PHOSPHORUS AND *POA ANNUA* - THE REST OF THE STORY

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A more appropriate title here is "Another Chapter in the Phosphorus - *Poa Annua* Story." The first chapter of this story opens with the observation of Sprague and Burton (1937) that *Poa annua* (hereafter referred to as PA), when grown alone in pots, exhibited a growth response to P applications made to a low P soil but not when made to a high P soil. Comparable greeenhouse studies conducted by Juska and Hanson (1967, 1969) produced similar results. They too grew no other grass species for comparison purposes. Rather, they drew upon earlier research experiences to conclude that PA does not differ from other bluegrasses in its responses to N, P, and K (Juska and Hanson, 1970).

The PA-phosphorus connection was strengthened in 1981 when Dest and Allinson reported that PA densities and survival in a golf course fairway were directly related to the leaf P content of PA. They found leaf P concentrations of 0.41 to 0.60% and compared these to P concentrations of 0.12 to 0.24% reported in the literature for health Kentucky bluegrass. This gave rise to the idea that PA has an unusually high P requirement that, if satisfied, favors PA encroachment in turf. Varco and Sartain (1986) demonstrated that maximum PA clipping weights are associated with high leaf P concentrations, in the range of 0.52%. The missing link in the argument that high soil P levels give PA a competitive advantage over other turfgrasses is evidence that other grasses have lower P requirements. The work of Lunt, Bronson and Clark (1967) suggests that this may be the case. The results of their study showed that the tissue P concentrations associated with maximum growth rates of other turfgrasses are approximately 0.47% for common burmuda grass, 0.45% for Kentucky bluegrass, 0.47% for Highland bentgrass, 0.32% for Emerald zoysia, and 0.42% for Alta fescue.

At this point we leave chapter 1 of the PA-phosphate story and move onto the second chapter. This chapter begins with the observation by several researchers that nutritional effects on PA encroachment in turf extend beyond just P. These include N (Sprague and Burton, 1937; Engel, 1977; Engel and Bussey, 1979), K (Waddington, et al, 1978) and S (Goss, 1974; Varco and Sartain, 1986). In total, these studies offer evidence that the effects of P on PA encroachment in turf are dependent on the levels of N, K and S applied with the phosphate. In fact, Dest and Allinson (1981) concluded that balanced N-P nutrition is required for optimum survival of PA in a mixed Kentucky bluegrass-bentgrass golf course fairway. The connection between N and P seems to be fairly straight forward and may apply to K and S as well. In one of our field trails where Kentucky bluegrass was grown on a soil originally high in P and fertilized with different N fertilizers containing variable amounts of P, leaf P concentrations bore no relationship to the amount of P applied. Rather, tissue N levels accounted for nearly 98% of the observed variation in tissue P concentrations. In other words, grass utilization of P under these circumstances was dependent on the N status of the plant.

This concludes the second chapter in the PA-phosphate story and leaves us with the notion that high soil P levels or applications of high P rates alone do not automatically signify rapid encroachment and survival of PA in turf. Our third chapter begins with the assertion that N is more crucial than P when it comes to PA invasion of bentgrass turf. In 1977, Engel reported research results from which he concluded that the key to minimizing encroachment of PA in bentgrass is minimal use of N. He also demonstrated that time of N application has a significant effect on the rate of invasion of bentgrass by PA. Continuation of this research by Engel and Bussey (1979) further supported the observation that N rate has a dominating effect on PA encroachment but also depends on the N carrier applied and when N is applied. Nitrogen rate, carrier and scheduling effects on PA population of bentgrass have also been reported by Sprague and Burton (1937), Waddington, et al, (1978), Dest and Allinson (1981), Snaydon and Howe (1986), and Dest and Guillard (1987).

What is so striking about the work of Engel and Bussey (1979) and Dest and Guillard (1987) is the magnitude of changes in PA populations associated with N fertilization of intensively managed turf. These changes match and in many cases surpass by a considerable amount the rates of PA encroachment and grass species populations shifts arising from variation of the P supply.

The fourth chapter in this PA-phosphate saga focuses on the work of Snaydon and Howe (1986). They applied an ecological approach in designing a study to determine whether it was above-or below-ground competition that controlled invasion of varying densities of perennial ryegrass by *Poa annua, P. trivialis* and *Festuca rubra* and the nature of that competition. They observed that in the case of PA in particular, the competition was below-ground and increased markedly with increasing ryegrass density (i.e. decreasing size of invasion gaps). Application of N alleviated the rootzone competition between PA and the ryegrass while P and K applications had little effect on PA seedling survival. This research provides a logical explanation for the observation by Dest and Guillard (1987) that the PA population in a bentgrass turf decreased with increasing bentgrass density and declined as much as 34% over a 3-year period when the annual N rate was reduced from 8 to 2 to 3 lb/M.

This fourth chapter in our story leads us to the concept that rapid invasion of turf by PA requires the presence of invasion gaps and adequate supplies of N to overcome root competition between the PA seedlings and the existing turfgrass plants. This does not preclude application of P and other essential nutrients from having an influence as well when their supplies are less than optimal with respect to N. Thus, given the right circumstances, one might be able to demonstrate that application of any one of the essential plant nutrients favors PA encroachment into pre-existing turf.

The idea that the presence of invasion gaps is a prerequisite for encroachment of turf by PA is certainly not new. Sprague and Burton concluded in 1937 that bentgrass density at the time of PA seed production is the controlling factor in the effects of different N fertilizers on the abundance of PA. Coincidence between bentgrass density and the time of PA seedset may well account for Engel's (1977) observation that late August and fall N applications encourage PA encroachment in bentgrass.

With these thoughts in mind, we established a field study to see what effect different soil test P levels and four N carriers, each applied at three rates, have on the invasion of a new stand of creeping bentgrass. The intent was to give the bentgrass a year to acclimate to the N treatments and then overseed with PA. Natural invasion by PA, most likely in August of the first full year of the study, thwarted this plan, but allowed observation of treatment effects on PA invasion by August of the second year of the study. The following spring, a well-intentioned golf course employee treated the plots with benefin plus trifluralin. This dramatically reduced the PA populations that spring and prompted overseeding one-half of each plot with PA the following August. Through this series of events, we were able to observe N treatment effects on natural invasion by PA and the re-establishment of PA populations from the natural invaders and the natural invaders plus the introduced PA seed.

In August of 1988, populations of PA were counted at the peak of inflorescence. Soil test P levels at that time ranged from 111 to 280 1b/A. Population counts were made again in May, 1990, by which time continual applications of activated sewage sludge and clipping removal had altered the range in soil test P levels to 65 to 245 lb/A. Under these conditions, there were no significant relationships between soil P levels and natural PA populations in 1988 (Figure 1) or PA populations in 1990 from the non-overseeded (Figure 2) or PA-overseeded plot areas (Figure 3).

Wide ranges in bentgrass verdure due to the N treatments and the casual observation that there was decidedly more earthworm activity in the activated sludge plots where PA populations were notably greater, prompted examination of the PA populations in relation to bentgrass verdure and earthworm activity recorded as numbers of casts in the plots. This analysis revealed that these two factors accounted for nearly 85% of the extent of natural invasion of PA in the plots by August of 1988. As shown in Figure 4, PA populations increased almost linearly with the numbers of earthworm casts present. Increases in bentgrass verdure partially off-set the apparent enhancement of PA establishment by the presence of large numbers of earthworm casts. The response surface shown in Figure 4 suggests that low bentgrass verdue prevented invasion by PA. Actually, this is indirect evidence that the low N rates that led to low verdure were insufficient to overcome rootzone competition between PA seedlings and bentgrass for N.

In May of 1990, bentgrass verdure and earthworm cast numbers accounted for 79% of the variation in the numbers of PA plants per plot. But in this instance, the influence of earthworm activity was nearly constant while bentgrass verdure was the dominant factor controlling PA populations (Figure 5). Virtually no PA was found at verdure levels about 1.35 g/dm^2.

Changes in PA populations between August, 1988, and May, 1990, (Figure 6) were largely accounted for by bentgrass verdure and earthworm cast numbers averaged over this period of time (R^2=0.857). Intermediate verdure, in combination with a high level of earthworm activity, was most effective in sustaining high PA populations. Low verdure and no earthworm activity or very high verdure actually led to reductions in the PA populations. In the case of low verdure, the effect is presumed to be that of strong rootzone competition for N that reduced PA seedling survival. The effect of high verdure was likely the creation of a situation in which there were few invasion gaps wherein PA could become established.

Does this research constitute the "rest of the story" regarding phosphorus and *Poa annua*? Undoubtedly not. As with any field study, the results may well be site specific and certainly do not apply to sites inhospitable to earthworms. On the other hand, the results do conform to what I see as our current understanding of how fertilization influences PA encroachment in bentgrass. The prerequisites for PA encroachment are the existence of invasion gaps, particularly when PA seed supplies are ample, adequate levels of all nutrients in the soil, and sufficient fertilizer N to overcome bentgrass root competition with the emerging PA seedlings.

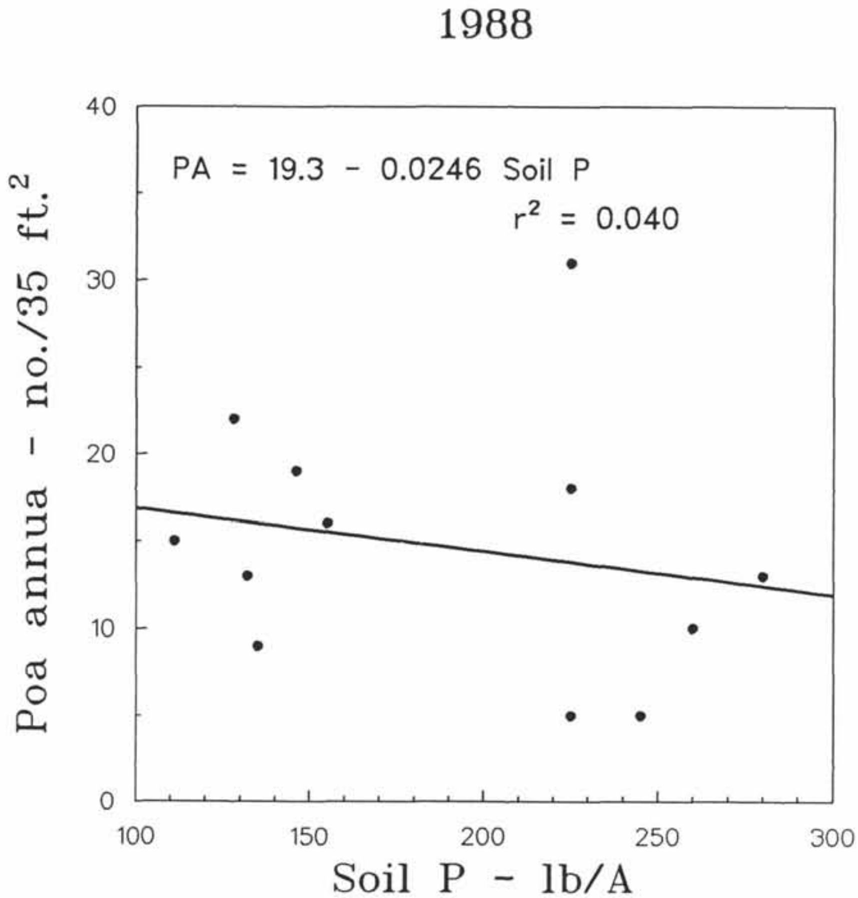

Figure 1. Relationship of soil test P level to numbers of *Poa annua* plants in creeping bentgrass turf in August of 1988.

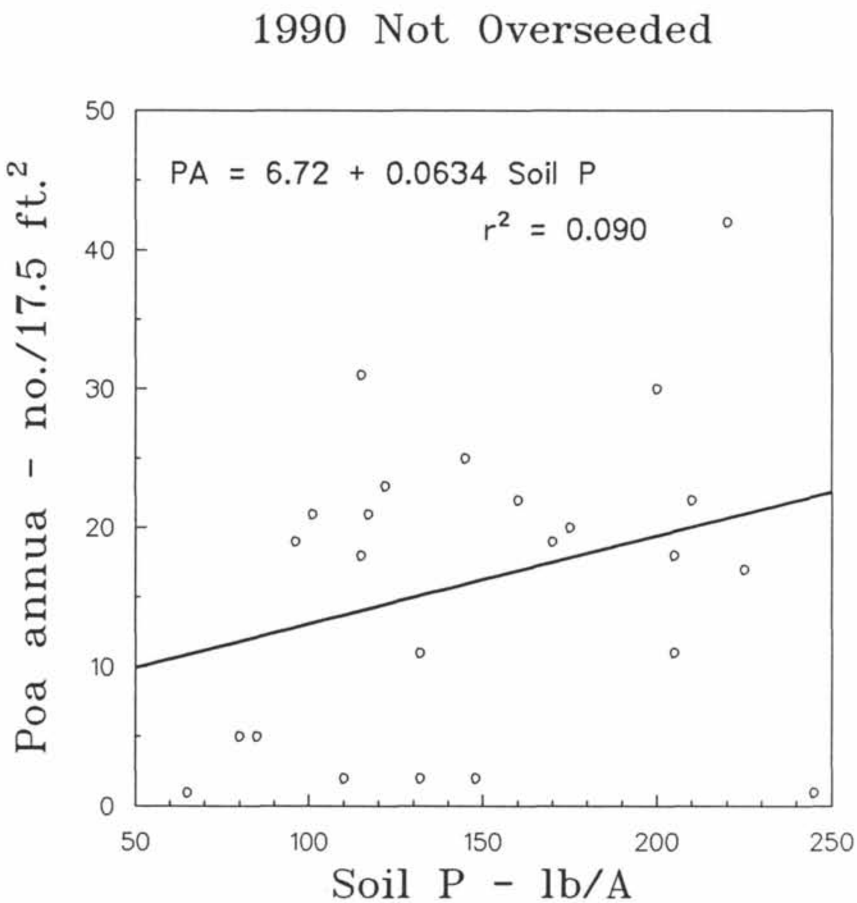

Figure 2. Relationship of soil test P level to numbers of *Poa annua* plants in creeping bentgrass turf in May, 1990, when not overseeded with *Poa annua* the previous August.

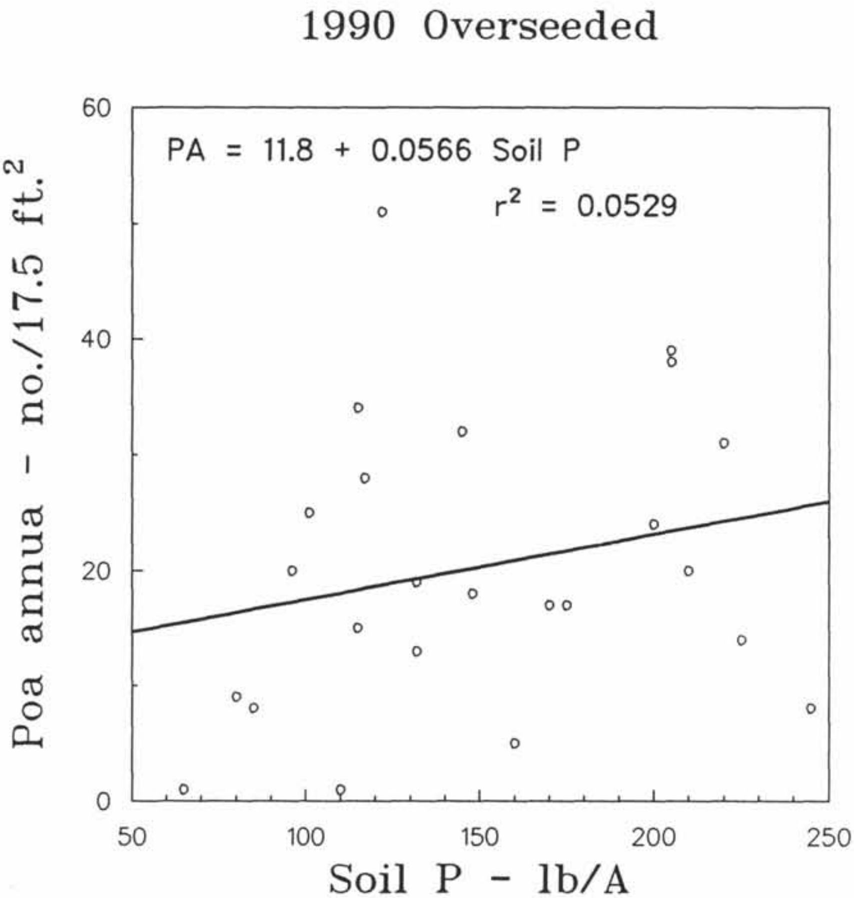

Figure 3. Relationship of soil test P level to number of <u>Poa annua</u> plants in creeping bentgrass turf in May, 1990, after overseeding with <u>Poa annua</u> the previous August.

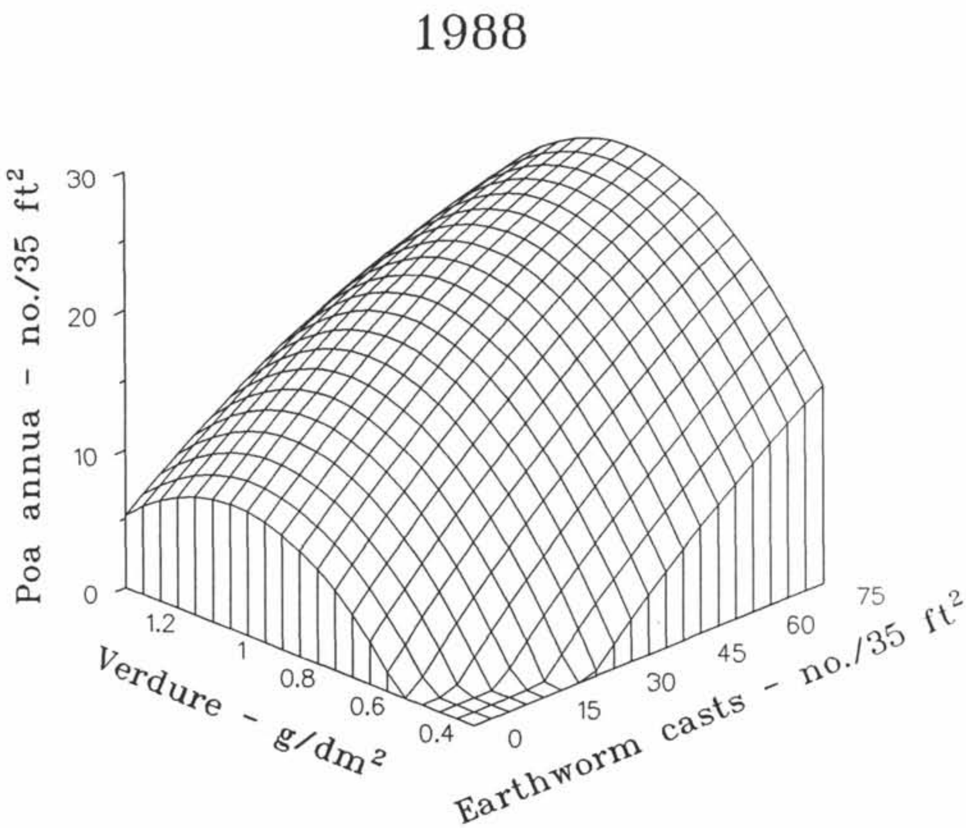

Figure 4. Response surface showing the influence of number of earthworm casts and verdure on the natural invasion of creeping bentgrass by Poa annua in 1988 (R^2 = 0.849).

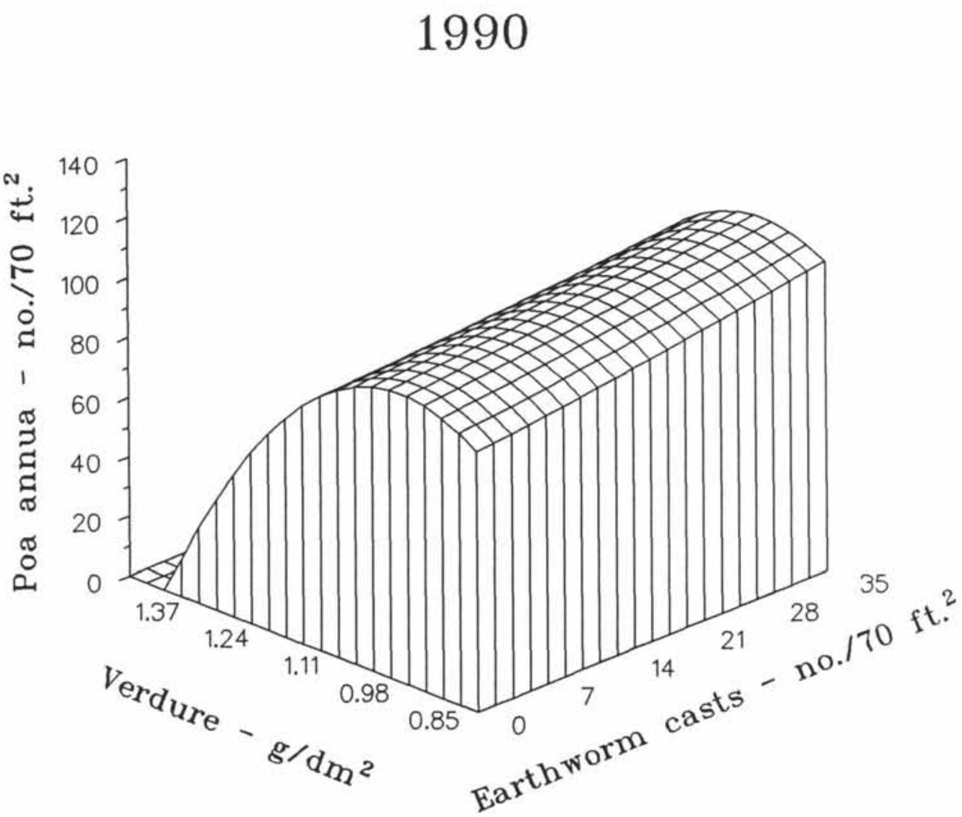

Figure 5. Response surface showing the influences of numbers of earthworm casts and verdure on the *Poa annua* population in creeping bentgrass in 1990 resulting from natural invasion and overseeding of *Poa annua* the previous year (R^2 = 0.792).

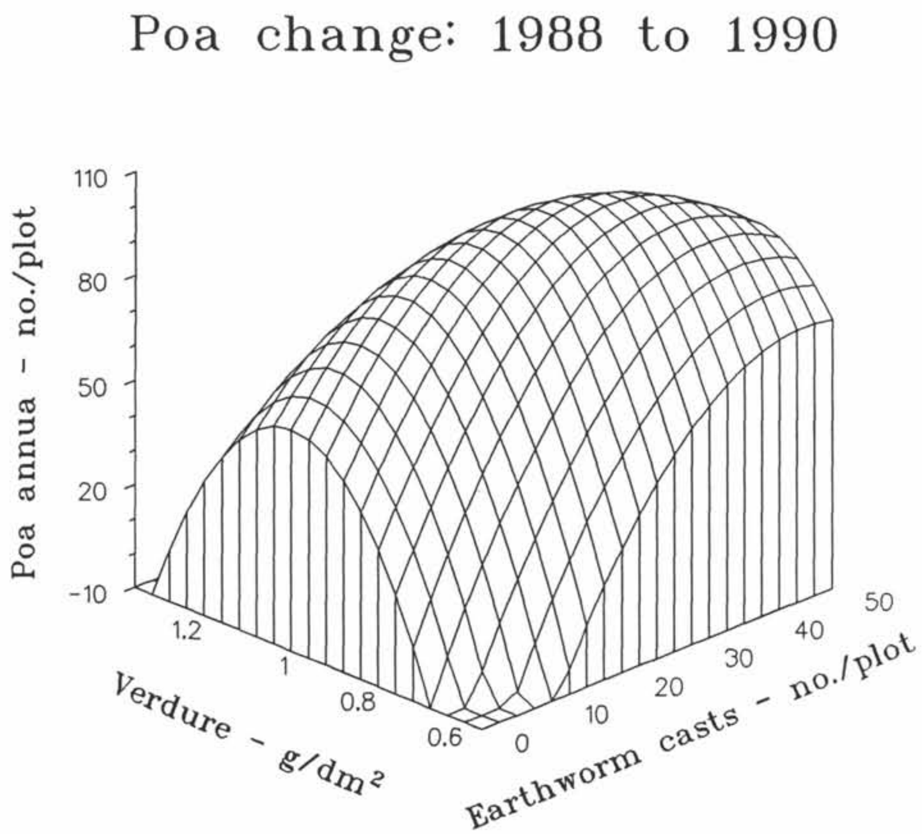

Figure 6. Response surface showing the influence of average number of earthworm casts and verdure on the change in the Poa annua population in creeping bentgrass from 1988 to 1990 (R^2 = 0.857).

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