

**Management of Reintroduced and Natural Populations
of *Amsinckia grandiflora***

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Abstract

The recovery of endangered plants requires the creation of new, self-sustaining populations within historic range and the enhancement of natural populations *in situ*. In the case of *Amsinckia grandiflora* Kleeb. ex Gray, new, reintroduced populations and enhanced natural populations are required by the draft recovery plan. The present study is part of an overall recovery effort to create and enhance those populations.

Pavlik (1990, 1991) reported on efforts to create new populations of *Amsinckia grandiflora* across the entire historic range of the species. One of those populations, at Lougher Ridge, was established during the 1989-90 growing season. Competition with annual grasses was shown to be a major constraint on survivorship, growth and nutlet output. As a result, the study suggested that management of the population beyond its first year should employ some combination of controlled burning and the application of a dilute, grass-specific herbicide (Fusilade®). One of the objectives of the present study was to compare *Amsinckia* responses to herbicide treatment with responses to a combined herbicide-burn treatment and to no treatment at all.

Until April 1991, the only natural populations of *Amsinckia grandiflora* were known from Site 300 of Lawrence Livermore National Laboratory (Alameda and San Joaquin counties). The largest of these, the "Droptower" population, consisted of 104 diminutive plants within a dense sward of introduced grasses. Inspections of senescing flowers and detailed studies of nutlet output indicated that such small plants were unlikely to produce more than a few nutlets each, if any. Therefore, another objective of this study was to enhance the Droptower population at Site 300 by applying Fusilade® in late winter.

The reintroduced population of *Amsinckia grandiflora* at Lougher Ridge was comprised of 1301 reproductive plants in 1991, an increase of 18% over 1990. These plants produced an estimated 51,400 nutlets, an increase of 44% over the number produced in 1990. Using a 4% yield estimate, next year's population could have as many as 2056 plants. Neither of the treatments for grass competition (Fusilade® or Fusilade® + burn) significantly enhanced plant size (and, therefore, nutlet production) in 1991. This is probably due to a temporal pattern of rainfall that brought large amounts of water to the

site during the spring period of maximum reproductive activity. Compared to years with rainfall distributed throughout the winter months, *Amsinckia* plants were subjected to less intense competition in 1991, even though surrounded by the usual sward of annual grasses.

The Droptower population of *Amsinckia grandiflora* consisted of 92 reproductive individuals in April of 1991, a decrease of 12% since the previous year. The plants were much larger than in 1990, probably reflecting the favorable temporal pattern of rainfall. An estimated 2053 nutlets were produced at the Droptower in 1991. If there is only 4% yield during 1991-1992 and no appreciable seed bank, then the population will decline to 82 individuals. Treatment of the Droptower population with Fusilade® did not improve plant size, and so enhancement of nutlet production was not achieved by artificial means. Apparently, the herbicide treatment did not release these plants from competition and nutlet production was lower than expected relative to plants in unsprayed control patches. Also, more *Amsinckia* individuals germinated in sprayed than unsprayed patches after the treatment date. The late-season plants were small at the time of census and most did not have open flowers. As a result, there were more non-reproductive plants in sprayed patches and a smaller tally of nutlets. The inability to detect enhancement, therefore, resulted from the timing of sampling as well as the unusual pattern of precipitation.

These results have direct management implications. Years with below-normal rainfall during the October to January period (e.g. 1990-91) would not require that the Lougher Ridge and Site 300 populations be manipulated with fire or herbicide. Years with near- or above normal rain in late fall (such as 1989-90), however, would require the manager to manipulate populations by treating with an appropriate herbicide a few weeks after grass emergence if these populations are to be enhanced over the next five or ten years.

Acknowledgements

This project owes much to the support and hard work of Ann Howald at the Endangered Plant Program. The cooperation of the landowners and managers was phenomenal - special thanks to Jim Lane and his staff at Site 300. I also appreciate the cooperation of Roger Epperson and his staff at Black Diamond Mines Regional Preserve. The project as a whole could not have been accomplished, however, without the hard work and generous contributions of Ronald Kelley and numerous biology students at Mills College.

Management of Natural and Reintroduced Populations of *Amsinckia grandiflora*

Bruce M. Pavlik

The recovery of endangered plants requires the creation of new, self-sustaining populations within historic range and the enhancement of natural populations *in situ*. New, reintroduced populations reduce the probability of extinction and restore the species to its fullest ecological potential. Enhanced natural populations are larger, less likely to lose their genetic variability, and less susceptible to small-scale perturbation. In the case of *Amsinckia grandiflora* Kleeb. ex Gray, both new and enhanced populations are required by the 1987 draft recovery plan (U.S. Fish and Wildlife Service). Unfortunately, there have been no other species of endangered plants that have been recovered by creating and enhancing populations *in situ* (Pavlik 1991).

Pavlik (1990, 1991) reported on efforts to create new populations of *Amsinckia grandiflora* from the vicinity of Antioch (Contra Costa Co.) to Connolly Ranch (San Joaquin Co.), across the entire historic range of the species. One of those populations, at Lougher Ridge in Black Diamond Mines Regional Preserve, was established during the 1989-90 growing season (Pavlik 1990). In March of 1990, it consisted of 1101 reproductive plants that produced 35,800 nutlets. Competition with annual grasses was shown to be a major constraint on survivorship, growth and nutlet output. As a result, the study suggested that management of the population beyond its first year should employ some combination of controlled burning and the application of a dilute, grass-specific herbicide. The general goal would be to enhance this reintroduced population by promoting germination, survivorship and nutlet output during the entire growing season.

Until April of 1991¹, the only natural populations of *Amsinckia grandiflora* were known from Site 300 of Lawrence Livermore National Laboratory (Alameda and San Joaquin counties). The Site 300 populations are small, and have been unable to grow during the last five to ten years (Figure 1). Census of the Droptower population in April 1990 revealed that most of the 104 individuals were unbranched, wilted, and less than 20 cm

¹The discovery of another natural population in Carnegie Canyon was made by Percy Mussels in April of 1991. It is located on private property about 3 km SE of the Droptower population, and is relatively large (3200 plants).

tall. Inspections of senescing flowers and detailed studies of nutlet output (Pavlik 1988, 1990, 1991), indicated that such small plants were unlikely to produce more than a few nutlets each, if any. The Droptower seed bank was likely, therefore, to be depleted at the beginning of the 1990-91 growing season. Furthermore, the unusual patterns of rainfall and temperature that began in November 1990 and lasted until late winter of 1991 were observed to inhibit *Amsinckia*² germination and growth at other (reintroduction) sites with much larger seed banks (Pavlik 1991). The prospect of two consecutive, sub-optimal years for the Droptower population warranted emergency management. The general goal of that management was to enhance the growth and nutlet output of plants in this natural population by reducing competition from annual grasses.

The specific objectives of the present study included; 1) enhancement of the Lougher Ridge population (promotion of germination, growth, and nutlet production) by controlling competition with annual grasses, 2) an experimental comparison of *Amsinckia* responses to herbicide treatment with responses to a combined herbicide-burn treatment and to no treatment at all, and 3) enhancement of the Droptower population at Site 300 by applying a grass-specific herbicide in late winter.

Methods and Materials

Lougher Ridge

During fall of 1990 the Lougher Ridge population was divided into two treatment areas so that 1990 nutlets in the seed bank would be equitably partitioned (18,900 in one half, 16,900 in the other). The line of division ran through the center of the fenced area, perpendicular to the slope on which it was located (Figure 2). Although other ways of dividing the area were considered, this one was easiest to manage (e.g. easiest to burn, spray and census) and would allow for a large, contiguous floral display if one treatment proved significantly better than the other.

The upper half of the fenced area was burned on 9 October 1990, using two sheetmetal "burn boxes" (Pavlik 1990). The 1.4 X 1.4 m boxes were moved so that contiguous patches could be burned in long strips parallel to the slope and the light

²*Amsinckia grandiflora* will often be referred to by its generic epithet.

prevailing wind (see Appendix A). Treatment of the upper half required burning four of these strips so that the entire area of last year's plots, buffer zones and access paths would be completely cleared of grasses. As small flames escaped the box, two liquid CO₂ fire extinguishers were used to put them out without adding moisture or solid chemicals to the soil. Strip burning also required the use of light watering beyond the burned area to ensure control of the burn. The lower half of the area was not burned at all.

A dilute solution of a grass-specific herbicide was applied to both halves of the population on 15 February 1991. The application was timed so late because regional rainfall was only 27% of normal on 31 January 1991 (Pavlik 1991). Light rains in late January followed by heavy rains in early February finally stimulated germination of annual grasses (and many *Amsinckia*). Each half of the population received 6 liters of a 1/10th strength solution of Fusilade® (ICI Corp.). The solution was made with 6.0 ml of Fusilade in 6 liters of water and 14 ml of a non-ionic surfactant (Monterey Herbicide Helper). A hand sprayer was used to produce a fine mist that wetted the grass blades and culms. Care was taken to prevent overspray and very little (if any) of the liquid dripped onto the soil surface. Native bunchgrasses that grew within the area were avoided. Dieback of the non-native grasses was obvious by 7 March. Native forbs, including monocots such as *Chlorogalum pomeridianum*, were not noticeably affected by the herbicide.

Census of the population took place on 1 April 1991, when *Amsinckia* plants were robust (25-32 cm tall) and near the peak of floral display. Each of the 20 treatment plots from 1989-1990 served as a reference for counting plants, since it appeared that most nutlets did not disperse far from their place of origin. Ten of those plots were in the upper half of the fenced area (fire + herbicide) and ten were in the lower half (herbicide only). All plants within a 2 X 2 m area centered on each treatment plot were counted as having their origin in that particular plot. This allowed later comparisons of seed bank size to the total number of reproductive plants for a given plot. Plants that grew between the 2 X 2 m areas were counted as part of the census but their origins were not assigned to plots. Finally, plants which dispersed and grew beyond the fenced area (and did not get fire or herbicide treatment) were tallied, measured, and their distances to the fence determined.

In order to estimate the nutlet production of the 1990-1991 population and to determine treatment effects in the two area halves, 100 plants were randomly selected and measured for shoot length on 1 April. Two reference stakes were located *a priori* in each half of the area (= 4 stakes total). A random numbers table was used to generate 25

compass bearings off of each stake (0 to 360°) and 25 distances in centimeters (0 to 400 cm). The plant nearest to a point described by each pair of bearing-distance coordinates had its shoot length measured and its floral morph (pin/thrum) determined. All plants that grew beyond the fenced area were measured as well. Shoot length was translated into nutlet output per plant using the equation developed at Lougher Ridge in 1990 (# nutlets/plant = 4.60 (shoot length in cm) - 79.25, $r = 0.77$ $P < 0.01$, Pavlik 1990).

Site 300: Droptower population

After emergence of the annual grasses at Site 300, a dilute solution of Fusilade® was applied with a hand sprayer to portions of the Droptower population. Five patches of habitat, centered around five clusters of flags that marked the positions of 1990 plants, were each given 800 ml of a 1/10th strength solution (4.1 ml Fusilade in 4.1 liters of water with 10.2 ml of non-ionic surfactant) on 19 February 1991. Each patch was different in size, but they averaged about two square meters in size. Very few (about 10) *Amsinckia grandiflora* seedlings were observed at that time, and they had only six to eight leaves each. Two additional patches in close proximity to the flags that did not contain plants last year also received treatment, while two patches that did have flags and plants were not sprayed.

A census was conducted on 13 March when the population in a "typical" rainfall year would have been in full bloom. There were many fiddleneck seedlings observed, but only 16 (one in flower) could be confirmed as *A. grandiflora* (the others were mostly *A. gloriosa*). A later census was conducted on 8 April. This census included total population size, pin/thrum ratio, spatial distribution, and non-destructive measurements of shoot length for every individual. Shoot length was translated into nutlet output per plant using the equation developed at Connolly Ranch in 1991 (#nutlets/plant = 3.42 (shoot length in cm) - 65.46, $r = 0.86$ $P < 0.01$, Pavlik 1991). The Draney Canyon population at Site 300 was also censused on 8 April (see Figure 1).

The effects of grass herbicide were determined by comparing shoot length and midday water potential of plants growing within and outside of treated patches. The water status of reproductive plants was measured with a Scholander-type pressure bomb. Branches of six *A. grandiflora* plants from two sprayed patches and branches of six plants from two unsprayed patches were excised and inserted into the bomb between 1330 and 1430

hours on 6 May. Most plants selected for measurement were vigorous and flowering at the time, although a few representative senescent plants were also included in the samples.

Results and Discussion

Lougher Ridge

A total of 1301 flowering plants of *Amsinckia grandiflora* were counted at Lougher Ridge on 1 April, 1991, an 18% increase over March of 1990 (Table 1). Overall population yield (yield = # reproductive 1991 plants/ # 1990 nutlets X 100) was approximately 4%. Last year's treatment effects on nutlet production had a significant influence on local population density this year, as most plants (1093) were found in or near the 20 plots. Plots that had the highest nutlet production in 1990 (burn and fusil plots) had the greatest numbers of reproductive plants in 1991 (Figure 3). Between the dense aggregations grew 187 plants whose showy floral displays began to coalesce with those in adjacent plots (see Appendix A). Sampling revealed that the pin/thrum ratio still favored pin individuals overall, but local aggregations (near two of the sampling stakes) had ratios close to 1.0. The plants were generally larger than in the previous year and more fecund: 51,364 nutlets were produced, a 44% increase over nutlet production in 1990. Using the 4% yield estimate described above, next year's population could have as many as 2056 plants.

Table 1. Comparison of characteristics of the Lougher Ridge population of *Amsinckia*, 1990 and 1991. Pin/thrum ratio and nutlet production in 1991 based on a random sample of 100 plants.

total # reproductive plants		plant population growth (%)	pin/thrum ratio		estimated # total nutlets produced		nutlet production growth (%)
1990	1991		1990	1991	1990	1991	
1101	1301	+18.2	1.36	1.27	35,800	51,400	+43.6

Twenty-one plants were found outside of the fence, dispersing an average distance of 1.9 m (4.2 m maximum). More than half had moved uphill to the south, presumably blown by strong north winds. These were surrounded by many *A. intermedia* plants which had grown tall after the heavy rains of February and March.

There were no obvious or measurable differences in the two *Amsinckia* subpopulations; the burning + Fusilade treatment was no more beneficial than the Fusilade treatment alone (Table 2). In fact, the combination treatment produced fewer plants despite a larger estimated seed bank (Figure 2). This led to a higher population yield in the area which had been treated only with herbicide. There were also no significant differences in plant size (mean maximum or mean) between the two treatment subpopulations. The addition of burning did not enhance growth or, therefore, nutlet production, over and above herbicide treatment alone. Of equal importance was the fact that treatment for annual grass competition by any means appeared unnecessary; plants in the treated areas (both population halves) and plants that had dispersed into untreated areas beyond the fence were the same size and produced the same number of nutlets.

Table 2. Effects of burning and herbicide treatment on the Lougher Ridge population of *Amsinckia*, 1991. $n = 50$ for sprayed and burned + sprayed estimates of mean plant size and mean nutlet production, while $n = 21$ for untreated plants beyond the fenced area. $n = 20$ for sprayed and burned + sprayed estimates of mean maximum plant size, while $n = 10$ for untreated plants beyond the fenced area. ANOVA comparisons of plant size found no significant differences ($P < 0.05$).

treatment	# of repro plants	P/T ratio	yield (%)	plant size		nutlet production	
				mean maximum (cm)	mean (cm)	mean (#/plant)	total (#/area)
Fusilade	747	1.78	4.4	30.3 ± 2.1	26.2 ± 4.6	41.3	30,866
burned + Fusilade	533	0.92	2.8	31.3 ± 3.3	25.2 ± 6.3	36.7	19,572
untreated	21	0.91	--	32.5 ± 4.8	26.8 ± 7.1	44.1	926

All plants, regardless of treatment, were significantly larger than 1989-90 plants in the grassy control plots (mean shoot length = 18.6 ± 2.8 cm) at Lougher Ridge (Pavlik 1990). This indicates that competition from annual grasses was not as important in 1990-91 as it was in 1989-90. Pavlik (1991) attributed this discrepancy, also observed at the nearby Black Diamond II population of *Amsinckia*, to an unusual pattern of spring rainfall that favored forbs throughout the region. The previous year of 1989-90, however, had its meager rainfall distributed evenly from October to March and competition was more intense for longer periods during critical life history phases.

Site 300: Droptower Population

The Droptower population consisted of 92 reproductive individuals in April of 1991, a decrease of 12% since March of 1990 (Figure 1, Table 3). The pin/thrum ratio was 2.0, much more skewed towards pins than in previous years, although 19 plants did not have open flowers at the time of census. The plants were much larger than in 1990, as 26 individuals had shoot lengths exceeding 30 cm and 2 individuals had shoot lengths exceeding 40 cm. There were, however, 29 small plants (shoots less than 19 cm) that were unlikely to produce more than 1 nutlet each. Applying the 1991 shoot length-nutlet production equation from the nearby population at Connolly Ranch provided an estimate of 2053 nutlets produced at the Droptower site in 1991. If there is only a 4% yield during

Table 3. Comparison of characteristics of the Droptower population of *Amsinckia* at Site 300, 1990 and 1991. Pin/thrum ratio in 1991 does not include 19 plants with unopened flowers. Nutlet production estimated using Connolly Ranch equation for 1991.

total # reproductive plants		plant population growth (%)	pin/thrum ratio		estimated # total nutlets produced		nutlet production growth (%)
1990	1991		1990	1991	1990	1991	
104	92	- 11.5	1.04	2.04	----	2053	----

1991-1992 and no appreciable seed bank, then the population will decline to 82 individuals. This prediction ignores the possible contribution of late-season plants that continued to flower for weeks after the April census was conducted (see below).

Treatment with the grass-specific herbicide Fusilade® did not improve mean or mean maximum plant size (Table 4), and so enhancement of nutlet production was not achieved by artificial means. Instead, the plants were larger in 1991 than 1990 because of a temporal pattern of precipitation that reduced competition with annual grasses during the reproductive period. Late winter-early spring rains favored *Amsinckia* rather than grasses in 1991, unlike the evenly-spaced rains that occurred from October to April in 1989-1990 (Pavlik 1990). As a result, the herbicide treatment did not release these plants from strong competition and nutlet production was lower than expected relative to plants in untreated control plots. This was also observed at the Lougher Ridge and Black Diamond II reintroduction sites (Pavlik 1991).

Measured nutlet production was lower than expected for another reason - the herbicide treatment had an unanticipated effect on the dynamics of the Droptower population. Approximately 24 *Amsinckia* individuals germinated in sprayed patches after the 19 February treatment date, compared to only 5 in unsprayed patches. It is possible that the absence of a live grass canopy allowed the rains of late February and March to better affect germination and seedling establishment. These late-season plants were small (≤ 19 cm shoot length) at the time of census and most did not have open flowers (16 treated and 3 untreated were pre-anthesis). As a result, there were more non-reproductive plants in sprayed patches and a smaller tally of nutlets. However, the

Table 4. Effects of herbicide treatment on the Droptower population of *Amsinckia*, 1991. ANOVA comparisons of plant size found no significant differences ($P < 0.05$).

treatment	# of plants	# of repro plants	P/T ratio	plant size		nutlet production	
				mean maximum (cm)	mean (cm)	mean (#/ repro plant)	total (#/treat patch)
Fusilade	53	37	2.36	35.5 \pm 4.7	22.1 \pm 8.9	25.0	927
untreated	39	36	1.70	34.6 \pm 2.9	27.1 \pm 6.6	31.3	1126

non-reproductive plants were green and vigorous at the time of census and were expected to produce significant numbers of nutlets in the weeks following sampling. This was also true of the older plants: those in sprayed patches were still growing and flowering at the time of census while those in unsprayed patches were mostly senescent. The inability to detect enhancement, therefore, resulted from the timing of sampling as well as the unusual pattern of precipitation.

Measurements of plant water status in early May support this interpretation. Midday xylem water potentials of plants in treated patches ($\Psi = -0.88 \pm 0.09$ MPa) tended to be higher and less variable than those in untreated patches ($\Psi = -1.18 \pm 0.32$ MPa), but the difference was not significant (ANOVA, $P=0.05$, 1/10 df). In general, the measured water potentials did not fall into the stressful range of -1.5 to -2.0 MPa associated with herbaceous dicots in annual grassland (Gulmon et al. 1983), although senescent individuals in unsprayed patches had water potentials as low as -1.67 MPa. Some low level of competition for water was occurring and plants in sprayed patches had an extended season for flowering, but overall these conditions did not affect nutlet production. This result was also observed this year at the Black Diamond II reintroduction site (Pavlik 1991). In a year with less spring rainfall, however, competition for water is likely to be a major factor in reducing *Amsinckia* reproduction at the Droptower site.

Conclusions and Management Recommendations

- 1) The reintroduced population of *Amsinckia grandiflora* at Lougher Ridge was comprised of 1301 reproductive plants in 1991, an increase of 18% over 1990. These plants produced an estimated 51,400 nutlets, an increase of 44% over the number produced in 1990. Using the 4% yield estimate, next year's population could have as many as 2056 plants.
- 2) Neither of the treatments for grass competition (Fusilade® or Fusilade® + burn) significantly enhanced plant size (and, therefore, nutlet production) in 1991. This is probably due to the temporal pattern of rainfall which brought large amounts of water to the site during the period of maximum reproductive activity. *Amsinckia* plants were subjected to less intense competition over shorter periods of time, even if surrounded by

annual grasses. These results have direct management implications. Years with below-normal rainfall during the October to January period (e.g. 1990-91) would not require that the Lougher Ridge population be manipulated with fire or herbicide treatments. Years with near- or above normal rain in late fall (such as 1989-90), however, would require the manager to manipulate the population by treating with an appropriate herbicide a few weeks after grass emergence.

3) The Site 300 Droptower population of *Amsinckia grandiflora* consisted of 92 reproductive individuals in April of 1991, a decrease of 12% since the previous year. The plants were much larger than in 1990, probably reflecting the favorable temporal pattern of rainfall. Applying the 1991 shoot length-nutlet production equation from the nearby population at Connolly Ranch provided an estimate of 2053 nutlets produced at the Droptower in 1991. If there is only 4% yield during 1991-1992 and no appreciable seed bank, then the population will decline to 82 individuals.

4) Treatment of the Droptower population with Fusilade® did not improve plant size, and so enhancement of nutlet production was not achieved by artificial means. Apparently, the herbicide treatment did not release these plants from competition and nutlet production was lower than expected relative to plants in unsprayed control patches.

Measured nutlet production was lower than expected for another reason - the herbicide treatment had an unanticipated effect on the dynamics of the Droptower population. More *Amsinckia* individuals germinated in sprayed than unsprayed patches after the 19 February treatment date. The late-season plants were small at the time of census and most did not have open flowers. As a result, there were more non-reproductive plants in sprayed patches and a smaller tally of nutlets. However, the non-reproductive plants were green and vigorous at the time of census and would eventually produce significant numbers of nutlets in the weeks following sampling. This was also true of the older plants: those in sprayed patches were still growing and flowering at the time of census while those in unsprayed patches were mostly senescent. The inability to detect enhancement, therefore, resulted from the timing of sampling as well as the unusual pattern of precipitation.

The same implications regarding management at Lougher Ridge apply to Site 300 (see conclusion # 2 above).

Literature Cited

- Gulmon, S.L., N.R. Chiariello, H.A. Mooney and C.C. Chu. 1983. Phenology and resource use in three co-occurring grassland annuals. *Oecologia* 58, 33-42.
- Pavlik, B. M. 1988. Nutlet production and germination of *Amsinckia grandiflora*. I. Measurements from cultivated populations. California Department of Fish and Game, Endangered Plant Program, Sacramento, CA. 27 pp.
- Pavlik, B. M. 1990. Reintroduction of *Amsinckia grandiflora* to Stewartville. California Department of Fish and Game, Endangered Plant Program, Sacramento, CA. 59 pp.
- Pavlik, B. M. 1991. Reintroduction of *Amsinckia grandiflora* to three sites across its historic range. California Department of Fish and Game, Endangered Plant Program, Sacramento, CA. 50 pp.
- U.S. Fish and Wildlife Service. 1987. Draft Recovery Plan for the Large-flowered Fiddleneck *Amsinckia grandiflora*. U.S.W.F.S., Department of the Interior, Sacramento, CA.

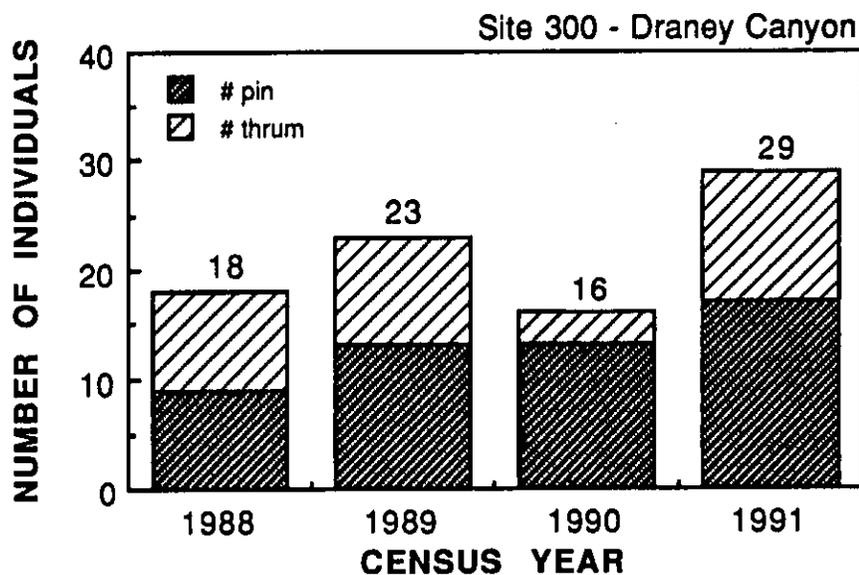
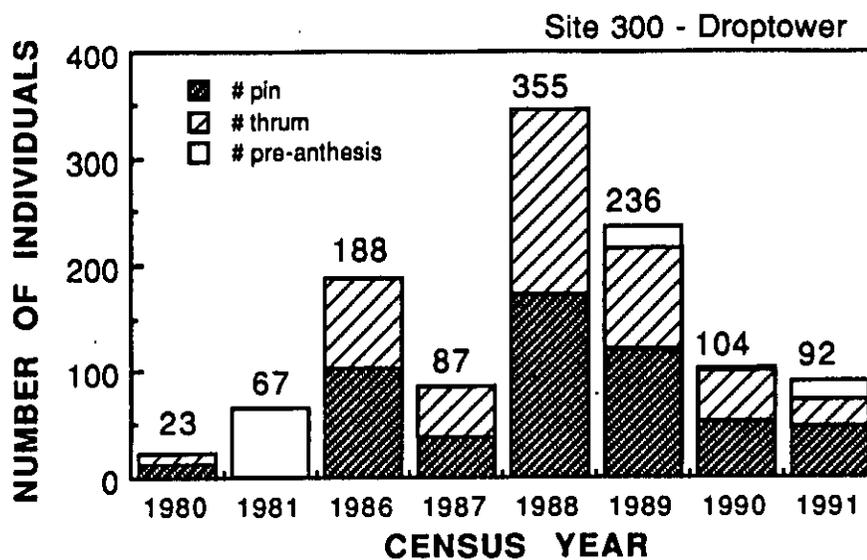


Figure 1. Spring census of the Droptower and Draney Canyon populations of *Amsinckia grandiflora* at Site 300, Alameda and San Joaquin counties, California. Total population sizes and the proportions of pin and thrum individuals are shown.

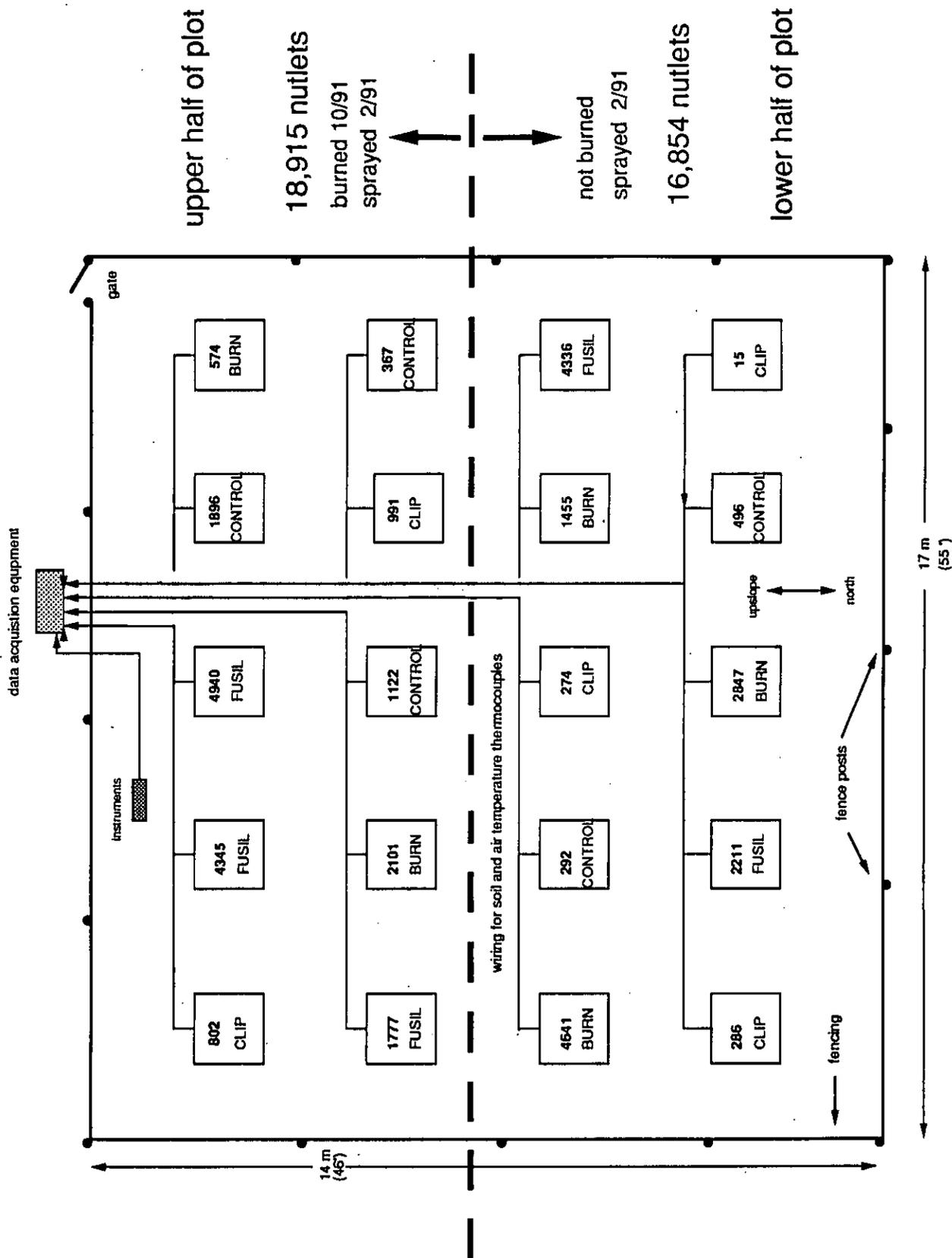


Figure 2. Lougher Ridge reintroduction site for *Amsinckia grandiflora*. Treatment plots of 1989-90 are shown, along with their estimated nutlet production (bold). Site was divided into two halves for treatment with Fusilade and fire (upper half) or just Fusilade alone (lower half).

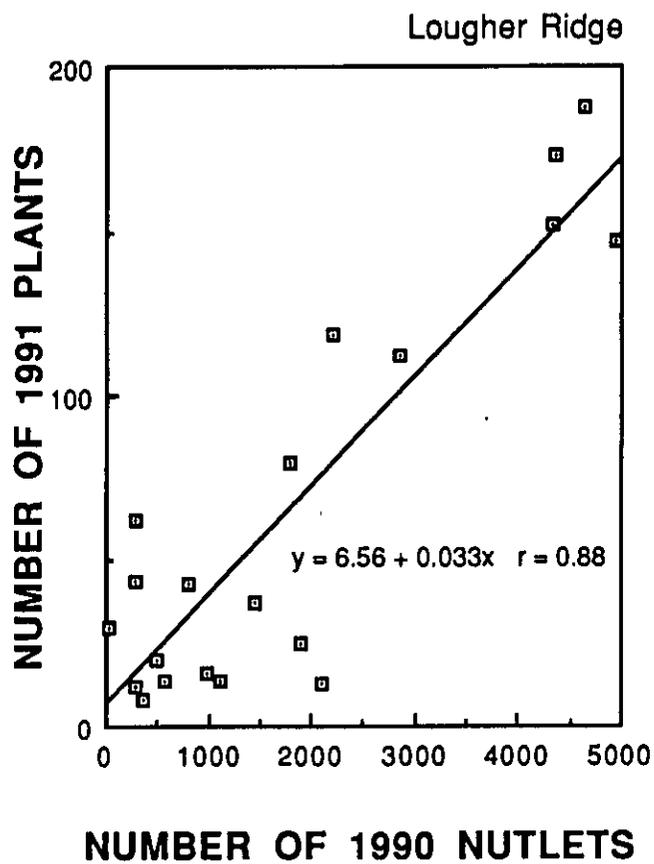


Figure 3. Relationship between 1990 nutlet production in the Lougher Ridge treatment plots and the number of reproductive plants found in or near those plots.