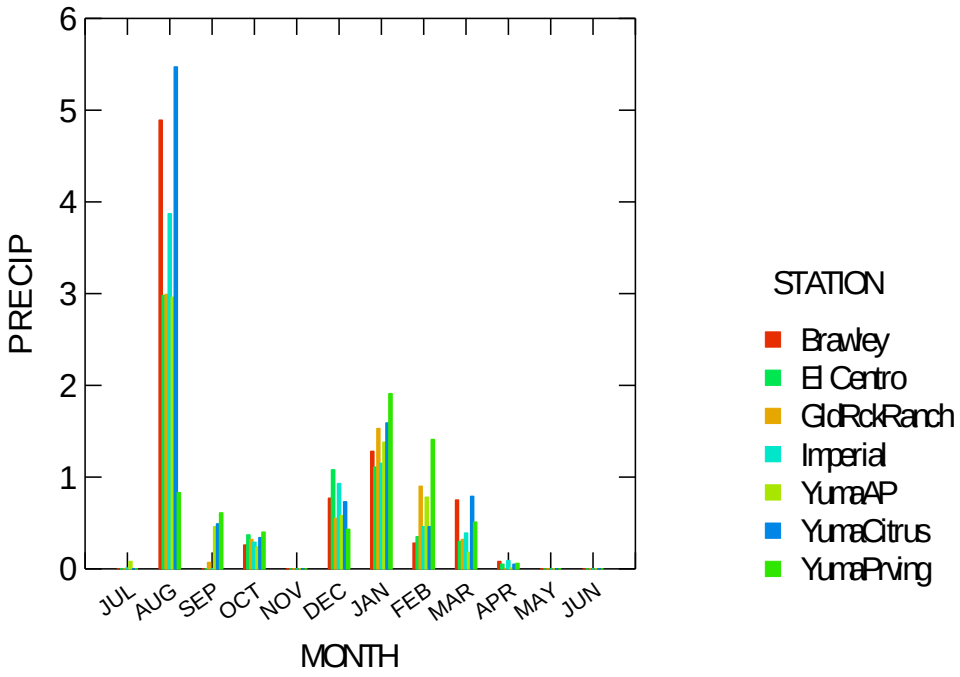

Figure 1. Monthly precipitation (in inches) for the period July 1977-June 1978 for 7 weather stations in the vicinity of the Algodones Dunes.

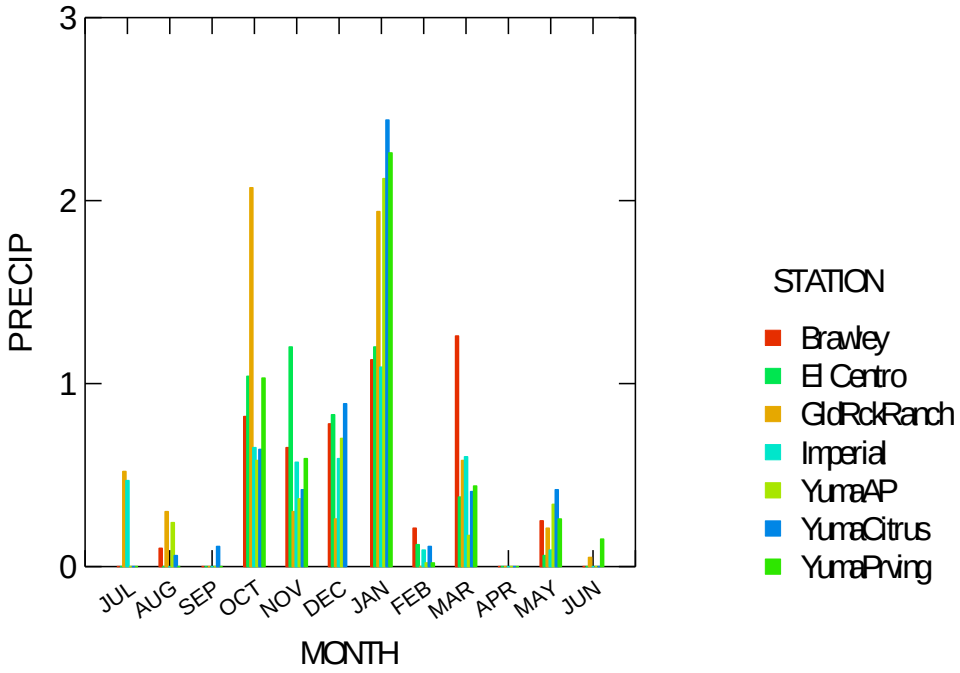

Figure 2. Monthly precipitation (in inches) for the period July 1978-June 1979 for 7 weather stations in the vicinity of the Algodones Dunes.