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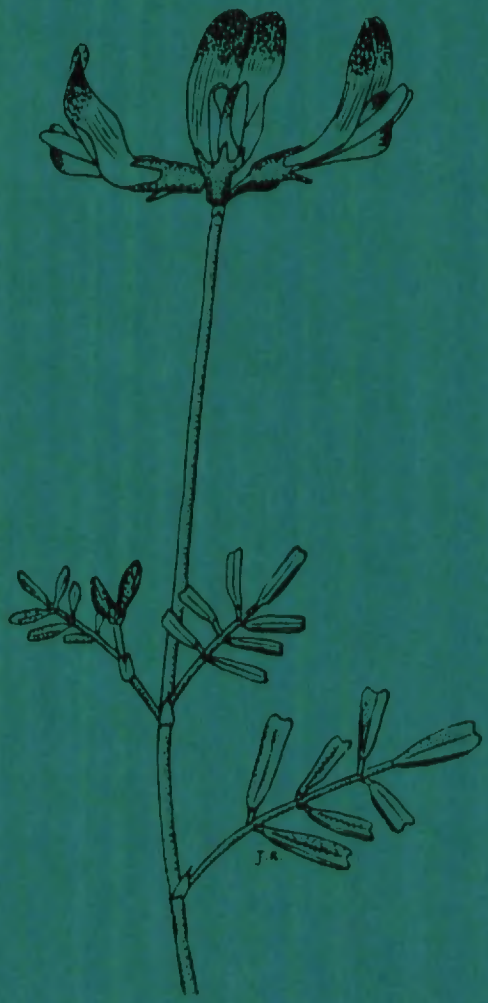

Submitted By:
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Submitted To:
Diane Steeck/Endangered Plant Program
California Department of Fish and Game - Natural Heritage Division
1416 9th Street • Sacramento, CA • 95814-2090

Funded By: Emergency Drought Relief Project
Project Contract No. CA HER 010693
July 1994

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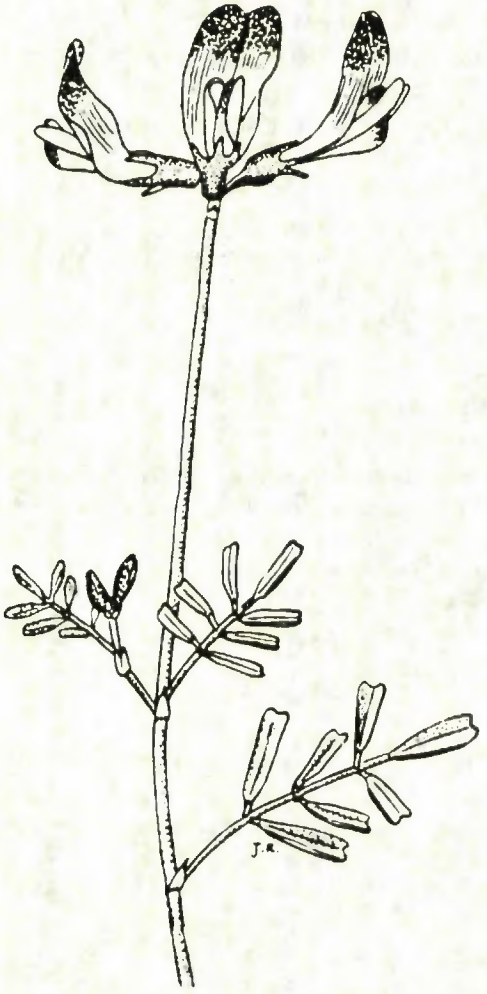

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The author would like to thank the California Department of Fish and Game (Emergency Drought Relief Program) for funding this study and The Nature Conservancy for coordinating the subcontract.

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A special thanks to my wife April whose computer literacy is continually opening new doors and has aided greatly in the production of this report.

ABSTRACT

Clara Hunt's milkvetch is a narrow endemic annual forb, restricted to a small portion of the North Coast Ranges of California. This species, listed by the state of California as Threatened, occurs in western Napa and eastern Sonoma counties. There are presently four known extant occurrences (populations) (Figure 1). During an extended period of below normal rainfall between 1985 and 1992, population sizes declined at regularly monitored sites. Population counts were at a record low in 1991 possibly due to this extended drought. In addition, accidental burial under a dredge soil stockpile damaged over 90% of the habitat of one population.

This study was initiated in February 1993 to gather information on the ecology of the species and to assess the extent and nature of the disturbance that has befallen the Conn Valley Road occurrence. Regular visits were made to that site between February and June 1993, and to a population site which most closely resembles it, west of St. Helena, Napa County. Periodic monitoring was conducted within a temporary constructed grid system. The Alpine School population was visited once in 1993 and the Bothe site was visited on a few occasions during the spring of 1993 and 1994.

This report documents the life cycle of this species as observed between February 1993 and May 1994 and discusses distribution, population size and seed production. This report also includes habitat data related to soil characteristics, rainfall, slope and aspect conditions and plant associations for each of the four sites.

A population census conducted at Conn Valley Road in 1992 (Howald, LeMaster, and Ruygt) showed a remarkable increase in size from the previous year after partial stockpile removal but also noted the introduction of threatening weedy species. It is apparent that further habitat restoration is needed to insure the persistence of this population. A proposal for habitat restoration is based on the observation that this species can withstand superficial habitat disturbance and respond positively.

It is recommended that measures be taken to remove additional stockpiled soil and control invasive weeds. A co-operative agreement (signed MOU) between the City of Napa and Department of Fish and Game permitting a reclamation program is necessary to effectively restore the site. A long term, annual monitoring and protection plan is also needed to insure survival.

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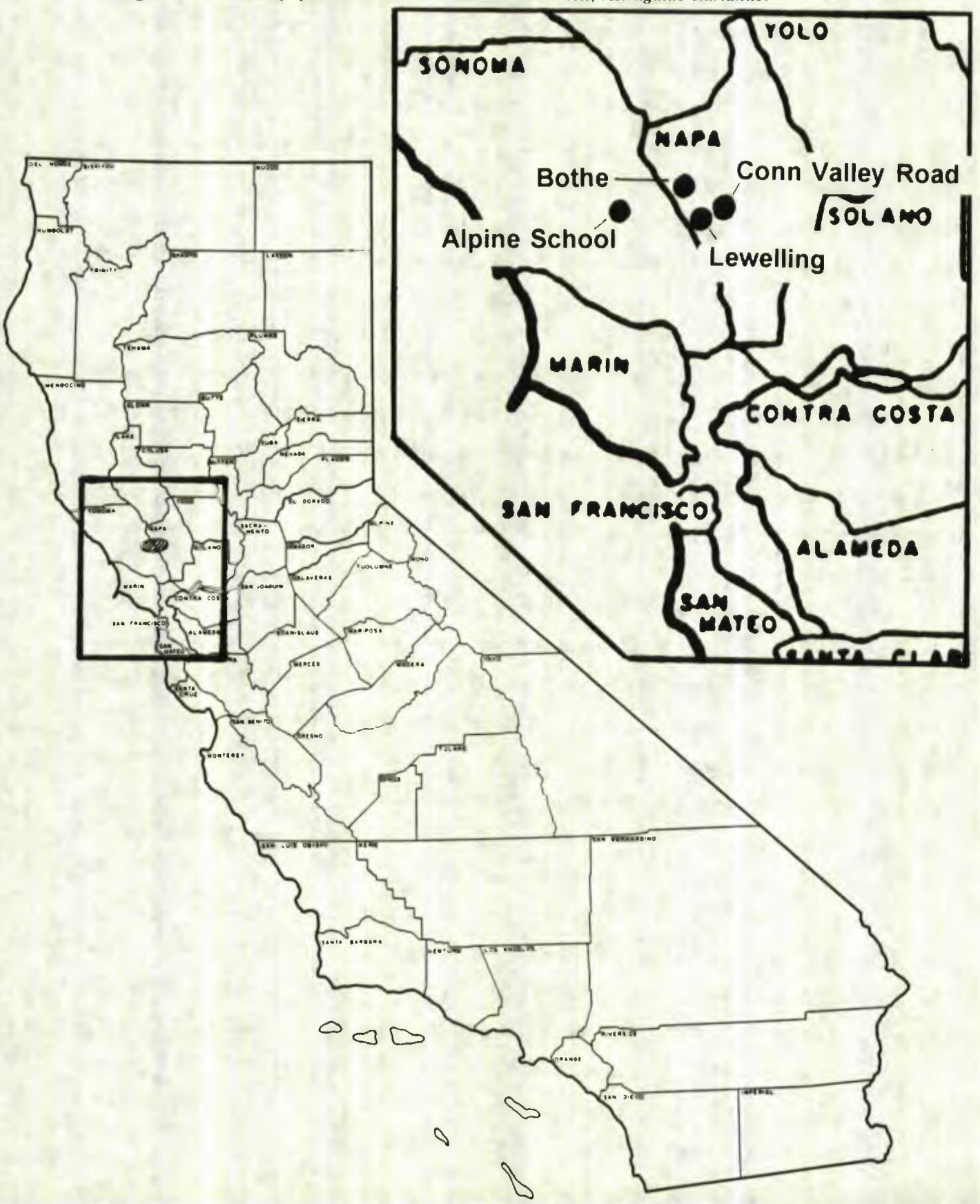
INTRODUCTION

Clara Hunt's Milkvetch is a small, spring flowering annual and a member of the Pea Family (Fabaceae). It was first collected by Clara A. Hunt in the "Napa Range: near St. Helena" (Jepson, 1925) in 1909. The species was described by Jepson in 1925 and known at that time from the type locality and Conn Valley. Subsequent reports for this species brought the total reported sites to 12 locations scattered from the St. Helena area to Middletown, Pope Valley and Knoxville. The Illustrated Flora of the Pacific States (Abrams, 1944) sites the range of the species as extending into the Sacramento Valley. Herbarium review and field searches determined that several of these reported occurrences were erroneous (McCarten, 1985) and these have been consequently deleted by the California Natural Diversity Database. This may be due in part to an illustration published in Abrams' flora depicting the flower keel as much shorter than the wings which identifies the closely related *Astragalus rattanii* var. *jepsonianus*. *Astragalus clarianus* also differs from that species by the presence of a gynophore, a short stipe on which the fruit is elevated. To date, only 6 occurrences have been authenticated, although the precise location of the type locality is unknown and may coincide with one of the other four extant occurrences.

Construction of a reservoir in Conn Valley, agricultural and residential development have all contributed to the reduction or elimination of habitat of this species. A number of collections voucher the Conn Valley site in Napa County and the Alpine School site in Sonoma County but the precise locations of these sites were not determined until they were relocated by William Grummer (park ranger, Bothe Napa Valley State Park) in 1984. His field work to develop an inventory of flowering plant species within park boundaries revealed an occurrence within Bothe Park in 1980. His description of the species to a friend, Alan Wight, led to the discovery of another population on the Lewelling Ranch in 1990.

During the fall of 1990, over 1,500 cubic yards of sediment dredged from the bottom of Lake Hennessey was stockpiled inadvertently on a population of Clara Hunts milkvetch (Conn Valley Road). The soil was to be temporarily stored for use by a group of topsoil vendors. No plants were located in the winter of 1990-1991 after burial and very low rainfall. In contrast, many plants were observed in 1991-1992 following partial reclamation of the site in March of 1991 and rainfall more favorable to milkvetch growth. Currently, the site is under pressure from competing weedy species. Population size during 1994 was near the record low.

Figure 1. Extant populations of Clara Hunt's milkvetch, *Astragalus clarianus*.



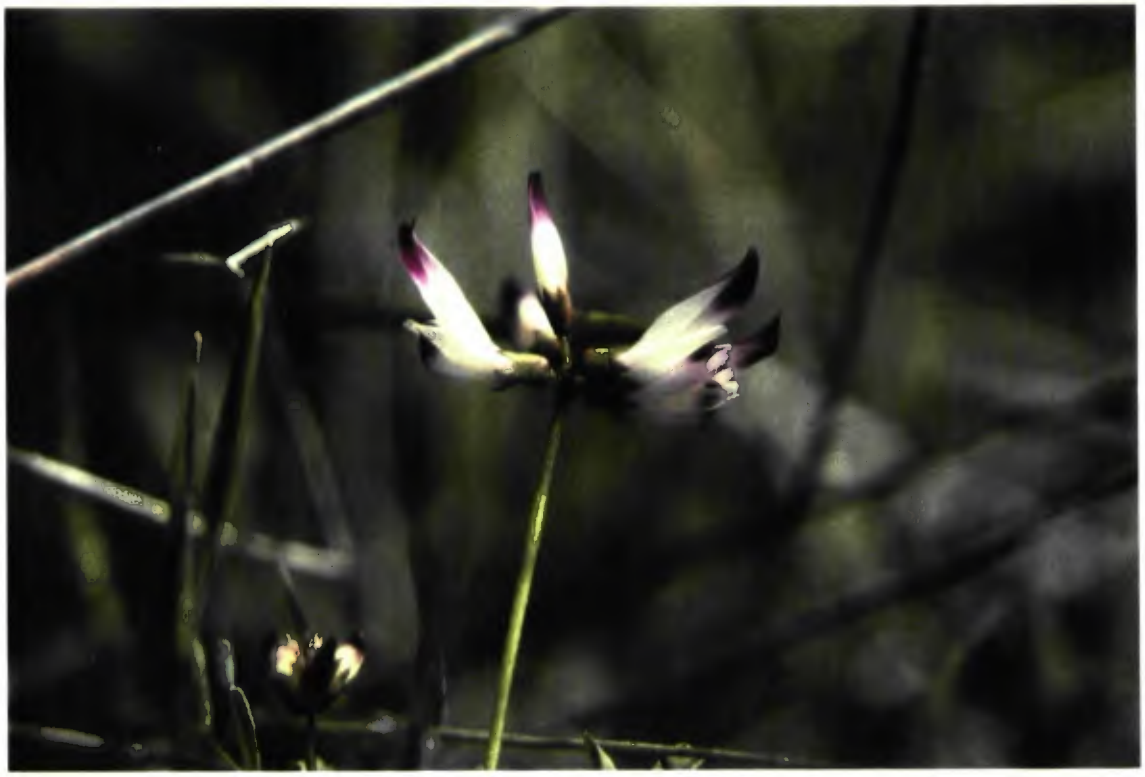


Figure 2. Closeup of an *Astragalus clarianus* flower raceme.

Figure 3. Clara Hunt's milkvetch plants in flower at Alpine School site.

PROJECT OBJECTIVES

The primary objective of this study is to gather data to elucidate the habitat requirements and ecology of Clara Hunt's Milkvetch to assist in developing a habitat restoration plan for the Conn Valley Road/Lake Hennessey population. Integral parts to this objective include:

1. Construction of a census and monitoring grid at both the Conn Valley Rd. and Lewelling Ranch sites and weekly to biweekly visits to gather ecological data.
2. Determining the 1993 population count of all four occurrences. Repeating the census of the Conn Valley Road and Lewelling population in 1994.
3. Plotting the distribution of each population on a topographic map and locations on aerial photographs for the Conn Valley Road and Lewelling sites.
4. Collecting data on germination, vegetative growth, flower and seed production.
5. Comparing the cover value of Clara Hunt's Milkvetch to that of associated species.
6. Observing pollinator(s), herbivores, and pathogens affecting the growth and development of the species.
7. Determining the extent and nature of damage to the Conn Valley Road site by comparing/ contrasting to conditions at the Lewelling site.
8. Recording soil characteristics and slope conditions within the habitat of the species and comparing to adjacent unoccupied habitat.
9. Comparing rainfall data for the sites, postulated from area weather stations and limited field collection, to population fluctuation.
10. Investigating the timing, methods and options for weed control and soil profile recovery at Conn Valley Road and make appropriate recommendations from findings.
11. Determining long term site management for Conn Valley Road population.
12. Assimilating historic population monitoring and specimen collection data with empirical data from this study.

MATERIALS AND METHODS

Construction of Monitoring Grids

Beginning in February of 1993, the Conn Valley and Lewelling sites were visited periodically to determine locations of *Astragalus clarianus* plants. The grid perimeter was selected to encompass the greatest number of individuals possible within a manageable study area. Construction of the grid at Lewelling began in mid-March and was completed during the April 7th census. Due to the proximity of the Conn Valley Road site to a popular fishing spot, the grid was laid out on the day of the census and removed immediately following completion of the census. One boundary was selected at each site to parallel a roadway or fence line which would be visible on the aerial photograph (Appendix 1). The grid of 4 m^2 cells (2m X 2m) was laid out using a 50 meter tape and a compass. Grid cells were delineated with wire flags spaced at 2 meter intervals (Figure 4). Following dismantling of the Lewelling grid, a few permanent stakes were placed to allow replication of the grid census in 1994 (Appendix 2-2). The Conn Valley Road census was replicated in 1994 by using site landmarks (Appendix 2-1).

Population Census

Each grid cell was assigned a code e.g. C15. Letters corresponded to the x-axis and numerals to the y-axis. A 3" X 5" card was placed in each cell with the assigned code. The census taker picked up the card upon entrance into the cell and recorded the number of plants found in addition to information on vegetation depth, associated species and physical features (in some cells only). Plants were flagged to facilitate counting and to prevent double counting. After completion of the grid census, the surrounding area was searched for additional plants. All plants located were recorded and subsequently plotted on "Clearprint 1000HP" drafting paper.

The Conn Valley Road site and Lewelling sites were censused by the author with assistance from several volunteers. The Bothe site was censused by the author and Bothe-Napa Valley State Park ranger Bill Grummer in 1993 and with the additional help of Ann Howald and Conci Mack in 1994. The Alpine School site was censused by Saxton Holt, a volunteer working for The Nature Conservancy under a "Landowner Protection Agreement".

Mapping Population Distributions

Aerial photographs of the Conn Valley Road and Lewelling sites were purchased from the Napa County Planning Conservation and Development Department. These photographs were taken by Pacific Aerial Surveys in May of 1989. Landmarks visible on the photos were correlated to census grid markers. The metric monitoring grid coordinates were translated into the english system to transfer to the 1" = 100' scale photos. Populations were mapped on topographical maps to the greatest level of accuracy possible. The grid areas were also plotted diagrammatically indicating site landmarks such as fences and tree canopies.

Monitoring of Germination, Growth and Maturation

The Conn Valley Road site was first visited on December 19, 1992 and the Lewelling Ranch site was first visited on March 3, 1993. Repeated visits were made at two week intervals until flowering was initiated. Visits were then made at weekly intervals. During these visits, measurements were taken of: plant height, leaf number, and leaflet size. The sample size of January and February measurements were determined by the number of plants which could be found in the field at that time. One meter plots were selected by March 15 at each site to collect the above-mentioned data in addition to other information described below. This allowed for site comparisons. Later visits recorded flower, fruit and seed production. Dates of first observation of flower and fruit development were recorded. A visit was made to the Lewelling site in mid-November 1993, following the seasons first significant rainfall to observe seedling plants and to record first germination for 1993-1994 season. A 1 m^2 plot was monitored biweekly to monthly to determine germination, seedling growth, and seedling mortality. Slide photographs were taken at each phase of *Astragalus clarianus* growth.

Vegetation Sampling

Cover estimates were made in selected one meter quadrats. One quadrat was sampled at Lewelling on March 22 and again on May 10 to document seasonal succession in species composition, relative cover and vegetative height. Three additional quadrats at Lewelling and two at Conn Valley Road were sampled on one occasion. Sampling quadrat locations was based on the presence of Clara Hunt's milkvetch and chosen to represent variability of the habitat.

1. Conn Valley-1 (CV-1) is located in grid-cell K9; selected because seedlings were first

observed here for this occurrence.

2. Conn Valley-2 (CV-2) is located in grid-cell H28; selected due to the concentrated number of ASCL plants, location below high water line of the lake and association with introduced grasses.

3. Lewelling-1 (L-1) is located in grid-cell Y7; selected because seedlings were first observed here for this occurrence.

4. Lewelling-2 (L-2) is located in cell CC13; selected due to the presence of pocket gopher activity and association with Larkspur (*Delphinium sp.*), not present in other quadrats.

5. Lewelling-3 (L-3) is located in cell CC24; selected in an area with low vegetative cover, relatively steep slope and prominent rockiness.

6. Lewelling-4 (L-4) is located in cell G26; selected in area of deeper soils with little slope, with denser and taller vegetation cover than other sites.

A collapsible frame was constructed of 1" X 1" pine with finishing nails placed at 5 cm. intervals. Twine was woven around the nails to produce 400 sampling points (Figure 5). The 1-meter grid frame was placed near the top of the vegetation and point intercepts were recorded by viewing from directly above and communicating the information to an assistant or a tape recorder. All vascular plant species intercepted at each point were recorded. Bare ground, ground litter or rocks were recorded when no plants were intercepted.

Species identification was made in the field although a few species could not be identified until subsequent visits when flowers were present. Associated species were recorded throughout the study whenever they were seen within 30 cm. (1 ft.) of Clara Hunt's milkvetch.

Measurements of associated species heights were made by averaging measurements of a few randomly chosen individual specimens. A species of moss was sent to Steven Rae, an expert, for identification.

The height of vegetation was visually estimated in about 200 of the 4 m^2 cells during the Conn Valley Road census in 1993. This was done to compare cells in which milkvetch occurred with cells in which the species was absent.

Figure 4. Laying out the grid for Lewelling census. Cards placed in 2 m X 2 m cells. Census-taker at right.

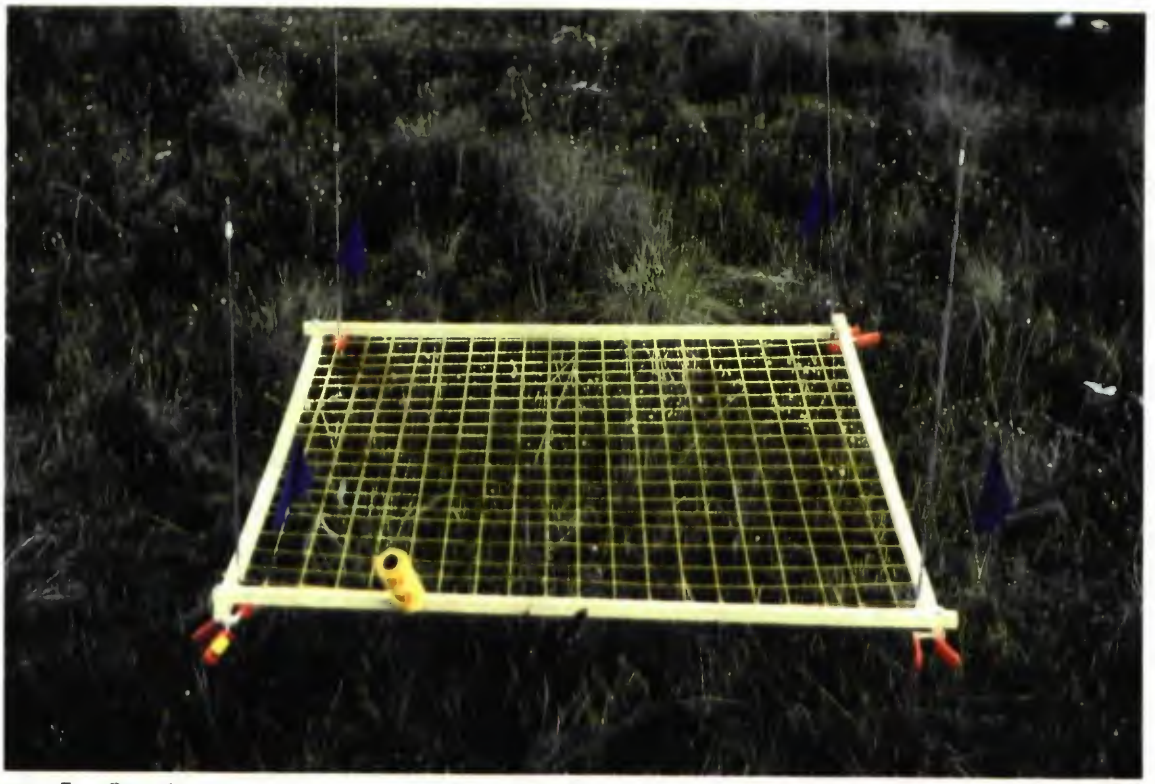


Figure 5. One by one meter, vegetation sampling quadrat; string divisions at .5 dm intervals.

Pollinators, Herbivores and Pathogens

Inspection of individual plants was made during each visit. Observations of direct or indirect impacts recorded. Feeding on stems, leaves, flowers or fruits were considered direct impacts. Mounding of soil by pocket gophers or field mouse runways were considered as potential indirect impacts.

Pollinator exclusion screens were placed in the field at Lewelling on March 21, 1994. Screens were constructed from modified tomato cages, fine screen (1 mm mesh) and an elastic band. The wire frame pinched the screen firmly to the ground. Each of five screens was positioned with a flagged control group of ASCL plants within three feet of the exclusion. Plants were collected on June 4, 1994 and taken into the lab and examined for seed production. Most of the fruit was mature, dry and had dropped before collection. Seeds were considered unfertilized or abortive if reduced in size, flattened, yellow in color or with highly distorted shape. It was not possible to distinguish clearly, the difference between abortive and unfertilized and they were therefore treated as one group.

Damage Assessment at Conn Valley Road

A list of encroaching weeds was recorded during periodic visits from February to May, 1993. A roughly constructed grid was laid out and pits dug at 2-meter intervals to estimate the volume of residual stockpile soils. A square-nose shovel was used to probe through to the native soil. The depth of the remnant stockpile was recorded and plotted on graph paper.

Soil Sampling and Habitat Requirements

Eight soil pits were excavated in total, including two pits in what appeared to be suitable but unoccupied habitat. Four soil pits were excavated at Lewelling, two at Alpine School and one each at Bothe and Conn Valley Road. At each pit, the following soil profile characteristics were recorded: apparent soil series, composition, horizonation, slope and aspect. Soil profile descriptions were somewhat limited by the small size of soil pits dug; to minimize impacts on ASCL habitat. With the exception of two Lewelling pits, all locations were within 1 meter of Clara Hunt's milkvetch. The remaining two pits at Lewelling were selected away from positions at which Clara Hunt's milkvetch was found but within areas that appeared to be suitable habitat.

Samples were sent to a laboratory (ETS, Petaluma) to determine calcium/magnesium levels, pH, nitrogen, phosphorus, potassium, manganese, nickel and aluminum. A soil sample of the stockpile soil was taken and characterized relative to the native habitat soils.

The aspect and incline of occupied slopes was determined at each population site using a compass with a built-in clinometer. Soil water holding capacity was estimated by using values for similar soil textures found in Soil Survey of Napa County (1978). Available water was computed by multiplying the root zone depth of ASCL, by the estimated milimeters of water available per centimeter of soil.

Climate

Rainfall data was based on measurements taken at the closest attainable field station to three of the four sites. Official weather stations are located 1-1.5 miles away from each site. Rainfall records were acquired from Bothe State Park (for Bothe site), Napa City Public Works Department (for Conn Valley Rd. site), St. Helena Public Library (article from the St. Helena Star) and the St. Helena Station, Department of Forestry (for Lewelling site). Additionally, a rain gauge was placed on the Conn Valley Road (one storm event in 1994) and Lewelling sites during two winter storms (12-10-1993, 5-6-1994) and Bothe during four winter 1993-94 storms to determine if rainfall at sites varied significantly from weather station data. Results of field collected rainfall and amounts recorded at official weather stations listed in Appendix 3.

Collection of Historic Data

Prior to the initiation of field work, records were searched at the California Department of Fish and Game's, Natural Diversity Data Base to collect available information on Clara Hunt's Milkvetch. Additional information was collected from the files of Bothe Napa Valley State Park (Annual Plant Watch - a CNPS program). Information collected included floristic descriptions, prior studies, field survey forms, and status reports.

RESULTS

Germination

The seeds of *Astragalus clarianus* have been determined to require scarification to initiate germination in the lab. This is done by nicking the seed coat with a razor blade. Seeds soaked overnight will then swell if the seed coat has been broken (Liston, pers. comm., 1994). This is accomplished under natural conditions by the rough textured sand grains and gravel in the soil. Rainfall, animal activity or some other natural force is needed to agitate soil particles and break the seed coat.

The Conn Valley Road population was first visited on December 19, 1992, prior to the initiation of a contract for this study. At that time, *Astragalus clarianus* had already germinated. Two plants approximately 3.5 cm. tall were located with a pair of cotyledons and a pair of trifoliate leaves. The state of these plants did not allow for determination of a first germination date for the 1992-1993 season. For this reason, the Lewelling site was visited on November 15, 1993, four weeks after the first significant rainfall of the 1993-1994 season on October 14 (about 25mm). Numerous plants had germinated by this time and were 1-2 cm tall. The date of germination of these plants was estimated to be November 1, 1993. Juvenile plants were observed as late as May 25 in 1993, perhaps germinating from rains falling on April 23 (8.5mm) or May 3 (2.5mm). This supports a previous report which states that germination occurs as early as October and as late as March, dependant on rainfall patterns (Hunter, 1989). In a 1 m^2 plot (L-1), monitored at Lewelling during the winter of 1993-1994, seedlings were observed from November until mid-March (Figure 6). No germination occurred after this time, probably due to low rainfall during the period from February 20 to April 23, 1994. This dry interval may also have contributed to the low (3 %) seedling mortality recorded in L-1 during that period.

Growth

Due to the difficulty in locating juvenile plants and the extended period of time during which germination occurs, the number of individuals used to monitor growth was variable (Table 1). Growth, as observed during 1993 and 1994, advanced at a slow rate from November until late February or early March at which time growth accelerated. A period of accelerated growth and

development occurred until mid or late April (Figure 7). Late germinating individuals (April-May) failed to mature, probably due to the lack of adequate rainfall to supply the plant's water demands. A lower rate of growth and height of flowering plants was measured during 1994 following a period of below normal rainfall. This was accompanied by decreased flower production (Table 2).

Mature plants ranged in height from 7.5-23 cm in 1993 and were predominantly unbranched although plants were observed with up to 5 branches. Branching originated from the third or higher stem node. The pinnately divided leaves contain seven to nine oblong emarginate leaflets although the first set typically has three leaflets followed by one or two leaves with five leaflets. The leaflets are blunt to notched at the tips (Jepson, 1925) and 4-6 mm long. Senescent plants remain erect or become decumbent.

Figure 6. **Results of seedling germination/mortality monitoring in a 1 m² plot at Lewelling, 1993-1994. Numbers represent number of individuals counted on selected dates and not actual date of germination. Seedlings were marked to track mortality.**

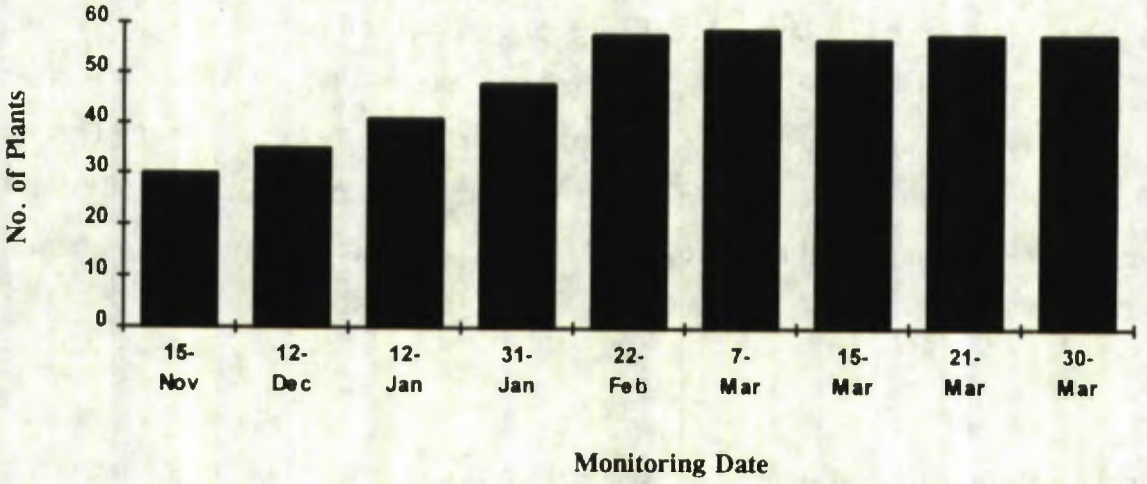


Figure 7. Growth rate (plant height) of *Astragalus clarianus* 1992-1993 and Lewelling compared in 1993-1994. Alpine School and Bothe sampled on one date only.

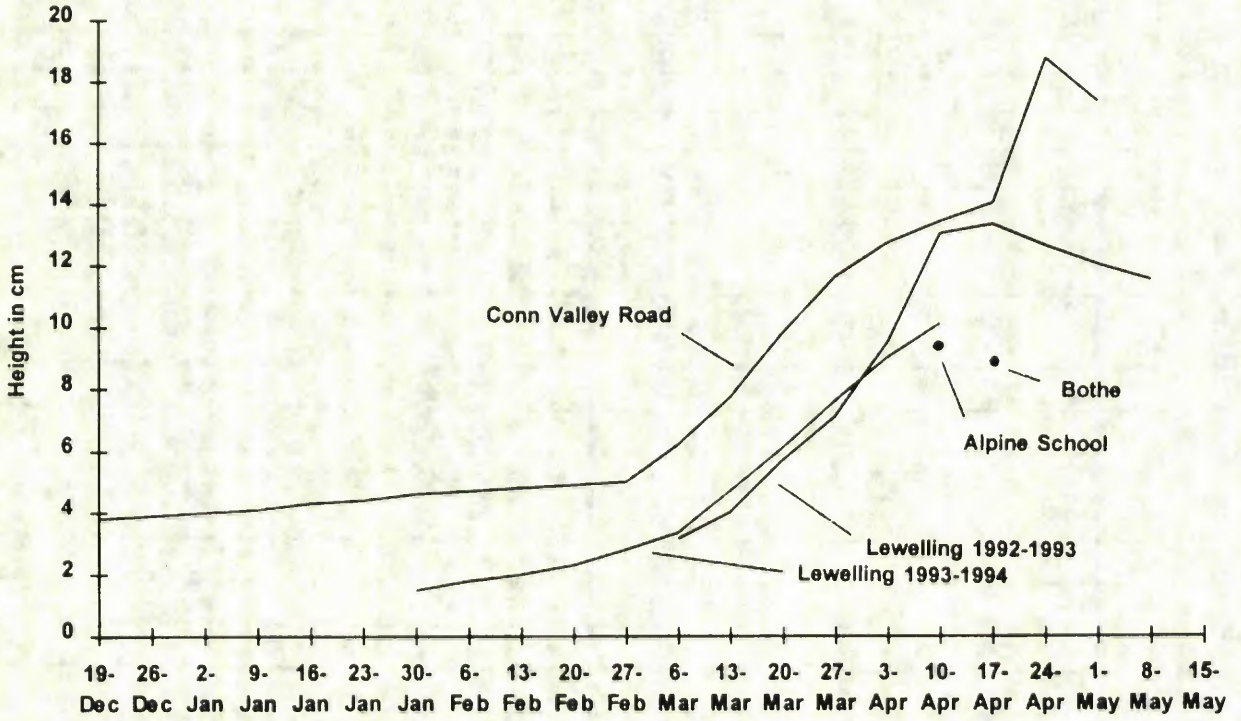


Table 1. Growth and development of *Astragalus clarianus*[1].

Conn Valley Road

DATE	HEIGHT-RANGE/cm	MEAN/cm	SAMPLE SIZE	DEVELOPMENT
12/19/92	--	3.8	2	Cotyledons and 1 pair of leaves
02/28/92	4.5-5.5	5.1	7	3-7 leaves
03/11/93	5.5-11.0	7.4	9	4-11 leaves, branching initiated, flower buds forming
03/24/93	6.0-15.0	11.1	13	Flowers on all plants seen
04/01/93	6.5-20.5	12.7	48	(census day)
04/16/93	9.0-18.0	14.0	3	Few plants forming fruit
04/22/93	15.0-23.0	18.7	4	Fruit and flowers present
05/04/93	13.5-22.0	16.9	5	Plants senescent, few with flowers
05/22/93	--	--	2	Fruit on plants; fallen plants dry; pods closed

Lewelling

DATE	HEIGHT-RANGE/cm	MEAN/cm	SAMPLE SIZE	DEVELOPMENT
03/03/93	1.3-4.2	2.9	16	4-10 leaves
03/15/93	2.0-7.5	4.4	26	23 of 26 plants with flower buds
03/22/93	3.5-9.0	6.2	25	Flowers expected to open in 2-3 days
03/30/93	5.0-12.5	7.8	6	Flowers open
04/10/93	8.0-18.5	13.0	12	(census day)
04/14/93	3.5-20.5	13.4	51	Plants +/- at peak flower
05/10/93	2.5-19.0	11.2	32	Fruit developing, few plants with flowers
05/25/93	--	--	--	Late germinated seedlings (<5 cm) observed

Bothe

DATE	HEIGHT-RANGE/cm	MEAN/cm	SAMPLE SIZE	DEVELOPMENT
04/08/93[2]	3.5-16.0	9.35	24	3 plants vegetative, 20 flowering, 1 in fruit

Alpine School

DATE	HEIGHT-RANGE/cm	MEAN/cm	SAMPLE SIZE	DEVELOPMENT
04/16/93[2]	5.0-12.5	8.8	55	Plants +/- at peak flower

[1] Data collected from individuals randomly selected on sampling date.
[2] Data collected on census day only.

Flower and Fruit Production

The opening of the first flower for individuals within a population is achieved somewhat synchronously. Essentially all plants observed at Conn Valley Road on March 25, 1993, bore open flowers whereas, 13 days prior all plants that could be found were in bud stage. The date of flower anthesis varied between occurrences which may be related to exposure, soil temperature and micro-climatic conditions. Plants at Conn Valley Road reached anthesis 5-7 days in advance of Lewelling in 1993 with flowering beginning about March 20 and March 25 respectively. Peak flowering was reached by the first week in April at Conn Valley Road and concluded there by May 4. Flowering peaked about April 14 and continued until at least May 10 (1993 season) at Lewelling. In 1994, flowering began at Lewelling about March 18, probably 5 days prior to the first observed flowering at Conn Valley Road. This is perhaps due to the very small size of the 1994 population at Conn Valley Road.

Flowers range in length from 11-14 mm and are white with purple on the keel tip and upper portion of the banner. The flower keel ranges from slightly longer than the wings at Bothe, to slightly shorter than the wings at Conn Valley Road.

The number of flowers produced on a peduncle ranged from one to six. Flowers often fall upon drying and do not necessarily result in the production of fruit (see below). Fruit development was first noted on April 16, 1993 at Conn Valley Road. The fruits were measured from 1.7-2.5 cm in length and were slender and curved at the tip. The length of 50 fruits sampled at Lewelling ranged from 1.8-3.5 cm. The fruits are elevated on a slender gynophore 1.4 - 2.5 mm long (Barneby, 1964) which is evident in the dried calyx. The fruit are at first green, and become mottled with red and finally dry brown to black. From data collected at Conn Valley Road and Lewelling in 1993 (Table 2) it is estimated that 35-50 % of the flowers developed a mature fruit.

In 1994, seed and fruit production were compared between 26 plants enclosed under five pollinator exclusion screens (Figure 8) and 29 control plants randomly selected outside the screens. Plants within the screens were found to have slightly (5%) more flower heads per plant and 25% lower fruit production (Table 3). Fruit parasitism and herbivore damage was substantially higher (67%) in the control group than in the test group as was the percentage of aborted seeds per fruit (90%).

Table 2. Fruit and flower production of *Astragalus clarianus 1992/1993 and 1993/1994.*

1992/93 Season

LOCATION	FLOWERS/HEAD				FRUIT/HEAD			
	RANGE	MEAN	SAMPLE SIZE	MONITORING DATE	RANGE	MEAN	SAMPLE SIZE	MONITORING DATE
Conn V. Rd.	1-5	2.95	21	4/10/93	0-4	1.47	19	5/04/93
Lewelling	1-6	3.11	27	4/14/93	0-3	1.14	101	5/10/93
Bothe	2-5	3.32	25	4/08/93	--	--	--	--
Alpine School	1-6	3.56	55	4/16/93	--	--	--	--
Total	**1-6**	**3.32**	**128**		**0-4**	**1.19**	**120**	**--**

LOCATION	HEADS/PLANT				SEEDS/FRUIT			
	RANGE	MEAN	SAMPLE SIZE	MONITORING DATE	RANGE	MEAN	SAMPLE SIZE	MONITORING DATE
Conn V. Rd.	2-6	3.80	5	5/04/93	--	--	--	--
Lewelling	2-7	3.38	50	4/14/93	6-9[1]	6.9[1]	19	5/10/93
Bothe	--	--	--	--	--	--	--	--
Alpine School	1-11	3.90	48	4/06/93	--	--	--	--
Total	**1-11**	**3.64**	**103**		**6-9**	**6.9**	**19**	**--**

1993\94 Season

LOCATION	FLOWERS/HEAD				HEADS/PLANT			
	RANGE	MEAN	SAMPLE SIZE	MONITORING DATE	RANGE	MEAN	SAMPLE SIZE	MONITORING DATE
Conn Valley	1-3	2.25	8	4/12/94	1-3	1.67	6	4/12/94
Lewelling	2-6	3.24	50	4/19/94	1-6	2.38	21	4/19/94
Bothe	2-4	3.53	15	4/12/94	1-3	2.43	7	4/12/94
Alpine School	--	--	--	--	--	--	--	--
Total								

[1] Data collected from the fruits of four plants.
[2] Alpine site not visited in 1994.

Table 3. Fruit and seed production of *Astragalus clarianus* (Lewelling) in 1993-1994. Comparison of plants within five pollinator exclosures to plants in five proximate control groups.

Factor Tested	TEST GROUP		CONTROL	
		n		n
Heads/Plant	1.90	29	1.81	26
Fruits/Plant	1.45	29	2.04	26
SEEDS/FRUIT	6.24	29	6.59	39
Percent of fruit parasitized by herbivore or pathogen	30	37	50	46
Percent of fruit not parasitized but with aborted seeds	35	37	39	46
Total percent of fruit with aborted seeds[1]	59	37	80	46
Seeds/fruit damaged by herbivore[2]	8	37	21	46
Total aborted seeds/fruit	1.41	29	2.67	40
NET SEEDS/FRUIT[3]	4.02	41	3.46	52

[1] Unfertilized seeds not distinguished from aborted seeds in this test.
[2] Some fruits opened up by herbivore and with some seeds gone. The total seed loss from herbivores is unknown.
[3] The "Net seeds/fruit" represents viable seeds as determined by visual inspection (No tetrazoline test).

Figure 8. Pollinator exclusion screens installed at Lewelling; March 1994.

Seed Production and Dispersal

Collection of seed production data was limited by population sizes and accessibility. No fruit was collected at Bothe and Lake Hennessey due to the small size of populations at these sites. The Alpine School was robust but not easily accessible to the author and therefore was not was sampled for seed production. Seed production for these sites were thus based on data from the Lewelling site which was both robust and easily accessible. The number of seeds observed per fruit ranged from six to nine which compares to six to twelve reported previously (Barneby, 1964). Seeds measured 3.5-4.7 mm in length when "green" and 2.2-3.5 mm when dry. This compares to 2.7-3.3mm reported by Barneby (1964). From four plants randomly collected on May 10 at Lewelling, 145 seeds were counted in 19 pods. Of the extracted seeds, 14 (10 %) were deformed or diminutive and apparently abortive. The net result is a calculated mean of 6.9, apparently viable (from visual inspection only; no tetrazoline test taken), seeds per fruit. This number was used to calculate seed production for 1992-93 populations using the following equation:

$$\frac{\text{Fruits}}{\text{Head}} \times \frac{\text{Heads}}{\text{Plant}} \times 6.9 \times \text{No. of Individuals} = \text{Est. Total Seed Production}$$

Table 4. **Seed production of *Astragalus clarinus* in 1992-1993.**

	Fruit Head	Heads Plant	Seeds Fruit	No. of Ind.	Est. Total Seed Production
Conn Valley Road	1.47	3.80	(6.9)	156	6,010
Lewelling	1.14	3.38	6.9	2,238	59,500
Bothe	(1.30)	(3.38)	(6.9)	101	3,060
Alpine School	(1.30)	3.90	(6.9)	2,660	80,650
Total For All Occurrences				**5,155**	**149,220**

Note: Fruits/Head and Heads/Plant was extrapolated from the Lewelling and Conn Valley Road data and are listed in parenthesis (not collected at other sites).

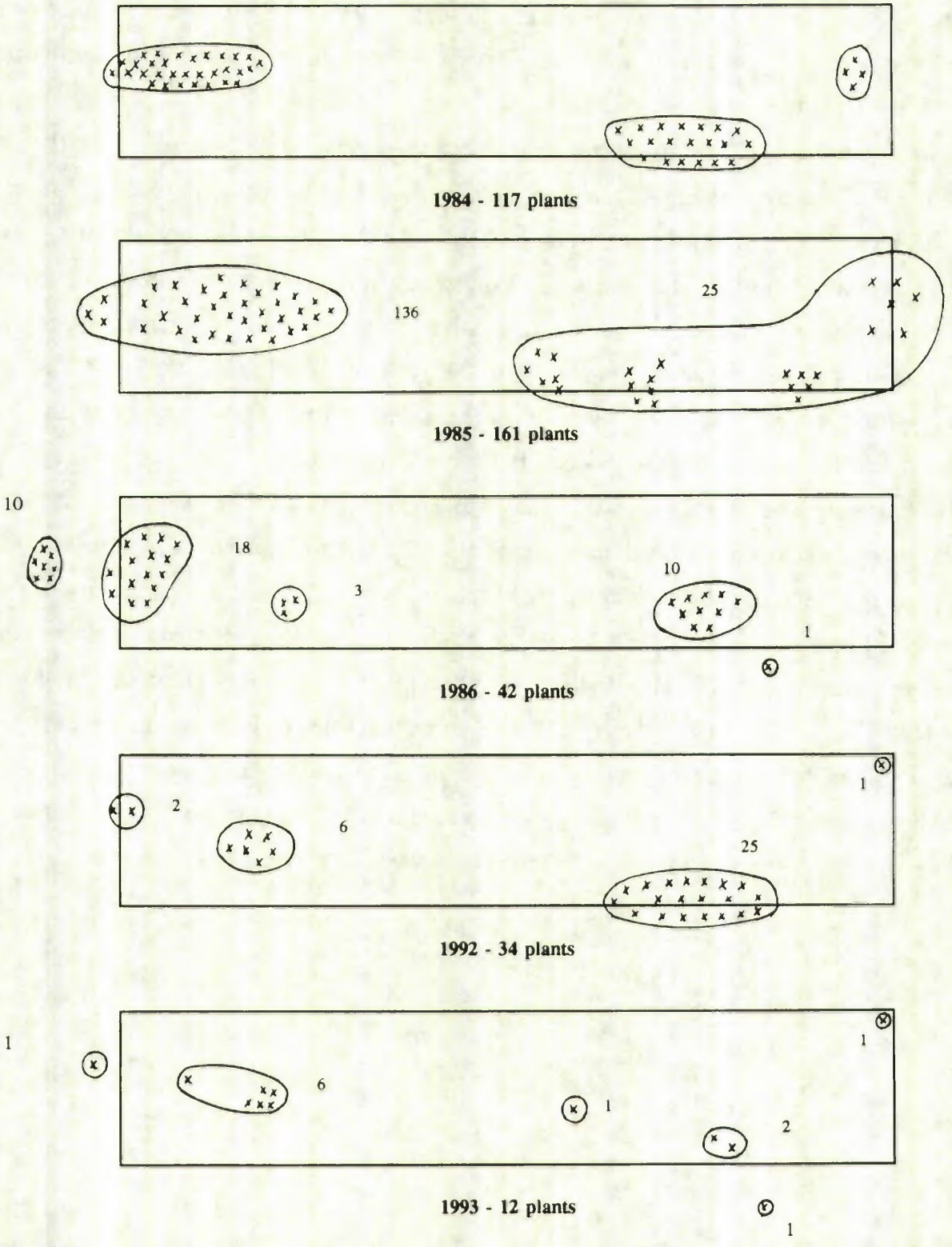
Seed production was measured at Lewelling again in 1993-1994. The total population size was up three-fold but heads per plant declined 30-45% and viable seeds per fruit (determined by visual inspection) declined 50% (Table 3). The net result is an estimated 30% decrease in total seed production per fruit compared to the 1992-1993 population.

Seed pods fall from the plants in June and seeds may remain within the pods until fall rains begin (Hunter, 1989). Some pods examined in June, 1993 were split open with some or all seeds extruded. At Lewelling, the darkened pods and seeds mimic the color of the, by then desiccated moss *Crossidium aberrans*.

Seeds germinate with fall or winter rains or remain dormant in the soil seed bank (Hunter, 1989). Early seasonal rains in October of 1993 produced substantial germination of seeds at Lewelling although some fruits remained unopened at the time of the November 15 visit. Using seed production as estimated above, total seed production can be compared to population size where population were censused in two consecutive years. The estimated percentage of seeds germinating and reaching a flowering state was 2.2% at Bothe during 1992-1993, 1.8% at Conn Valley Road during 1992-1993, and 4.2% at Lewelling during 1993-1994. A much lower germination level of .23% was measured Bothe and .15% at Conn Valley Road during 1993-1994 following below normal rainfall. The confidence of this data is reduced by the measured difference in viable seeds per fruit found between 1993 and 1994 populations at Lewelling. The percentage of seeds contributing to the seed bank was not investigated during this study.

Precise plant locations within a 3m X 16m quadrat at Bothe were mapped diagrammatically for a ten year period (Grummer, 1984-93). The data demonstrates very little movement through the period (Figure 9). While density of Clara Hunt's milkvetch may change dramatically from year to year, location did not vary greatly within the period. (The apparent decline in the number of individuals within the quadrat is discussed in a following section). The distribution of the plants at Lewelling showed little mobility between 1993 and 1994 populations.

Figure 9. Historic changes is distribution of *Astragalus clarianus* within a 3 m X 6 m quadrat at Bothe.



Source: Records of William Grummer/Bothe State Park; "Annual Plant Watch" conducted during April by California Native Plant Society.

Figure 10. Fruiting and seedling plants both present at Lewelling on May 22, 1993.

Figure 11. *Astragalus clarianus* with maturing fruit; May 5, 1993.

Plant Associations

Clara Hunt's Milkvetch occurs in a variety of plant associations. Therefore, it is difficult to draw conclusions about its habitat requirements based on this parameter alone. The Conn Valley Road population is located at the edge of a woodland dominated by gray pine (*Pinus sabiniana*) with full sun exposure (Figure 12). This may differ from the historic condition, prior to placement of the reservoir. A number of sapling pines are visible within and near the site. The Lewelling population is located in small meadows or openings within a mixed woodland/forest mosaic with black oak, coast live oak, gray pine, ponderosa pine and douglas fir. The brushy understory includes toyon and leather oak (Figure 13). The Alpine School population lies within open areas of a grassland/woodland mosaic dominated by blue oak and scattered oregon oak with the grassland component dominated by annual grasses and forbs. About 40 % of the 1993 population at Alpine was located in open grassland near a low ridge (Figure 14). The Bothe population lies in small openings in a woodland dominated by blue oak and common manzanita with scattered mountain mahogany and common buckbrush (*Ceanothus cuneatus*) (Figure 15).

A number of associated species are present at all four sites: indian soap (*Chlorogalum pomeridianum*), blue dicks (*Dichelostemma capitatum* ssp. *capitatum*), true baby stars (*Linanthus bicolor*), slender cottonweed (*Micropus californicus* var. *californicus*), and dwarf plantain (*Plantago erecta*). In addition, ten species are common to three of the four sites. Only those species found within approximately 3 dm (1 ft) of Clara Hunt's Milkvetch were recorded as associated species. For a complete list of associated herbaceous species refer to Table 5. Roots of woody plants were encountered in the excavation of soil pits but could not be traced to the source species. These plants possibly exert influences on ASCL but because of the difficulty of root identification, were not included in the list of associated species.

Figure 12. *Astragalus clarianus* growing in grassland at Conn Valley Road, Napa Co.

Figure 13. *Astragalus clarianus* growing in a mixed woodland/forest mosaic at Lewelling Ranch, Napa County.

Figure 14. *Astragalus clarianus* growing in oak woodland at Alpine School site in Sonoma Co.

Figure 15. *Astragalus clarianus* growing in blue oak woodland at Bothe-Napa Valley State Park.

Table 5. Species associated with *Astragalus clarianus*

SCIENTIFIC NAME	ALPINE SCHOOL	BOTHE	CONN VALLEY	LEWELLING
Achyrachaena mollis			X	
Aegilops triuncialis			X	
Agoseris heterophylla			X	X
Aira caryophyllea	X			
Aphanes occidentalis				X
Anagallis arvensis		X	X	
Athysanus pusillus				X
Brachypodium distachyon		X		
Briza maxima	X			
Briza minor	X			X
Bromus diandrus			X	
Bromus hordeaceus	X	X		X
Calochortus luteus				X
Castilleja attenuata	X			X
Castilleja densiflora ssp. *densiflora*	X			
Castilleja rubicundula ssp. *lithospermoides*				X
Centaurea solstitialis			X	
Cerastium glomeratum	X		X	X
Centaurium muhlenbergii				X
Chlorogalum pomeridianum	X	X	X	X
Cicendia quadrangularis	X			X
Clarkia amoena ssp. *huntiana*	X			X
Collinsia sparsiflora	X			X
Crassula connata			X	X
Crossidium aberrans (moss)				X
Danthonia californica var.				X
Delphinium variegatum ssp. *variegatum*	X	X		X
Dichelostemma capitatum ssp. *capitatum*	X	X	X	X
Dodecatheon hendersonii	X			
Elymus multisetus				X
Erodium botrys	X			
Erodium cicutarium	X	X		
Euphorbia crenulata		X		
Galium murale		X	X	
Gastridium ventricosum				X
Genista monspessulana				X
Githopsis specularioides			X	
Hedypnois cretica				X
Hemizonia congesta ssp. *luzulifolia*			X	X
Hesperevax sparsiflora var. *sparsiflora*			X	X
Heterocodon rariflorum		X		
Hypochoeris glabra		X		
Juncus occidentalis	X			X
Lactuca saligna				X
Lasthenia californica	X		X	X
Linanthus bicolor	X	X	X	X

SCIENTIFIC NAME	ALPINE SCHOOL	BOTHE	CONN VALLEY	LEWELLING
Lolium multiflorum			X	X
Lomatium dasycarpum				X
Lomatium nudicaule	X			
Lomatium utriculatum			X	X
Lotus humistratus		X		
Lotus wrangelianus	X		X	X
Lupinus bicolor	X		X	
Luzula comosa		X		
Madia sp.		X		
Medicago polymorpha			X	
Micropus californicus ssp. *californicus*	X	X	X	X
Microseris douglasii			X	
Montia fontana				X
Nassella pulchra	X		X	X
Pectocarya pusilla	X	X		X
Pentachaeta exilis	X			
Perideridia kelloggii				X
Phlox gracilis	X	X		
Plagiobothrys tenellus		X		
Plantago erecta	X	X	X	X
Plantago lanceolata	X			
Plectritis ciliosa		X		
Poa secunda ssp. *secunda*	X		X	X
Polygonum californicum				X
Ranunculus californicus	X			
Ranunculus occidentalis		X		X
Rigiopappus leptocladus				X
Rumex crispus			X	
Sanicula bipinnatifida	X	X		X
Scandix pecten-veneris	X			
Senecio vulgaris			X	
Sherardia arvensis	X			
Sidalcea hartwegii	X	X		
Sisyrinchium bellum	X			X
Soliva sessilis		X		
Sonchus oleraceus			X	
Stellaria nitens				X
Trifolium albopurpureum var. *albopurpureum*			X	
Trifolium depauperatum var. *depauperatum*	X	X		X
Trifolium gracilentum var. *gracilentum*		X		X
Trifolium microcephalum	X			
Trifolium microdon		X		X
Trifolium variegatum	X			
Triphysaria eriantha	X			
Triphysaria versicolor ssp. *faucibarbata*	X			
Triteleia laxa			X	
Vulpia sp.	X	X	X	X
Wyethia angustifolia	X			

Vegetative Cover

Sampling of quadrats that included Clara Hunt's Milkvetch, demonstrated the variability of species associations within different micro-habitats and succession through the growing season. Total cover of vegetation within study quadrats ranged from 45-90% (Table 6) with bare ground and litter comprising a significant portion of all quadrats. At Lewelling, a portion of the "bare ground" was occupied by *Croccidium aberrans*, a moss more typical of drier parts of the state of California (Rae, pers. comm.). Sampling of L-1 at the onset of flowering and at the conclusion of flowering at Lewelling (Table 8) show minimal change in total cover between these points in time with bare ground comprising about 17% of the quadrat area. There was an estimated 10% increase in litter cover values observed as some spring annuals dry up and perennials approach summer dormancy. (The confidence of these data are affected by the difficulty in precise replication of sampling points due to viewer error.) A marked contrast in total cover was measured between CV-1 and CV-2 which was located near the high water line of Lake Hennessey and was partially submerged in early 1993. Quadrat L-4 showed the highest total cover and was located on a very shallow incline at the forest-grassland transition. Sparse vegetation cover in Clara Hunt's Milkvetch habitat was consistent in all four occurrences and may be a necessary condition from a standpoint of competition for light and nutrients. This could be the subject of further research. Relative cover estimates shown in Table 6 show the lack of any strong dominants but rather that the habitat supports a complex assemblage of herbaceous plants with as many as twenty-two species in a 1 meter quadrat. The height of associated species ranged from 6-25 cm (Table 7) and did not overshadow the milkvetch even in late successional development. Seasonal changes in species composition show a succession by summer annuals and maturation of some spring annuals and perennials.

Vegetation height within the grid system at Conn Valley Road was visually estimated to average 26 cm in 184 cells unoccupied by Astragalus clarianus. Vegetation was dense in nearly all of these cells. In comparison, vegetation height was estimated at 23 cm in 22 occupied cells on the same date but vegetation density was rated as "medium" in most of these cells (only a subjective assessment of density was used).

Table 6. Density of *Astragalus clarianus* and cover of plant species in one meter quadrats (cover in %).

SPECIES	QUADRAT CODE AND MONITORING DATE (1993)					
	L-1 3/22	L-2 3/30	L-3 4/26	L-4 4/26	CV-1 3/24	CV-2 4/14
# OF ASCL PLANTS	27	7	9	9	5	7
Astragalus clarianus	2.0	1.3	3.8	0.5	0.8	1.9
Aegilops triuncialis					27.0	34.9
Agoseris heterophylla	8.3	2.2	0.5	0.5	2.2	0.5
Aphanes occidentalis		3.2				
Athysanus pusillus		0.5				
Briza minor				0.7		
Bromus hordeaceus				0.5		
Calochortus luteus				0.1		
Centaurea solstitialis						0.3
Cerastium glomeratum						0.3
Chlorogalum pomeridianum	4.4	0.7	0.3		21.7	
Clarkia amoena ssp. *huntiana*	0.5	2.0				
Collinsia sparsiflora	2.0	3.6	2.8			
Crassula connata					0.8	
Danthonia californica var.				1.5		
Delphinium variegatum ssp. *variegatum*		11.4		0.2		
Dichelostemma pulchellum	13.8	12.2	9.7	1.7	18.2	
Genista monspessulana				0.2		
Hesperevax sparsiflora var. *sparsiflora*	0.1			0.1		
Juncus occidentalis				0.1		
Lasthenia californica	4.4	0.5		2.0		
Linanthus bicolor	1.4	0.2		8.9	0.5	
Lomatium dasycarpum	9.4	11.2	26.6			
Lomatium utriculatum				0.7	1.5	
Lotus humistratus			0.5			
Lotus wrangelianus	2.2	0.3		0.1	0.1	
Lupinus bicolor						1.0
Medicago polymorpha						2.0
Micropus californicus ssp. *californicus*		0.2		1.5	0.3	
Nassella pulchra	6.0			24.3	3.7	
Perideridia kelloggii			0.2			
Plantago erecta		9.7				
Ranunculus occidentalis			6.6	8.5		
Sanicula bipinnatifida		0.1	0.1			
Sisyrinchium bellum			0.5	2.5		
Stellaria nitens		NH				
Trifolium gracilentum var. *gracilentum*	2.8		1.5	2.0		
Trifolium microdon		0.1		30.6		0.5
Vulpia sp.			1.5		0.3	
POACEAE	4.7	9.5	6.4	4.5		
bare ground	18.0	19.0	7.2	2.0	8.5	21.1
litter	19.4	12.5	28.6	7.2	14.7	37.0
rock	0.3	1.0	2.0			
TOTAL NON-VEGETATION COVER	37.7	32.5	37.8	9.2	23.2	54.4
TOTAL VEGETATION COVER	62.3	67.5	62.2	90.8	76.8	45.6

L = Lewelling CV = Conn Valley Road

Table 7. **Relative height (cm) of species associated with *Astragalus clarianus*.**

SPECIES	LOCATION / DATE (1993)			
	Conn V. 2/28	Conn V. 3/24	Lew 3/3	Lew 5/10
Astragalus clarianus	5.1	11.1	2.9	11.2
Aegilops triuncialis	8-15	18		
Agoseris heterophylla	6-7	5-10		20
Cerastium glomeratum	3			
Chlorogalum pomeridianum	20-25		18	12-25
Collinsia sparsiflora			3-5	
Crassula connata	1.5	1.2		
Dichelostemma pulchellum	30	30		
Elymus multisetus				20
Githopsis specularioides	1.5			
Lasthenia californica				15-18
Linanthus bicolor	4-5	9	2-3	6-12
Lomatium dasycarpum			5-10	
Lomatium utriculatum		16		12-17
Lotus wrangelianus	5	5		12
Micropus californicus var. californicus		10		
Nassella pulchra	8-10	15	15-20	
Perideridia kelloggii			12	
Ranunculus occidentalis			10	
Trifolium gracilentum var. *gracilentum*	3			25

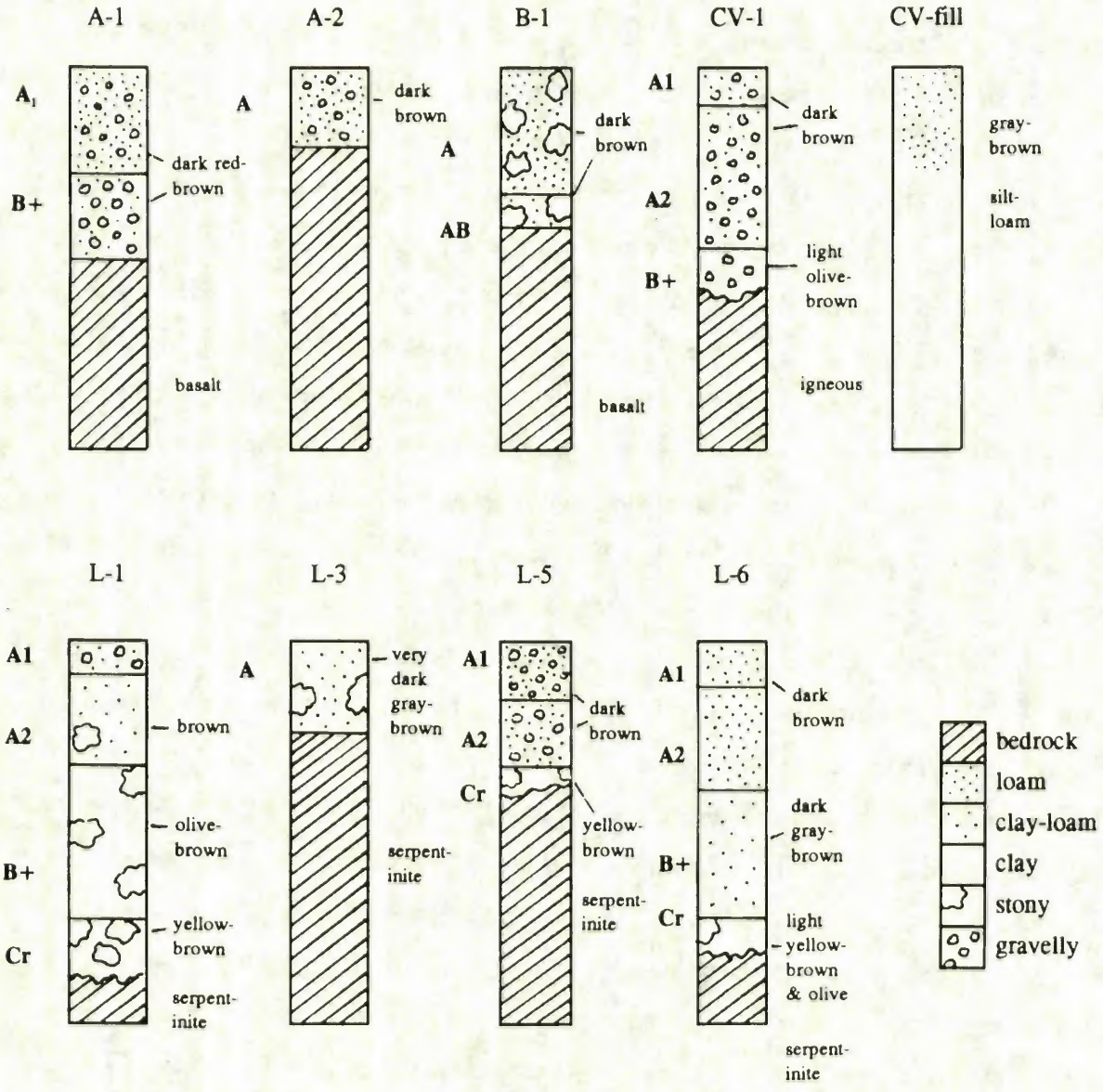
Table 8. Plant succession in monitoring quadrat L-1 (Cover in %).

SPECIES	MARCH 22	MAY 10
Astragalus clarianus	2.0	4.0
Agoseris heterophylla	8.3	9.5
Bromus hordeaceus		0.3
Calochortus luteus		1.0
Clarkia amoena ssp. huntiana	0.5	1.0
Chlorogalum pomeridianum	4.4	2.6
Collinsia sparsiflora	2.0	0.2
Dichelostemma capitatum ssp. *capitatum*	13.8	0.8
Elymus multisetus		2.9
Gastridium ventricosum		0.3
Hemizonia congesta ssp. *luzulifolia*		1.1
Hesperevax sparsiflora var. *sparsiflora*	0.1	
Lasthenia californica	4.4	4.0
Linanthus bicolor	1.4	2.4
Lomatium dasycarpum	9.4	11.3
Lomatium utriculatum		0.7
Lotus wrangelianus	2.2	4.5
Nassella pulchra	6.0	0.7
Poa secunda ssp. *secunda*		0.5
POACEAE (undetermined)	4.7	0.8
Rigiopappus leptocladus		0.3
Trifolium gracilentum var. *gracilentum*	2.8	3.9
Vulpia sp.		1.3
TOTAL VEGETATION COVER	62.0	54.1
BARE GROUND	18.0	16.3
LITTER	19.4	29.2
ROCK	0.3	

Soils

Soils examined in pits excavated within ASCL habitat showed a range of variation in soil depth, color, gravel content and drainage class based on soil parent material (Figure 16). These physical properties were found to vary within and between occurrences and can be divided into two categories. The Conn Valley Road and Lewelling populations occur in soils formed from serpentine bedrock, without (Lewelling) or with (Conn Valley Rd.) the inclusion of volcanic or other metamorphic components. Both exhibit chemical characteristics of serpentine soils. The Conn Valley Rd. site may be underlain by igneous bedrock with serpentine gravel present in the

Figure 16. Profiles of soil test pits. All bars represent 32 inches (81 cm) depth.



Source: Joel Butterworth; Field Sheets for Recording Soil Characteristics.

A = Alpine School B = Bothe CV = Conn Valley Road L = Lewelling

[1] **A, A1, A2, AB,** and **B+** indicate soil horizons.

soil profile (Table 9). The Alpine School and Bothe populations both occur on soils formed in place from basalt bedrock and exhibit similar chemical characteristics.

Soil depth to bedrock varied from 8-23+ inches within the eight soil pits excavated (Figure 17). Soil texture varied within the soil profile from very gravelly or stony loam in non-serpentine occurrences, to loam or clay loam with or without a gravel fraction in serpentine occurrences. The drainage classes of all soil samples were found to vary little from "moderately well" and "well" in seven sites to "somewhat excessive" at one site. All soils sampled were found to be acidic, ranging from medium to strongly acid (5.2-6.0). Soils derived from serpentine ranged in pH from 5.5-6.0 which is at the low end of the range of 5.6-7.8, described in California Serpentine (Kruckeberg, 1984) for 15 serpentine soils. Soils derived from volcanic bedrock ranged in pH from 5.2-5.3 for ASCL sites at Alpine School and Bothe. These levels are similar or below levels stated in the soils series profile descriptions (Napa County Soil Survey, 1978). Complete soil profile discriptions can be found in Appendix 4.

Laboratory analysis of soil composition investigated chemical characteristics within the root zone of Clara Hunt's milkvetch (Table 10). This was determined to be 10 cm (4 inches) after excavation of an individual plant with a root depth of 7 cm.

Macro-nutrients become less available, particularly below a pH of 6.0 (Barbour, Burk and Pitts, 1987), a condition in common to nearly all soils sampled. Available nitrogen (NO_3) was determined not to be deficient at Lewelling although samples taken outside apparent habitat (L-5 and L-6) carried 50% higher levels of NO_3. Levels of phosphorus or potassium on serpentine are usually below normal that which is needed for normal growth and may become controlling factors for plant survival (kruckeberg, 1984). Phosphorus (PO_4) levels ranged from 12 to 28 ppm with levels measured in samples taken at L-5 and L-6 falling in the middle of this range. Therefore, milkvetch appears to tolerate a range of phosphorus levels and does not appear to be factor limiting milkvetch distribution. Potassium levels varied by 60%, from 129 to 205 ppm. with an average of 167 ppm. This compares with an average of 222 ppm for the two distant samples although the entire range for this nutrient is amenable to the growth of many species (Conrad, 1993).

Manganese varied by a factor of 11 among the eight soil samples collected with the greatest contrast falling between L-5 and L-6 collected at Lewelling. Soil manganese levels of 4 ppm

are marginal for plant growth with 1 ppm considered to be very low (Conrad, 1993). Very low levels were found in Bothe and Lewelling soil samples. Somewhat higher levels were measured in samples taken at L-5 and L-6 at Lewelling. Tolerance to low manganese may be a key parameter determining milkvetch habitat at Bothe and Lewelling.

The calcium/magnesium ratio varied from 0.172 on the serpentine soils of the Lewelling site, to 3.340 on the basalt derived soil of Bothe. The Lewelling samples are well below the average of 0.271 measured from 13 samples collected by Kruckeberg on serpentine in various locations from California to British Columbia (Kruckeberg, 1984). Readings of 0.200 or lower are considered to be extreme (McCarten, 1986). Based on this data, Clara Hunt's milkvetch appears to have the ability to tolerate low levels of calcium and potentially toxic levels of magnesium. Samples taken near, but outside of the apparent habitat, at Lewelling did not vary greatly from those taken in proximity to ASCL with regards to Ca/Mg. Conn Valley Road soils are less severe, with 50% higher levels of calcium and 25% lower levels of magnesium. Levels of calcium in volcanic derived soils at Bothe and Alpine School were found to be 3.5-5 times greater then those on serpentine soils at Lewelling and had 3-5 times lower measured levels of magnesium. Ca/Mg ratios on volcanic soils ranged from 2.24-3.34 which is 10 times that of serpentine soils but well below the ratio of 32/1 listed for three non-serpentine soils (Kruckeberg, 1984) for comparison to serpentine soils. These soils fall within the range of 1.32-6.95, measured for eight soils tested in the San Rafael Mtns. (Woodell at al. 1975). A soil sample collected at a vineyard site near Calistoga showed a Ca/Mg ratio of 2.97 (2320/780) which also falls within the range of soils tested (Phil Blake, pers. comm.).

Elements such as Nickel, Aluminum and Boron may be toxic to many plant species in strongly acidic soils (McCarten, 1986) such as was found in the soil samples taken from Conn Valley Road and Lewelling. Nickel levels in serpentine soils was found to be 7 to 22 times higher than in samples taken from volcanic derived soils. This is well above "typical" levels for this element (Conrad, pers. com. 1993). This suggests an apparent tolerance of Clara Hunt's milkvetch to levels of nickel which are toxic to many plants. The two samples collected outside of ASCL habitat at Lewelling (L-5 and L-6) showed a nickel content of about one-fifth that measured within milkvetch habitat (L-1 and L-3) possibly reflecting it's inability to compete successfully with the other species occurring in this less restrictive micro-habitat at this site. Nickel does not appear to play the same role on volcanic soils, where Clara Hunt's milkvetch

is present in soils with much lower levels of this mineral.

Aluminum levels varied six-fold within the sample set with samples collected at L-5 and L-6 falling in the lower to middle part of the range and the Alpine School samples measuring near the extremes of the range. The significance of aluminum in ASCL habitat is probably not related to extreme levels of this element but rather its influence in acid soils. Aluminum bonds with phosphorus and in acidic soils this compound becomes less soluble and reduces the availability of phosphorus to plant growth (Barbour, Burk, and Pitts 1987).

The stockpile (fill) soil was examined to compare physical characteristics. The fill material appears to differ most from other samples (based on visual inspection only, no chemical analysis done) in the lower organic matter content and silt loam composition which was formed as an alluvium. All other soils sampled were formed in place (residuum). Fill soil is of medium acidity and probably has a lower cation exchange capacity and dissimilar chemical characteristics as a result of its origin (Joel Butterworth, pers. comm.).

Table 9. Summary of soil physical properties

SITE NAME	OBSERVED SOIL SERIES	DRAINAGE CLASS	WHC[1] (mm)	PH[2]	DEPTH[2] (cm)	TEXTURE	SOIL ORIGIN
A-1	undetermined	well	8.1	5.2	20	very gravelly loam	basalt residuum
A-2	Hambright	somewhat excessive	8.9	5.2	18	very gravelly loam	basalt residuum
B-1	Hambright	well	6.3	5.3	35	very stony loam	basalt residuum
CV-1	undetermined	moderately well	14.2	5.6	41	gravelly clay loam	serpentine & basalt
L-1	Henneke	moderately well	10.7	5.5	28	clay loam	serpentine residuum
L-3	Montara	well	11.7	6.0	20	clay loam	serpentine residuum
L-5	undetermined	well	14.2	5.3	33	loam	serpentine residuum
L-6	Montara	moderately well	13.5	5.4	28	gravelly loam	serpentine residuum

Source: Joel Butterworth, 1993
Series observed may differ from mapped unit.
[1] Water Holding Capacity - based on 10 cm root depth; adapted from Soil Survey of Napa County, 1978
[2] pH and soil depth of A horizon applies here; complete soil profile description in Appendix.

Table 10. Soil nutrient supply (units in parts per million)

SITE NAME	NH3	NO3	PO4	K	Ca/Mg	Ni	Mn	Al
A-1	28	5	20	129	2.24	.8	4.5	2.3
A-2	30	6	28	199	2.88	.6	3.4	.7
B-1	11	5	16	190	3.34	.4	1.7	1.1
CV-1	37	4	16	144	.367	6.0	4.6	1.0
L-1	33	6	12	205	.178	9.0	1.4	2.2
L-3	40	4	12	134	.172	6.9	.8	1.9
L-5	20	7	18	230	.369	1.8	8.7	1.3
L-6	35	8	12	214	.187	1.4	3.9	.5

Source: Environmental Technical Services, Petaluma 1993

A = Alpine School B = Bothe CV = Conn Valley Road L = Lewelling

Figure 17. Soil pit excavated at Bothe for analysis of soil physical properties.

Climate

Average rainfall estimated for ASCL sites (taken from off-site stations) range from 690 mm (27.3") per year at Conn Valley (on site rain gauge measured equal rainfall during a single storm event to that taken at Lake Hennessey water treatment plant. Average rainfall computed from 30 years of records taken at treatment plant.) to 975mm (38.4") per year at Bothe (A -8% adjustment was made to official rainfall measured over a 30 year period at Bothe State Park weather station. Placement of a rain gauge on site during 4 storms in winter, 1993-1994

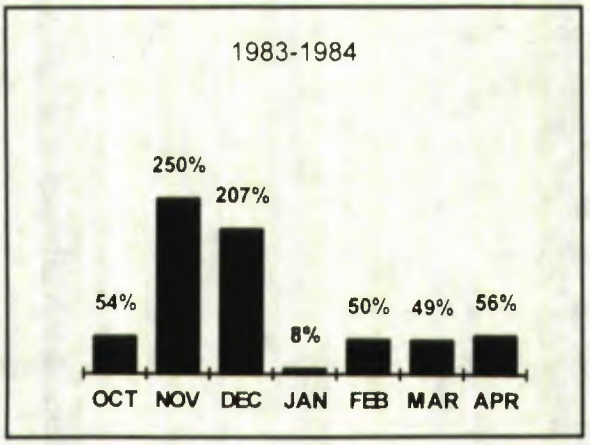
measured 8% lower amounts than taken at the weather station.) Average rainfall is estimated at 1190mm (46.8") at Lewelling for the same period (A +20% adjustment was made to average rainfall measured over a 30 year period at the St. Helena weather station as aresult of rainfall taken on site during two winter-spring storms in 1994.) and 990mm (39.0") at Alpine School in a seven year period (1986-1993 collection on site by landowner). This range of average is typical for much of Napa and Sonoma counties.

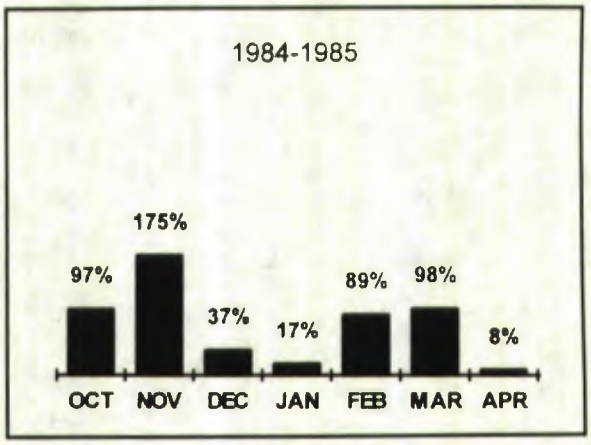
Although rain may occur in any month of the year, 95% of it falls between October 1 and May 1. This seasonal pattern of rainfall is typical for most of California and is not locally unique. Total annual rainfall at a site may vary dramatically from 1600mm (63") recorded at Bothe in 1986-87 to 560mm (22") measured there the following year. Monthly totals likewise vary greatly. For example, 8% of normal rainfall was recorded at Bothe in October of 1988, while 208% of normal was recorded the following October (Figure 18). Comparing November rainfall at Bothe, during the years 1983-1992, to mean November rainfall and the number of plants counted within the annually monitored quadrat, an apparent positive correlation is seen between rainfall and population size (Figure 19). This correlation was not seen when October-November, November, November-December or November-March rainfall totals for the 10 year period, where compared to plants counted in the same Bothe monitoring plot.

The four sites may be compared by considering soil physical properties. Estimating Water Holding Capacity (Table 9) from USDA soils survey tables, Conn Valley road receives 70% of the average annual rainfall of Bothe but the available water holding capacity is estimated at 225% of Bothe, indicating that less rainfall is needed to supply similar soil moisture. This assumes that rain falls at a rate which produces little or no runoff. Average annual rainfall at Lewelling is about 20% higher than that of Bothe and soil water holding capacity is about 80% greater. Therefore, these soils may absorb a higher percentage of incident rainfall and possess the capacity to remain wet for a longer period of time. (This may have been an important factor in the size of the population of milkvetch at Lewelling in 1994). Average rainfall at Alpine School is nearly the same as Bothe but the soil has a water holding capacity which is 40% greater. Soil permeability was estimated as moderate to moderately slow for all soils examined.

Seasonal patterns of temperature fluctuation are similar at all four sites although they may vary in magnitude. Wind velocities and relative humidity was not measured during this study and could be a subject for further study.

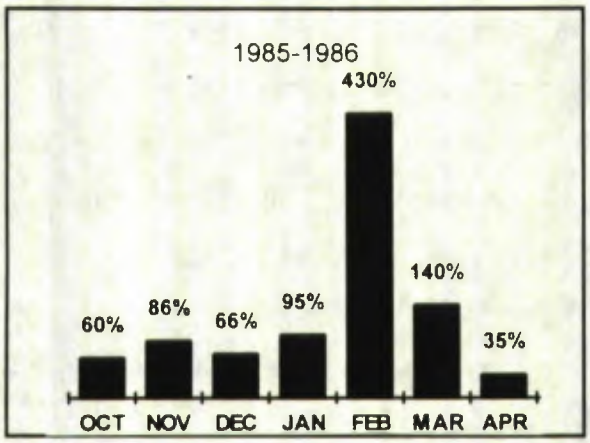
Figure 18. Rainfall data for Bothe charted as percent of "average"[1]. Numbers below each chart indicate number of plants counted in 3 m X 16 m quadrat.

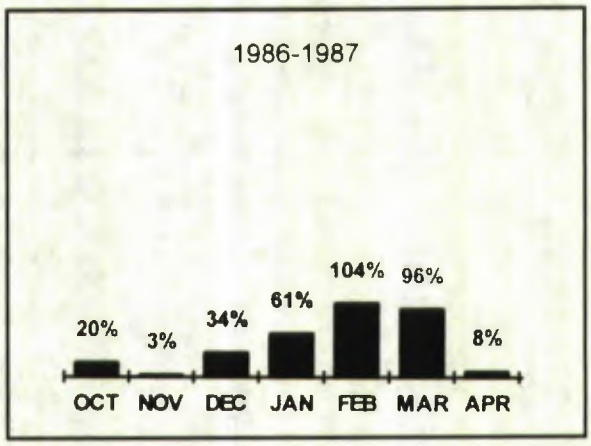




# of plants counted: 134

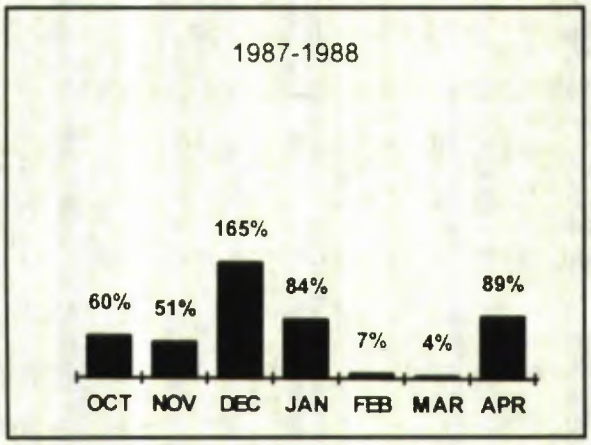
161

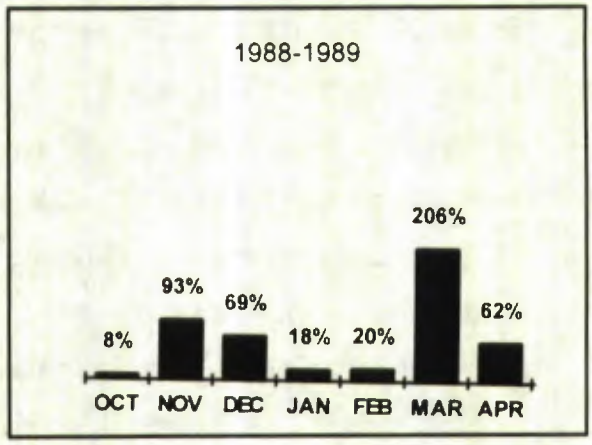




42

64

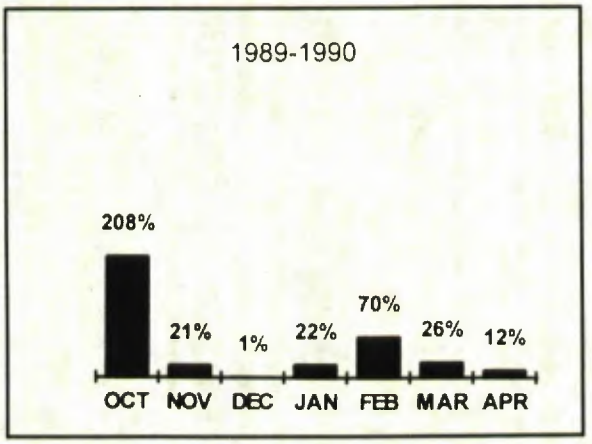


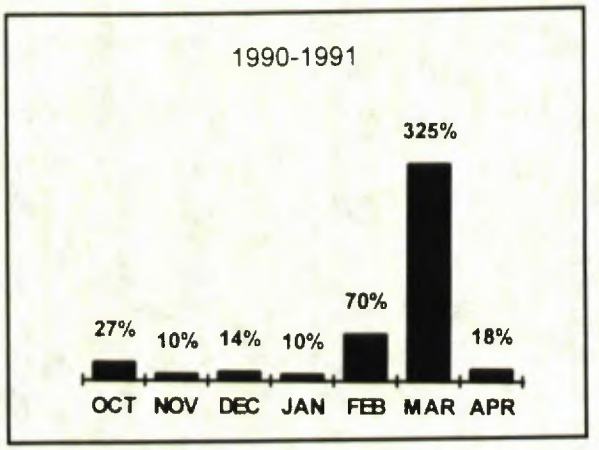


8

67

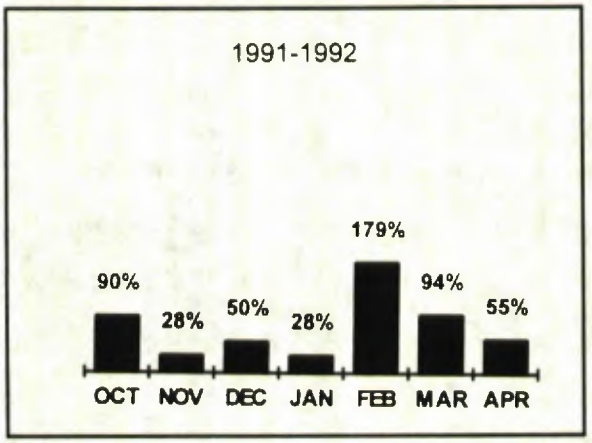
% of Normal Rainfall (cont.)

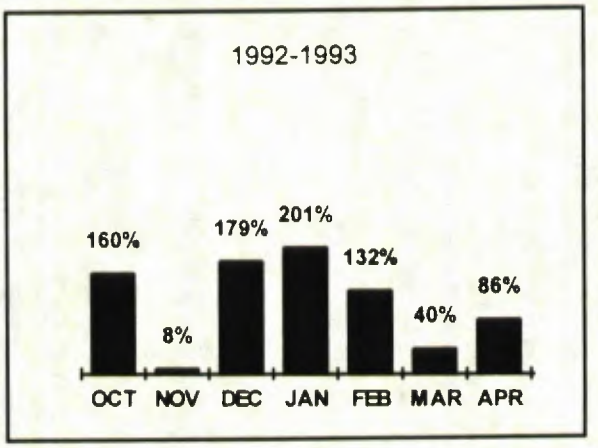




# of plants counted: 31

11



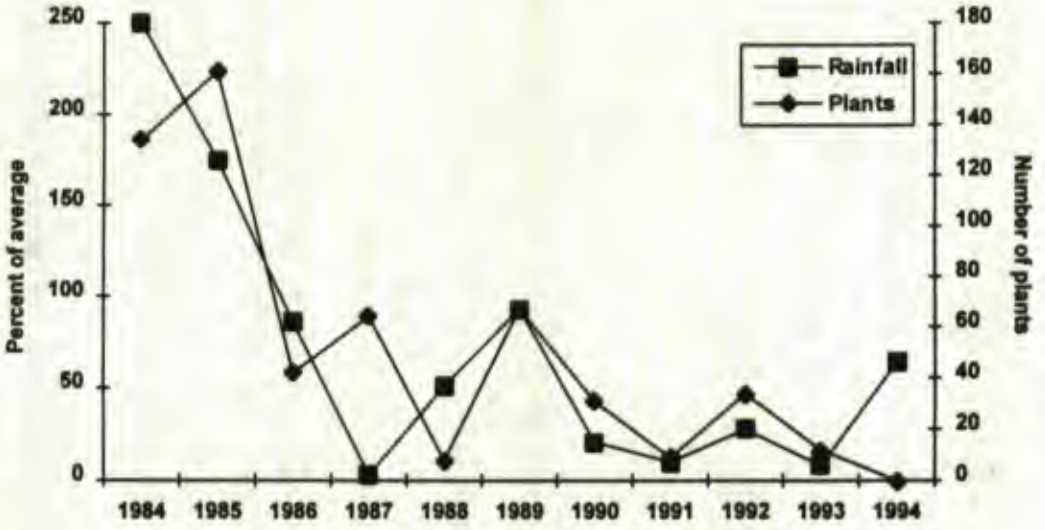


34

12

[1]Average rainfall determined from 30 year period (1964-1993).

Figure 19. Comparison of November rainfall to quadrat censuses.



Aspect, Slope and Elevation

The slope aspect of Clara Hunt's milkvetch occurrences ranges widely from west to north and east (Figure 20) while the slope incline is generally slight. ASCL habitat at Conn Valley Road (CV) varied from 4-6 degrees slope on a valley margin with a western aspect. Slopes at Bothe (B) were about 2 degrees and adhered to one side of a low ridge with a southwestern aspect. The Lewelling (L) population showed more variability with slopes ranging from 0 - 10 degrees and aspect from north northwest to west southwest and follows a low ridge. Similarly, the Alpine School (A) site varied from 0 to 13 degrees slope with an aspect varying from east to north northwest from slope bottom to near the top of a ridge. All three Napa County sites are located among hills, at low elevations near the floor of a valley. The Alpine School occurrence in Sonoma County lies at mid-elevation but is similarly located relative to a coast range vale. The elevation ranges from 100-105 m at Conn Valley Rd, 95-115 m at Lewelling, 130-185 m at Bothe, and 240-275 m at Alpine School. (Distribution maps of ASCL populations in Appendix 5)

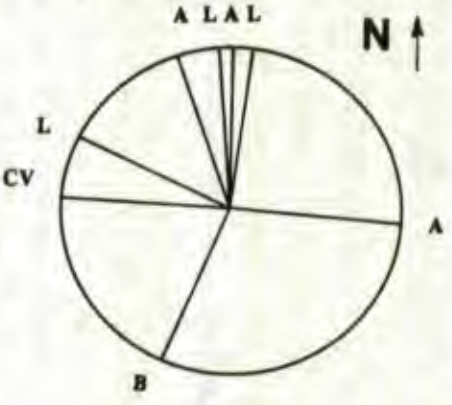


Figure 20. Slope aspect

Herbivory, Pollination and Other Animal Influences

The level of herbivory was estimated to be low in 1992-93 and at no time was damage observed which prevented plant maturation and fruit production. On a number of occasions, damage to the apical meristem, flower heads, and fruit was observed on Clara Hunt's Milkvetch. Partial loss of leaves, particularly the lowest stem leaves was observed. The causal agent is probably night active because herbivory was not observed during visits which ranged from 8:30 am to 7:00 pm. This type of damage was not quantified. A spittle bug (*Aphrophora* sp.) was observed on Clara Hunt's Milkvetch near Alpine School but no damage was noted. An aphid was seen on ASCL at Lewelling but no damage was observed.

Of a more important nature, was predation of flower heads and seed pods. Flower heads were severed at the middle to upper portion of the peduncle. In a limited sampling of 17 flower heads at Lewelling on April 10, 12% (2) were found severed. The causal agent for this damage may be mice but such activity was not observed.

Seed pod damage due to penetration of the fruit wall was found to result in the loss of part or all of the seed set. This damage was probably the result of insect activity although again, no agent was observed. Damage was recorded for 3% of 115 fruits sampled at Lewelling on May 10, 1993. Herbivore damage was recorded for 17% of 46 fruits sampled at Lewelling in June, 1994. Of 19 pods taken from four plants randomly collected at that time, 10% (14/145) of the seeds appeared abortive. This may have been caused by disease invasion but may also be plant induced. About 30% of the fruits sampled had lesions (red circular spots, often with brown center) on the fruit wall resulting from either an insect or pathogen. Seeds adjacent to these lesions were usually abortive although this was not quantified. Self pollination has been investigated by others as a possible factor causing seed abortion (Karron, 1989).

There were many opportunities to observe a pollinating agent during site visits in 1993 and 1994. Attempts to locate a pollinator were unsuccessful which suggests that a pollinator may be active at night or twilight. The flower keel firmly encloses the stigma and only in one case out of hundreds was the keel tip observed as bent away from the stigma. This may indicate a pollinator had "tripped" this flower but such activity was never observed. This implies the probability that this species is, in large part, self-compatible. Species within section *Leptocarpi*, subsection *Californici* have been found to be self-compatible and capable of self-fertilization (Liston 1992). This was confirmed by screening plants at Lewelling in 1994 (Table 3). Fruit

production of screened plants produced 70% as many fruits per plant as the control group. The "net" production of seeds was 16% higher in the test group which was due in part to the reduction of herbivore activity and an unexplained decrease in impacts to fruit and seed from an unknown pathogen. About 22% of seeds sampled in fruits untampered by herbivores or pathogens were abortive or unfertilized in the screened plants while the portion rose to 40% in the test group.

The presence of rodent activity within the habitat of Clara Hunt's Milkvetch was noted at all sites except Alpine School. At Conn Valley Road, well-used runways (field mice?) were observed as early as December. A relationship of this activity to plant distribution was not uncovered during this study and may be a subject for further research. Activity of pocket gophers (mounds and tunnels) was noted at Lewelling and Bothe throughout the year. This was particularly evident at Lewelling in late fall and early spring. Open tunnels and five mounds were observed a 1-meter plot (L-2), on March 15, 1993. On June 12, 1993, recent gopher mound formation was observed at Lewelling in a location of high ASCL density during the 1993 census. The role this soil aeration in habitat maintenance and seed dispersal for milkvetch is unclear. Further research may show a benefit to milkvetch from this type of soil disturbance.

Excavation of the root system of Clara Hunt's Milkvetch shows swelling along the main roots which may indicate a mycorrhizal association. The part which this plays in controlling population distribution was not determined.

During April 1994, pig rooting was first observed at Lewelling in a small portion of milkvetch habitat prior to maturation of the plants growing there. Extensive shallow (7-10 cm) disturbance (possibly 30% of the grid area) by pigs was found during a visit there on June 4, 1994. This activity occurred following seed maturation but may have long term impacts for this population.

Population Census

In 1993, populations were counted by exhaustive searching and flagging at the Conn Valley Rd., Lewelling and Bothe sites. A total of 156 individuals were counted within and outside of the grid set up at the Conn Valley site on April 1 (Figure 21). This is 48% of the 1992 census total. The Bothe population was counted on April 8, with 101 plants counted at that site which is 92% of the 1992 census (An estimated population of 200 individuals in 1992 by Ann Howald

would indicate the 1993 population to be about 50% of the 1992 population size). The Lewelling population was counted on April 7, 1993 and totaled 2,238 individuals (Figure 23). This five-fold increase over the 1992 estimate, reflects and the counting of individual plants while the 1992 population size was a visual estimate. The Lewelling population was found to be more extensive than previously known, measuring 950 m from east to west. The Alpine School population was counted on April 16, 1993 and was visually estimated at 2,660 individuals. This represents 60% of the previous year census total. All 1993 counts were taken within 7 days of 1992 census dates.

Population sizes declined sharply at all sites except Lewelling in 1994 (Table 11). Populations at Bothe and Conn Valley Road both declined over 90% from the previous year. Population size at Alpine School declined by over 60% in 1994. The Lewelling population in contrast increased by about 300% from the previous year.

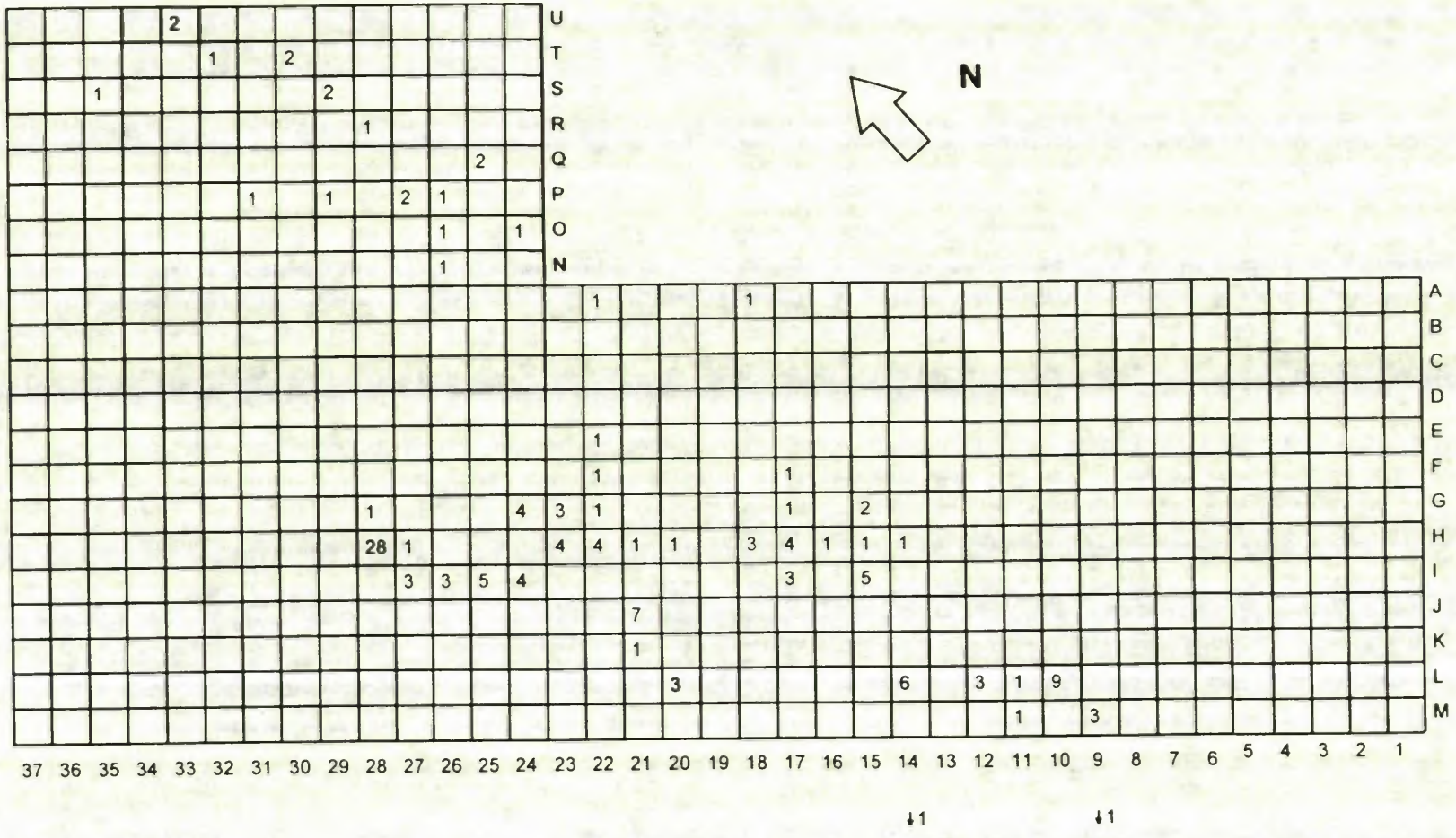
Placement of a census grid at the Lewelling and Conn Valley Rd. sites permitted precise mapping of species distribution. Populations were observed to be clustered in patches of various densities with some scattered outlying individuals (Figures 21-24). Densities of up to 92 individuals in a 2 m X 2 m grid cell and 27 individuals in a 1 m square (L-1) were recorded at Lewelling in 1993. Densities increased to a maximum of 382 individuals in a 4 m^2 cell in 1994 and 58 plants in L-1. (Summary of historic ASCL site visits in Appendix 6)

Table 11. Summary of 1990-1994 population censuses

	1992	1993	1994
Alpine School	4,500	2,660	994
Bothe State Park	110	101	7
Conn Valley Road	325	156	9
Lewelling	450*	2,238	6,192

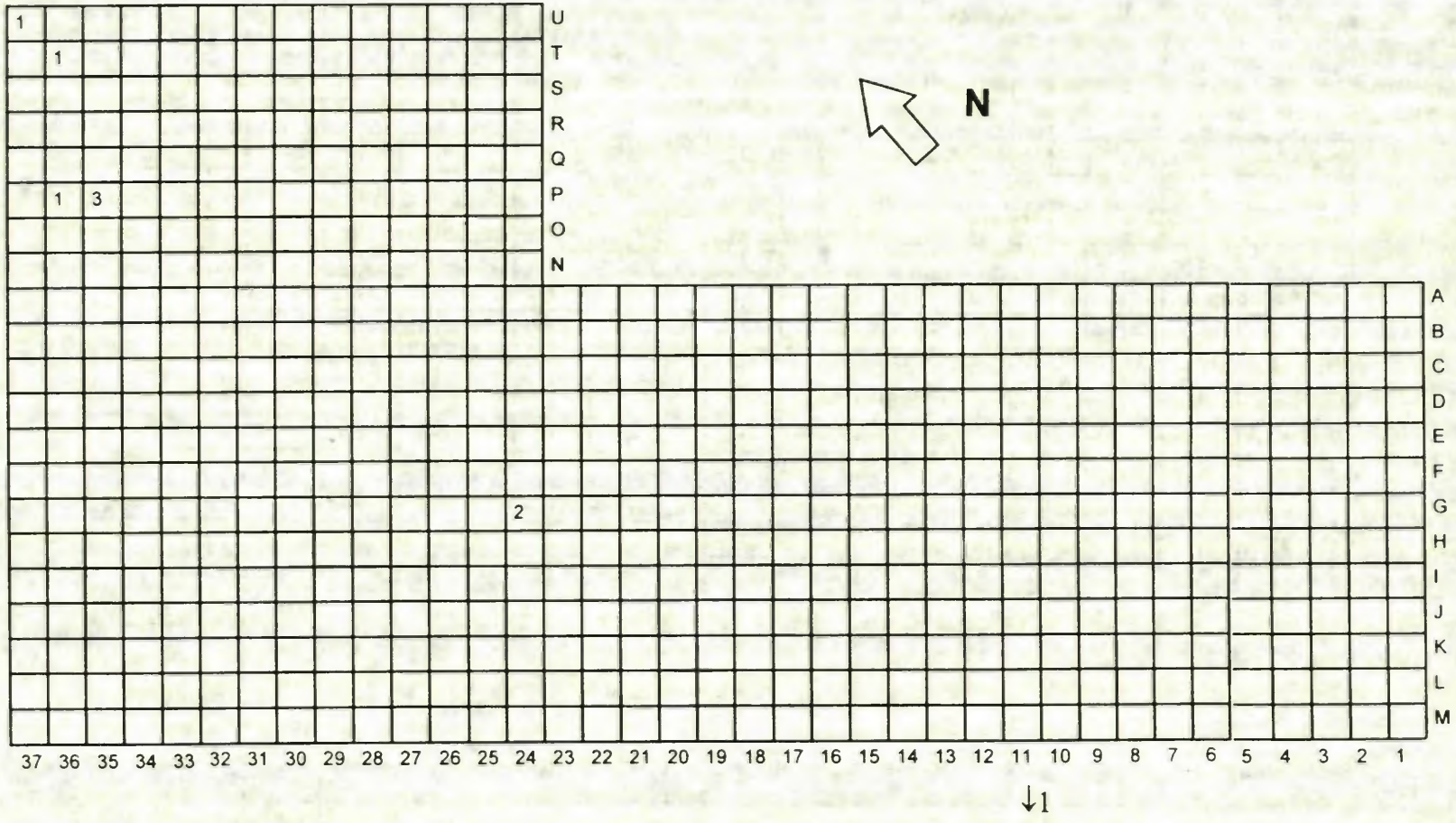
* visual estimate of portion of population

Figure 21. Conn Valley Road grid census results, 4/1/93 - *Astragalus clarianus*



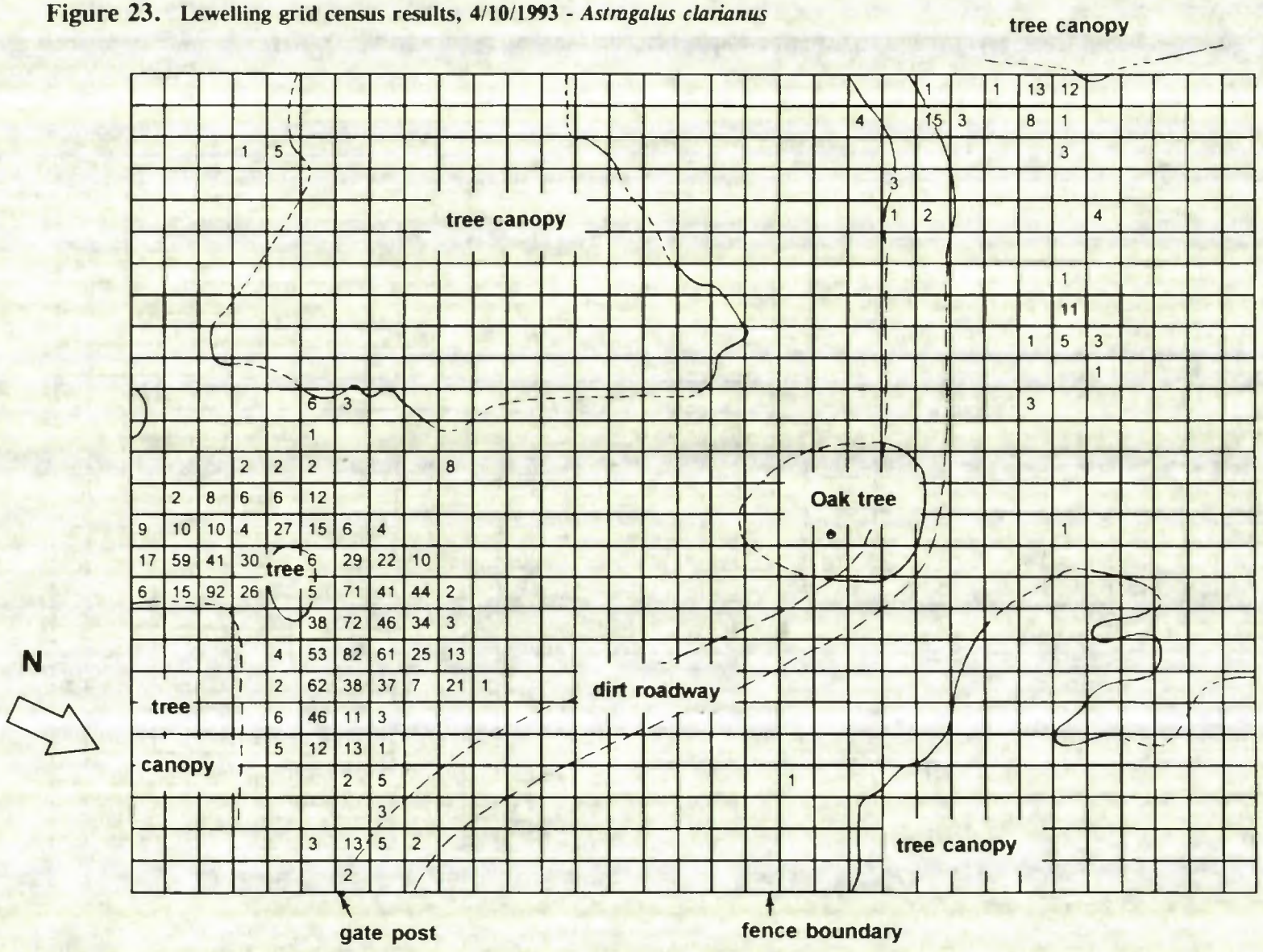
Cells measure 2x2 meters - Total # of individuals counted indicated in each cell; if blank, then no ASCL found
Arrow indicates location of plant is off the grid.

Figure 22. **Conn Valley Road grid census results, 4/1/94 - *Astragalus clarianus***



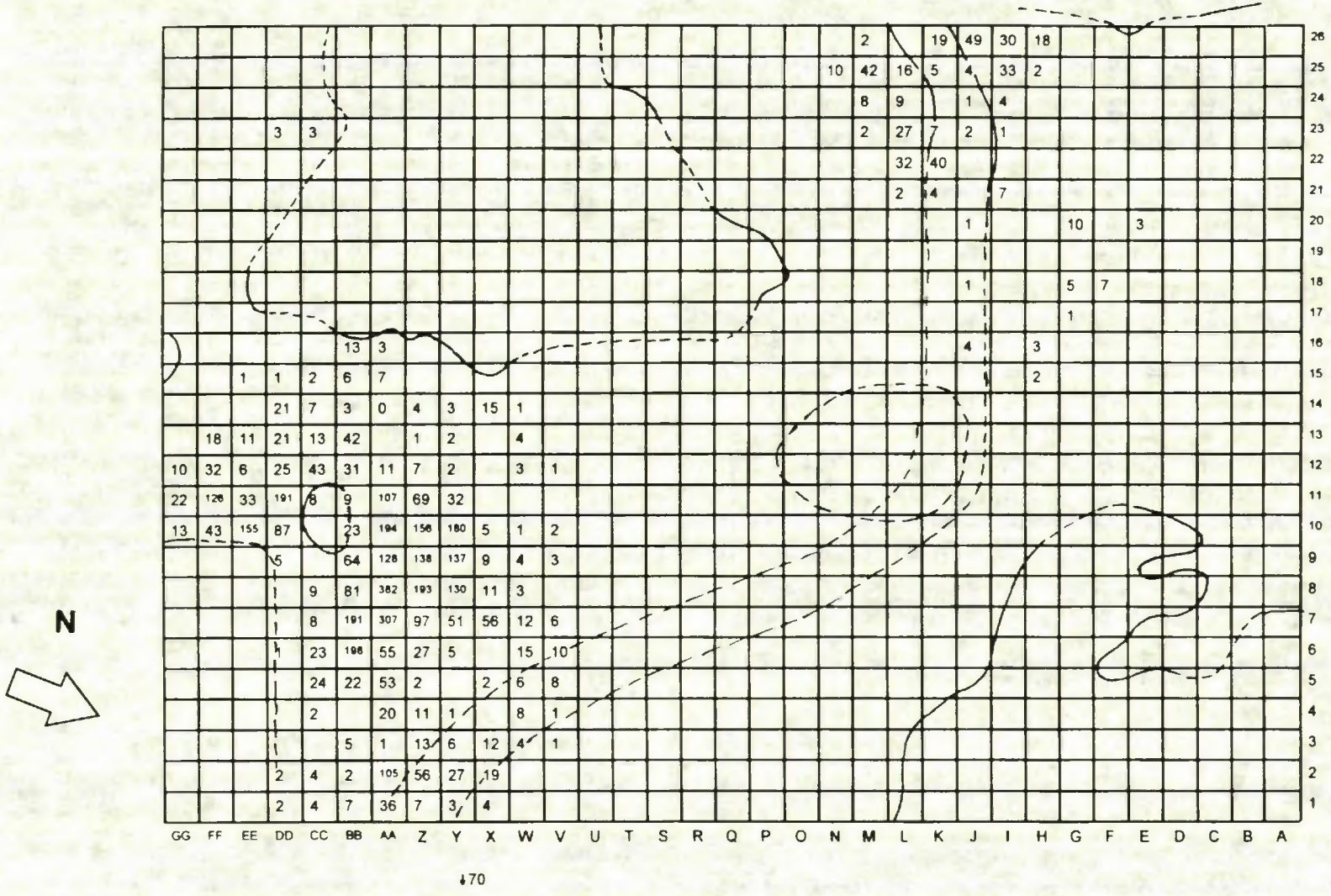
Cells measure 2x2 meters - Total # of individuals counted indicated in each cell; if blank, then no ASCL found
Arrow indicates location of plant is off the grid.

Figure 23. Lewelling grid census results, 4/10/1993 - *Astragalus clarianus*



Cells measure 2x2 meters - Total # of individuals counted indicated in each cell; if blank, then no ASCL found.

Figure 24. **Lewelling grid census results, 4/5/1994 - *Astragalus clarianus***



Cells measure 2x2 meters - Total # of individuals counted indicated in each cell; if blank, then no ASCL found.

Habitat Disruption of the Conn Valley Road Site

History

In the fall of 1990, the City of Napa permitted a group of topsoil vendors to remove sediments from the drought-exposed bed of Lake Hennessey. This was done to recover some capacity of the reservoir while providing inexpensive topsoil for retail. A Department of Fish and Game Stream Alteration Agreement was required for this activity. A temporary stockpile measuring about 30 m X 15 m and 3 m high was accidentally placed on, what was at that time considered to be, the largest extant population of Clara Hunt's Milkvetch (Figure 25). Over 30% of the habitat of ASCL was disturbed. Meetings ensued in January of 1991 between the City of Napa, topsoil vendors, the Department of Fish and Game and California Native Plant Society to develop a restoration strategy and a Draft Proposal was written by DFG.

Removal was done in part by the topsoil companies as needed but this stagnated when this need declined. The Department of Fish and Game installed a fence preventing traffic into the area from Conn Valley Road in February, 1991. The City of Napa provided a tractor and truck to remove the bulk of the remaining topsoil. Some additional work was done by a hand crew from the California Conservation Corps under the supervision of Sandra Morey of DFG. Some finer scale removal of stockpile soil was done in a 6 m X 3 m area by this author in January, 1992. At the beginning of this study in February, 1993, a layer of residual topsoil covered a portion of the habitat to a depth of 0-14" and has an estimated volume of 80 cubic yards.

Present Conditions

The condition of the site can be sub-divided into an eastern and western half. The eastern portion, where topsoil was removed in 1992, recovered surprisingly in the first year following excavation with a population of 325 robust individuals. This may be a result of reduced plant species competition and optimal rainfall. This area has since been degraded by the invasion of weedy species (Figure 27), particularly goatgrass (*Aegilops triuncialis*). This weed has invaded not only the area disturbed by the dumping of dredge materials but has also extended into unaffected areas south of the high voltage tower. A significant percentage of the 1993 population occurred near the edge of the disturbance in the western half and in the area that was "detailed" (soil removed with hand tools) at the center of the site. A list of competing weeds in this area is included in Table 12.

Table 12. Competing plants in eastern half of disturbed area at Conn Valley Road

Scientific Name	Life Form	Fruit Matures
Aegilops triuncialis	annual grass	June
Bromus hordeaceus	annual grass	May
Cerastium glomeratum	annual forb	April
Lolium multiflorum	annual grass	May
Medicago polymorpha	annual forb	April-May
Sonchus oleraceus	annual forb	most of year
Trifolium hirtum	annual forb	May
Vicia villosa ssp. *varia*	annual forb	April-June

The western half of the stockpile remained on the site until the fall of 1992. Once that part of the pile was removed, no detail work was done because it was assumed that few plants historically occurred here. The bulk of the remaining topsoil is here (Figure 26). A map drawn of the population distribution (Grummer, 1985) show a portion of the historic population as occurring within this area (Figure 25). This soil is characterized as a silt loam, differing from the native soil which is a gravelly clay loam. This soil supported a number of hydrophytic species in 1993 resulting from seeds deposited prior to excavation from the lake bed. These species were overwhelmed by a late season growth of yellow star thistle (*Centaurea solstitialis*) and sweet clover (*Melilotus indicus*). Only 2 ASCL plants were found in this portion of the site in 1993. The list of competing weeds in this area is presented in Table 13 .

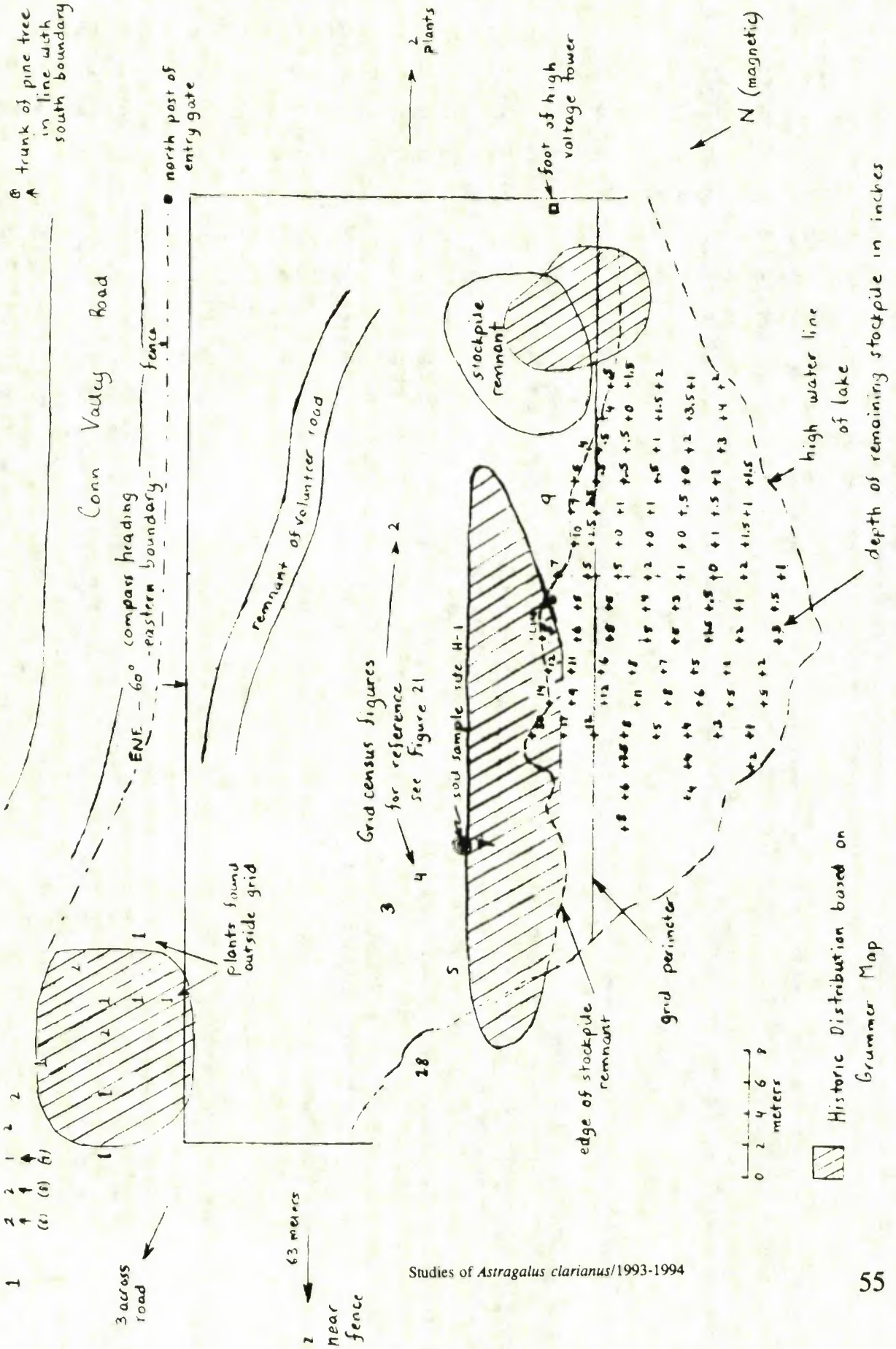
Table 13. Competing plants in western half of disturbed area at Conn Valley Road

Scientific Name	Life Form	Fruit Matures
Artemisia douglasiana	native perennial	
Bromus diandrus	annual grass	April
Carduus pycnocephalus	annual forb	May-July
Centaurea solstitialis	annual forb	summer-fall
Chamomilla suaveolens	annual forb	March-April
Conium maculatum	perennial forb	
Erodium botrys	annual forb	March-April
Erodium cicutarium	annual forb	March-April
Geranium dissectum	annual forb	April-May
Hirschfeldia incana	perennial forb	summer-fall
Lupinus succulentus	annual forb	April
Malva nicaaensis	biennial forb	spring-fall
Melilotus indicus	annual forb	late spring
Mentha pulegium	perennial forb	July-Aug
Picris echioides	annual forb	March-May
Raphanus sativus	annual forb	spring-fall
Rumex crispus	perennial forb	
Senecio vulgaris	annual forb	Feb.-May
Silybum marianum	annual forb	May
Sonchus oleraceus	annual herb	March-May
Spergula arvensis	annual forb	March-April
Xanthium strumarium	annual herb	Aug

Some physical work has been carried out under this contract to test further restoration strategies. This included clipping of a 7 m X 3 m test plot in a dense stand of goatgrass (*Aegilops triuncialis*) occurring within ASCL habitat. This was done on May 4 and June 21, 1993 at a time when goatgrass was developing seed heads. Some grass, cut at the May visit, set additional seed heads. Grass cut in June was beginning to drop seed. This effort reduced goatgrass density in the test plot in 1994 although this species was still prevalent.

Further excavation of topsoil was undertaken by the author in a 12 m X 7 m area on the western portion of the site. This was done over a period of several visits with soil placed in scattered piles for later transport. Vegetation was sparse in the cleared area in 1994. A single robust milkvetch plant with 160 flowers was found in this area during the April census. By June, 1994, the cleared area was dominated by yellow star thistle, spurry (*Spergularia arvensis*), and hayfield tarweed (*Madia congesta* ssp. *luzulifolia*).

Figure 25. Conn Valley Road site disturbance in relation to historic population.



Recovery Strategy and Options

Weed removal in the eastern half may be attempted with a hoe, weed puller, or hand clippers. Timely clipping would be most effective for annual grasses as they mature somewhat synchronously. Hand removal would be a necessity for annual and perennial forbs at a schedule that prevents seed drop. Refer to table 12 for timing. While a selective herbicide could assist in controlling grasses, the use of herbicides as a potential means of weed control is not a viable alternative at this site. The City of Napa Public Works Department has a policy stated in the Permit For Entry (Ridenhour, 1994) of no herbicide use near a public water supply (Lake Hennessey).

Soil excavation in the western half of the site should be preceded by weed removal by scraping surface with shovels. A tractor will be required to transport the final volume of stockpile soils. Initial work should be done with hand tools to concentrate remaining topsoil into small piles.

Figure 26. *Astragalus clarianus* at Conn Valley Road buried under soil dredged (topsoil stockpile) fron Lake Hennessey in 1990. (Photo by W. Grummer)

Figure 27. Invasion of Conn Valley Road milkvetch habitat by weedy plants following topsoil removal April, 1993.

DISCUSSION OF FINDINGS

A population census of Clara Hunt's milkvetch has been conducted at Bothe-Napa Valley State Park annually since 1983. The Conn Valley Road occurrence has been censused since 1985. This has been done by the Napa Valley Chapter of California Native Plant Society as part of their "Annual Plant Watch" activity. The Lewelling site was added to this program in 1991. The Alpine School population has been censused intermittently by four different observers for five of the last eight years. The intent of prior counts has been to either determine precise numbers within a sample plot (Bothe) or to estimate total population size and distribution (all other sites). This was done by counting portions of the population and extrapolating this sample to estimate the total size of the population. This limits the direct comparability of these numbers with those obtained during the 1993 and 1994 counts. General trends in the fluctuation of population size can be noted from previous data only for years in which counts covered comparable areas. The number of plants counted at Conn Valley Road, Bothe and Alpine School in 1993, all appear to be down by 40-50% from the previous year while the dramatic increase in population size at Lewelling can be explained as resulting from a more complete count of that site. Populations declined sharply at Bothe and Conn Valley Road in 1994 while less severly at Alpine School and increasing at Lewelling. Populations sizes have been shown to fluctuate dramatically from a few individuals (1988, 1991 and 1994) to many hundreds over the period of one or two years. This suggests that care must be taken when interpreting the findings of surveys conducted for this species during low count years. A low count year, especially when associated with below average rainfall, does not indicate a permanent decline in population size.

Clara Hunt's Milkvetch is a species with a highly restricted distribution. It occurs at low elevations (95-275 m) on gradual slopes (0-13%). Investigation of its edaphic requirements, indicate an adaptation of ASCL to habitats marginal or restrictive to competing species. This is despite its occurrence in a variety of plant associations. Soil physical and chemical properties appear to be the principal factor in limiting vegetation density in ASCL habitat, thereby reducing the competition from other species.

Levels of competition which vary within and between ASCL sites, probably play a role in excluding this species from the full range of its edaphic tolerances (potential habitat). Nitrogen and phosphorus are lower than nearby soils but do not appear to be deficient. A low Ca:Mg

ratio coupled with a high nickel content at the Lewelling and Conn Valley Road sites may be the principal factor determining available habitat at those sites. Low available manganese could be an additional factor at Lewelling. ASCL occurs at Alpine School and Bothe in soils which have lower nickel levels and higher Ca:Mg levels which are more representative of "balanced" soils (McCarten, 1986). Tolerance to low manganese levels may be the principal factor determining available habitat at Bothe. Again, this may be by excluding other plant species and reducing vegetation cover. Shallow, strongly acidic soil which drains very rapidly may be the principal factor determining available habitat at Alpine School. Soil acidity is a common denominator to all soils in which milkvetch occurs. Acidity increases the toxicity of nickel when present at high levels and reduces the availability of soil nutrients. All ASCL soils were also found to be rocky, shallow and well drained. In summary, Clara Hunt's milkvetch is adapted to poor soils which exclude competition from other species. It cannot be overlooked that further analysis of micronutrients not investigated during this study might show that ASCL has a critical demand for a particular element. Likewise, other elements were not investigated to determine if ASCL has a high tolerance to other naturally occurring soil toxins.

The limited number of soil samples analyzed during this study are insufficient to determine the relative influence of soil factors on distribution. A range of tolerances to several edaphic variables is displayed. This is probably the result of synergy of a number of soil characteristics within differing plant associations and climatic conditions. This ability of Clara Hunt's milkvetch to tolerate hostile conditions in a micro-environment which excludes or reduces the presence and density of competing species is supported by low cover estimates recorded during this study.

Average annual rainfall for the four sites ranges from 690-1190 mm annually and does not appear to be the principal limiting factor for milkvetch distribution. Water holding capacity (WHC) of the various ASCL soils may compensate for discrepancies in average rainfall. The higher WHC at Lewelling may explain the sizable population there in 1994 while all other populations declined in size. The difference of WHC between Bothe and Alpine School may explain the less severe decline in population size at Alpine School in 1994. A comparison of annual monitoring records at Bothe show an apparent positive correlation between ASCL population size (within a 48 m^2) and November rainfall (Figure 19) indicating a critical need for rain at this time to initiate seed germination. A high rate of germination at Lewelling following

rain in mid-October 1993 show that a correlation to November rain may be oversimplified and that the optimum time for rainfall includes portions of both months. Prolonged rainless periods following germination and during a period of rapid growth in February-April would be expected to reduce the chance of seedling survival although mortality was low during a dry period occurring in 1994. Dry spring conditions appeared to reduce the potential for successful seed production by decreasing the number of flower heads per plant and fruits per head. Soil temperature and photoperiod may also play an important part in germination and could be subjects for further study.

Destruction of milkvetch habitat has certainly played a part in reducing or eliminating populations and remains a threat today. The historic location in Conn Valley collected in the 1930's by Baker has been developed as an orchard and the type locality at St. Helena is considered extirpated. A lack of communication led to damage of the Conn Valley Road site in 1990. The Lewelling population was threatened in 1994 when a reservoir was proposed there. A residential development has been proposed near the Alpine School population (Saddle Mountain Development).

A primary limiting factor in the distribution of ASCL may be seed dispersal. This is indicated by the stability of ASCL "patches" within the Bothe annually monitored quadrat. The apparent lack of a dispersal agent limits the potential for colonization of new habitat. The only evidence of more rapid colonization was seen on a reservoir dam at the Alpine School site. This could be as the result of soils including ASCL seed being transported during construction.

Clara Hunt's Milkvetch may produce a seed count 40 times the size of the current year's population under favorable conditions. In contrast, seed production declined to an estimated 6 viable seeds per plant in 1994 (Lewelling). The rate of losses from herbivores and pathogens was found to be highly variable during 1993-1994 and in need of further study. The apparent color mimicry of dry fruits to dried *Crossidium aberrans* suggests a need for further study. The percentage of the seed crop which bypasses germination and contributes to a seed bank is probably also highly variable. The size of the seed bank was not investigated and is unknown. The ability of seeds to remain dormant in the soil was evidenced in 1992 when several hundred plants grew at Conn Valley Road where eight plants were found in 1991. This ability provides a means of weathering unfavorable rainfall years or habitat disturbances.

Clara Hunts' Milkvetch has been suspected of being largely self-fertile and self-compatible and this is supported through pollinator exclusion testing in 1994. This adaptation may be an important means of survival for this narrow endemic which often undergoes sharp annual population fluctuations. Although ASCL is self-fertile, genetic diversity is high between and within populations reflecting the variability of the habitat (Liston 1993). This independence from a pollinating agent insures seedset even in years of low germination (Karron, 1989) This characteristic could also assist in seed production in a greenhouse situation. This method may be worthy of consideration to supplement natural population regeneration at Conn Valley Rd.

Clara Hunt's Milkvetch occurs in habitats where bare ground and litter comprise as much as 55% of the "cover". Some individuals found in areas bared after topsoil removal at Conn Valley Road were particularly robust (visual estimate). The sparsely vegetated crown of a reservoir dam (seeds may have been in fill) at Alpine School supported 138 plants in 1993 (Saxton survey). Milkvetch cover, even in optimum habitat conditions was found to be minor (from 1-5% in 1993) within sample plots. In contrast, competition from aggressive alien species observed at Conn Valley Road in 1993 reduces or eliminates milkvetch habitat and impedes restoration. The height of competing weeds here is as much as three times that seen in natural habitat architecture and cover is often 100% in unoccupied cells. This excludes light at ground level which may be critical for germinating seedlings.

RECOMMENDATIONS

Alpine School - Negotiate an agreement with landowner to construct a small exclosure to determine effects of cattle grazing on ASCL plants there. This enclosure should permit entry of indigenous herbivores, pollinators etc. A portion of one subpopulation should be fenced to permit comparison to the adjacent unfenced subpopulation. This fencing should remain in place for at least three years. Comparison between the fenced plot and an equal size portion unfenced portion of the same subpopulation (control) should record number of plants, plant size, vegetation depth, and flower or fruit production. This may be done at the same time as the annual census currently conducted at the site. Analysis of the results of this study would be needed to determine what, if any, action should be considered to enhance this population.

Bothe - It is the opinion of this researcher that the present condition of the plant community at this site is impacting ASCL habitat by competing for light and nutrients. A limited controlled burn or clearing should be considered in an area where decaying or encroaching brush has reduced or eliminated the presence of milkvetch. Mr. Grummer should be consulted to determine the existence of such a location. Marla Hastings of the California Department of Parks and Recreation should be contacted to seek funding under their prescribed burn program. The California Department of Forestry should be consulted to determine a safe method of such an endeavor. Foot traffic through this population has been minimal in the past. This should be monitored at least once annually during the flowering season of ASCL and protective measures taken if foot traffic should become threatening.

Conn Valley Road - Further restoration of this site is warranted. Possible activities to achieve this goal include:

1. Employ CCC or volunteers to clear away existing topsoil piles and remaining topsoil layer with flathead shovels. The interface between topsoil and native soil can be readily recognized by a change from gray-brown to red soil color. The two soil types cleave apart easily by prying with a flat nose shovel placed vertically into the ground. A small tractor would expedite the transfer of this material to an alternate storage site.
2. Harvest goatgrass seed prior to seed drop. Cut at 6" height at end of May to early June.

Possible tools for this purpose are hedge clippers, scythe, or mower. Hand weed dense patches of bur clover with standard weed puller in April when ASCL is visible to prevent damage to those plants. This procedure should be carried out for a minimum of two years.

3. Arrange a monitoring program with CNPS or other voluntary persons or organization with specific recovery success assessment criteria. This should include several small plots monitored for ASCL presence and percent cover of native species.

4. Monitor level of disturbance from recreational activities. This should be done at a minimum in spring along with other monitoring activities and twice during peak summer use. Any site disturbance should be reported to the Department of Fish and Game.

5. Collect small number of seed for greenhouse culture. A few plants (3-5) may be taken in a year when this number is no more than 5 % of the total population.

6. Install a sign near entry gate which indicates the cooperative effort between the California Department of Fish and Game and City of Napa to restore native plant habitat (possibly also California Native Plant Society).

7. The City of Napa is presently considering elevation of the dam on Lake Hennessey which would inundate this population of milkvetch. Such action should be opposed unless some means of on site mitigation can be performed.

Lewelling - Provide for the protection of the species by establishing a landowner protection agreement or conservation easement with the Lewelling family. At present, 90 % of the ASCL habitat on the property is excluded from cattle grazing. These present practices should be maintained under an agreement or easement. Realignment of the fence to encompass presently grazed ASCL habitat should be pursued. Some landowner incentives for such an action should be provided. The impact of pig rooting on this population should be monitored in 1994-1995. It should be determined if steps are necessary to control their numbers. This would be based on the level of weed invasion and ASCL germination in disturbed compared to undisturbed areas. Immediate action to control these animals may be the most sensible choice to prevent further potentially significant impacts.

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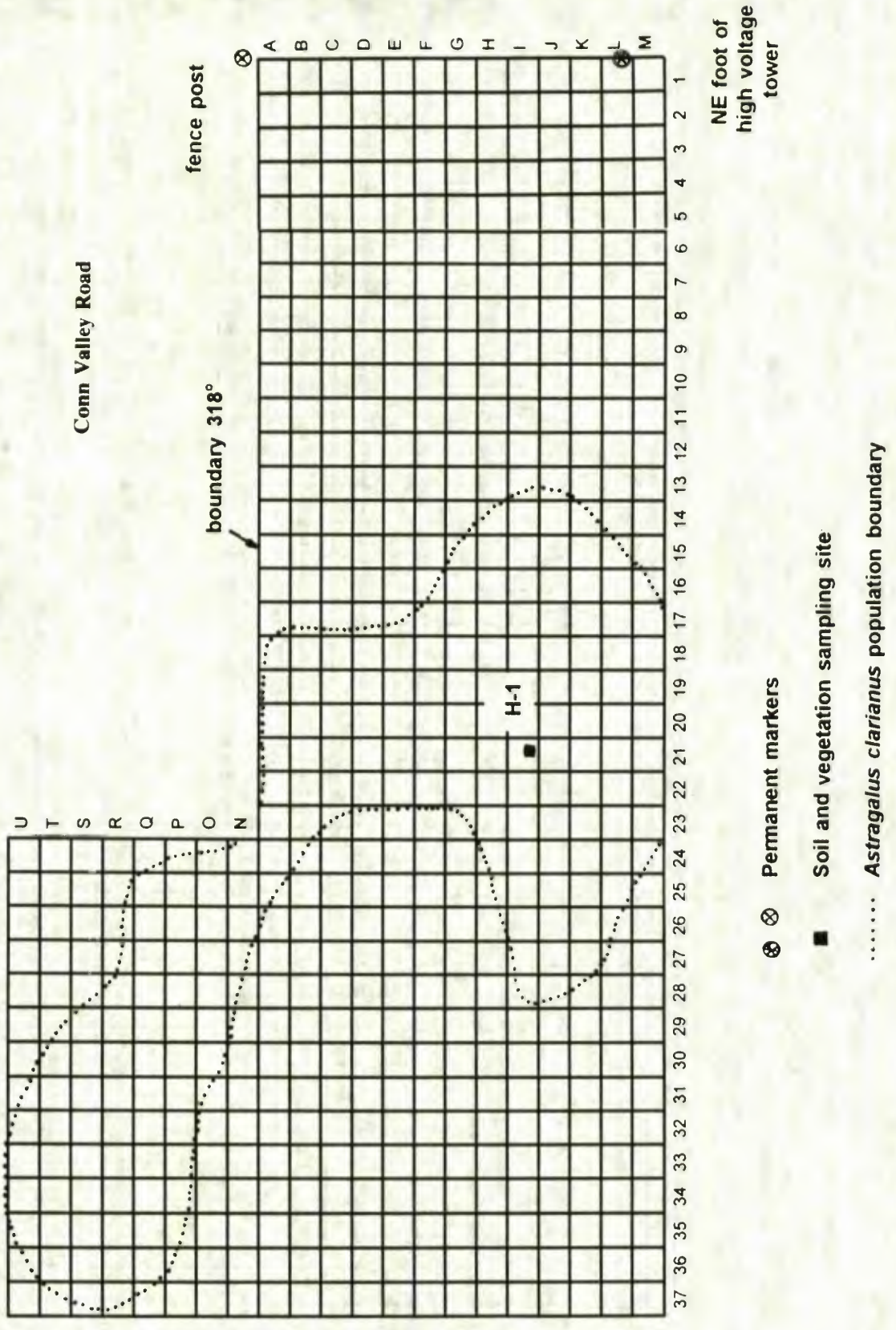
Appendix 1-1. Aerial photograph, Conn Valley Road census grid site (EO 11). Photograph scale is 1:1875.

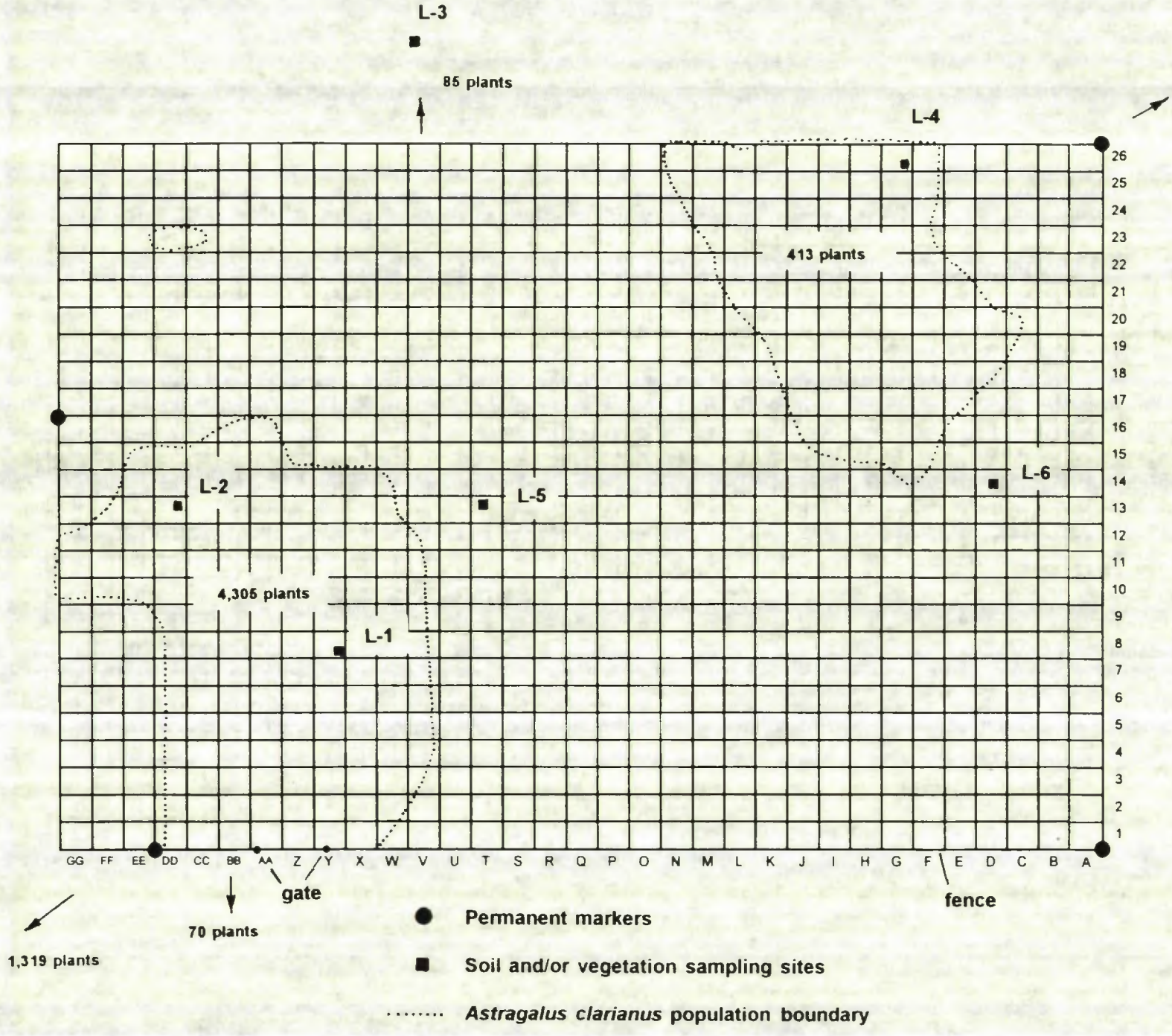
N

Appendix 1-2. Aerial photograph, Lewelling census grid site (Occ. 12). Photograph scale is 1:1875.

N

Appendix 2-1. Map of Conn Valley Road with location of site markers, soil test pit site.





Appendix 2-2. Map of Lewelling with location of site markers, soil test pit sites.

Appendix 3. Monthly rainfall records for Clara Hunt's milkvetch sites.

	Alpine School								Source: Middleton O'Brien				
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1986-87	0	0	3.0	.9	.3	3.8	5.0	6.8	7.1	.4	0	0	27.3
1987-88	0	0	0	1.4	5.1	9.6	7.5	.6	.2	2.6	1.6	.8	29.4
1988-89	0	0	0	.3	8.2	4.0	1.3	1.5	12.3	1.5	.2	0	29.3
1989-90	0	0	2.3	4.4	2.8	0	7.2	4.1	2.0	.5	7.0	0	30.3
1990-91	0	0	0	1.1	.7	1.1	.8	3.9	17.0	.6	.1	0	27.2
1991-92	0	0	0	3.2	1.5	2.9	2.1	10.2	4.7	2.2	0	.7	27.5
1992-93	0	0	0	5.6	.6	11.3	13.2	6.9	4.0	2.2	2.4	1.2	47.4

	Bothe								Source: Bothe Napa Valley State Park				
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1982-83	0	0	1.50	4.74	10.71	6.19	2.07	14.31	19.80	3.75	1.00	.01	64.08
1983-84	0	.26	.25	1.36	15.58	15.13	.67	3.46	3.10	1.38	.22	.40	44.75
1984-85	0	.17	.06	2.43	10.89	2.70	1.50	6.08	6.26	.21	0	.03	30.33
1985-86	0	.01	1.19	1.51	5.38	4.12	8.16	29.54	8.88	.85	.77	0	60.41
1986-87	0	0	3.40	.50	.21	2.47	5.23	7.12	6.12	.19	.12	0	25.36
1987-88	0	0	0	1.50	3.19	12.05	7.20	.52	.27	2.19	1.30	.88	29.10
1988-89	0	0	0	.20	5.83	5.05	1.52	1.40	13.11	1.52	15	.26	29.04
1989-90	0	0	?	5.20	1.34	.05	1.86	4.79	1.68	.30	?	0	(15.22)
1990-91	0	0	.18	.68	.61	1.01	.87	4.82	20.66	.45	.43	.66	30.37
1991-92	.01	.15	0	2.26	1.75	3.68	2.38	12.26	5.97	1.38	0	1.33	31.17
1992-93	0	0	0	4.01	.51	13.05	17.79	9.08	2.54	2.10	1.92	1.17	52.17
1993-94	0	0	0	1.53	4.00	5.98	3.50	6.16	.60	1.80	1.10	.03	24.70

Appendix 3. (cont.)

	Conn Valley Road								Source: City of Napa, Public Works Dept.				
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1982-83	0	0	1.69	3.10	7.10	3.40	9.93	11.05	11.46	3.34	.38	0	51.45
1983-84	0	.18	.46	.82	11.17	10.53	.55	2.18	1.62	1.06	.12	.16	28.85
1984-85	.01	.44	.40	1.88	8.08	2.09	1.54	3.79	4.53	.15	0	.06	22.97
1985-86	0	0	.82	1.18	3.29	2.99	4.78	18.69	6.99	.59	.38	0	39.71
1986-87	0	0	1.00	.42	.11	1.50	3.72	4.28	3.98	0	.07	0	15.08
1987-88	0	0	0	1.75	2.79	6.97	5.54	.44	.36	1.91	.65	.57	20.98
1988-89	0	0	0	.04	3.57	2.60	.94	.96	6.25	.35	.11	0	14.82
1989-90	0	0	1.64	2.84	1.70	0	4.01	2.52	1.01	.11	2.17	0	16.00
1990-91	0	0	.15	.18	.32	.87	.53	3.89	13.05	.31	.10	.50	19.90
1991-92	0	.25	0	1.71	1.03	2.69	1.91	9.21	4.70	0	0	.68	22.18
1992-93	0	0	0	3.18	.27	8.22	13.21	8.51	2.05	.99	1.75	0	38.18
1993-94	0	0	0	1.14	2.38	1.63	--	--	--	--	--	--	--

	St. Helena (Lewelling)								Source: St. Helena Star				
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1982-83	0	0	1.95	4.55	10.36	5.41	11.23	16.98	14.53	4.15	.54	0	69.70
1983-84	0	.32	.48	1.38	12.53	13.26	.54	3.14	1.53	1.13	.17	.09	34.57
1984-85	0	.23	0	2.04	11.9	2.11	1.47	4.83	4.98	.26	0	.04	27.91
1985-86	0	0	.87	1.20	7.51	4.13	5.88	25.60	8.09	.65	0	0	53.93
1986-87	0	0	1.85	.12	.12	2.10	4.28	5.38	4.86	.14	0	0	18.85
1987-88	0	0	0	1.11	5.01	9.34	7.01	.66	.02	2.42	.84	.46	26.87
1988-89	0	0	0	.08	5.75	4.55	1.35	1.04	10.60	.42	.03	.05	23.87
1989-90	0	0	1.80	3.36	1.96	0	8.19	3.58	1.46	.25	3.48	0	24.08
1990-91	0	0	.21	.77	.51	.86	.51	5.39	16.37	.27	.01	.39	25.29
1991-92	0	.09	0	2.05	1.58	2.80	3.21	9.15	6.34	.94	0	.95	27.11
1992-93	0	0	0	3.46	0	13.21	13.13	9.33	2.53	1.74	1.65	1.35	46.40
1993-94	0	0	0	1.22	1.69	4.53	2.73	3.79	.24	1.77	1.27	0	17.24

Appendix 3. (cont.)

Monthly Average Rainfall for Clara Hunt's Milkvetch Sites

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Total
Alpine													
Bothe	.06	.07	.45	2.50	6.23	7.29	8.58	6.86	6.35	2.45	.45	.30	41.59
Conn V.	.06	.10	.34	1.47	4.05	4.62	5.86	4.63	4.10	1.53	.36	.17	27.29
Lewelling	.05	.12	.41	2.11	5.43	6.01	7.50	5.97	4.95	2.10	.33	.17	33.15

Bothe, Conn Valley & Lewelling average rainfall determined for period 1963-1993, Alpine 30 year data not available. Averages determined from closest official weather station for all sites except Alpine School. Alpine School average determined from 7 years of records collected on site.

Comparison of Rainfall Recorded at Official Station to On-Site Collections

Location	Date	Official Station	ASCL Site
Bothe	12-12-1993	4.60	4.20
"	01-30-1994	3.50	3.30
"	02-15-1994	2.35	1.86
"	02-20-1994	3.02	3.05
Lewelling	12-12-1993	1.09	1.43
"	05-08-1994	.72	.75

Appendix 4. Detailed soil profile descriptions.

Profile "L-1"

A1 - 0 to 3 inches, brown (10YR 4/3) clay loam, dark brown (7.5YR 3/2) moist; moderate fine and medium subangular blocky structure; hard, firm, sticky and plastic; common very fine roots; common fine interstitial pores; strongly acid (pH 5.5); gradual smooth boundary.

A2 - 3 to 11 inches, brown (10YR 4/3) clay loam, dark brown (7.5YR 3/2) moist; weak medium subangular blocky structure parting to massive; hard, firm, sticky and plastic; common medium roots; few very fine interstitial pores; strongly acid (pH 5.5); abrupt wavy boundary.

Bt - 11 to 23 inches, olive brown (2.5Y 4/3) clay, dark brown (7.5YR 3/2) moist; massive; extremely hard, firm, sticky and plastic; very few very fine roots; few very fine interstitial pores; medium acid (pH 5.8), diffuse wavy boundary.

Cr - 23 to 28 inches, variegated yellowish brown and dark greenish gray (10YR 5/4 and 5GY 4/1) weathered serpentine.

Parent material: serpentine residuum
Drainage class: moderately well drained
Permeability: moderately slow
Soil Survey map unit: Forward gravelly loam, 9 to 30 percent slopes
Observed soil series: morphologically similar to Henneke
Remarks: A1, A2 and Bt horizons contain 15 percent serpentine gravel; Cr horizon contains 40 percent serpentine gravel

Profile "Near L-3"

A - 0 to 8 inches, brown (10YR 5/3) clay loam, very dark grayish brown (10YR 3/2) moist; moderate medium subangular blocky structure (upper 2 inches weak moderate granular structure); hard, firm, sticky and slightly plastic; common very fine and few coarse roots; common fine interstitial pores; medium acid (pH 6.0); abrupt irregular boundary.

R - 8 inches, hard serpentine.

Parent material: serpentine residuum
Drainage class: well
Permeability: moderately slow
Soil Survey map unit: Forward gravelly loam, 9 to 30 percent slopes
Observed soil series: morphologically similar to Montara
Remarks: A horizon contains 10 percent serpentine gravel

Profile "L-5"

A1 - 0 to 5 inches, brown (10YR 4/3) gravelly loam, dark brown (7.5YR 3/2) moist; weak fine subangular blocky structure; slightly hard, firm, sticky and plastic; few medium and very few fine roots; few fine interstitial pores; strongly acid (pH 5.4); clear broken boundary.

A2 - 5 to 11 inches, dark brown (7.5YR 3/2) gravelly clay loam, dark brown (7.5YR 3/2) moist; weak medium subangular blocky structure; slightly hard, firm, sticky and plastic; very few fine roots; very few very fine interstitial and vesicular pores; reaction unknown; clear wavy boundary.

Cr - 11 to 14 inches, light yellowish brown weathered serpentine.

Parent material: serpentine residuum
Drainage class: well drained
Permeability: moderate

Appendix 4. (cont.)

Soil Survey map unit: Forward gravelly loam, 9 to 30 percent slopes
Observed soil series: similar to Montara
Remarks: A1 and A2 horizons contain 20 percent subrounded serpentine and basalt gravels

Profile "L-6"

A1 - 0 to 4 inches, strong brown (7.5YR 4/6) loam, dark brown (7.5YR 3/3) moist; weak medium subangular blocky structure; slightly hard, firm, slightly sticky and slightly plastic; common fine roots; few medium interstitial pores; strongly acid (pH 5.3); gradual smooth boundary.

A2 - 4 to 13 inches, brown (7.5YR 4/4) loam, dark brown (7.5YR 3/3) moist; moderate medium subangular blocky structure; slightly hard, firm, slightly sticky and slightly plastic; few fine roots; common fine interstitial and vesicular pores; reaction unknown; abrupt smooth boundary.

Bt - 13 to 28 inches, dark grayish brown (2.5Y 4/2) clay loam, very dark grayish brown (2.5Y 3/2) moist; weak medium subangular blocky structure parting to massive; very hard, very firm, very sticky and plastic; very few fine roots; very few very fine interstitial pores; reaction unknown; clear smooth boundary.

Cr - 23 to 28 inches, variegated light yellowish brown and olive brown weathered serpentine (?).

Parent material: serpentine residuum (?)
Drainage class: moderately well drained
Permeability: moderately slow
Soil Survey map unit: Forward gravelly loam, 9 to 30 percent slopes
Observed soil series: none identified
Remarks: A1, A2 and Bt horizons contain 10 percent serpentine, red chert and extrusive rock gravels

Appendix 4. (cont.)

Profile "A-1"

A - 0 to 8 inches, dark brown (7.5YR 3/3) very gravelly loam, dark reddish brown (5YR 3/2) moist; weak fine subangular blocky structure; hard, friable, slightly sticky and slightly plastic; many fine roots; many very fine interstitial pores; strongly acid (pH 5.2); clear wavy boundary.

Bt - 8 to 16 inches, dark reddish brown (5YR 3/3) very gravelly clay, brown (7.5YR 4/3 moist); weak fine and medium subangular blocky structure parting to massive; very hard, very firm, sticky and plastic; few fine roots; very few very fine interstitial pores; strongly acid (pH 5.5).

Parent material: basalt (?) residuum
Drainage class: well drained
Permeability: moderately slow
Soil Survey map unit: Goulding cobbly clay loam, 15 to 30 percent slopes
Observed soil series: none identified
Remarks: one percent of ground surface covered by stones; slightly irregular topography; A and Bt horizons contain 60 to 70 percent basalt gravel

Profile "A-2"

A - 0 to 7 inches, dark brown (7.5YR 3/2) very gravelly loam, very dark grayish brown (10YR 3/2) moist; moderate fine and medium granular structure; slightly hard, friable, slightly sticky and slightly plastic; many fine and medium roots; common fine and medium interstitial pores; strongly acid (pH 5.2); abrupt irregular boundary.

R - 7 inches, hard basalt.

Parent material: basalt residuum
Drainage class: somewhat excessive
Permeability: moderate
Soil Survey map unit: Felta very gravelly loam, 30 to 50 percent slopes
Observed soil series: similar to Hambright
Remarks: A horizon contains 60 percent basalt gravel

Profile "B"

A - 0 to 11 inches, brown (7.5YR 5/4) very stony loam, dark brown (7.5YR 3/2) moist; moderate fine and medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine roots; common medium interstitial pores; strongly acid (pH 5.3); gradual wavy boundary.

AB - 11 to 14 inches, brown (7.5YR 5/4) very stony clay loam, dark brown (7.5YR 3/2 moist); weak medium subangular blocky structure; few fine roots; abrupt irregular boundary.

R - 14 inches, hard basalt.

Parent material: basalt residuum
Drainage class: well
Permeability: moderate
Soil Survey map unit: Hambright-Rock outcrop complex, 2 to 30 percent slopes
Observed soil series: similar to Hambright
Remarks: A and AB horizons contain 40 percent basalt pebbles and stones

Appendix 4. (cont.)

Profile "CV-1"

A1 - 0 to 3 inches, dark brown (7.5YR 3/4) gravelly clay loam, dark reddish brown (5YR 3/2) moist; moderate fine and medium subangular blocky structure; hard, very firm, slightly sticky and slightly plastic; common very fine roots; common fine interstitial pores; medium acid (pH 5.6); gradual smooth boundary.

A2 - 3 to 16 inches, dark reddish brown (5YR 3/3) gravelly clay loam, dark reddish brown (5YR 3/2) moist; weak medium subangular blocky structure; few fine roots; common fine interstitial pores; medium acid (pH 5.6); abrupt wavy boundary.

Bt - 16 to 19 inches, light olive brown (2.5Y 5/4) gravelly clay; massive; no roots; very few very fine interstitial pores.

Parent material: mixed igneous rock (?) residuum
Drainage class: moderately well
Permeability: moderately slow
Soil Survey map unit: Haire loam, 2 to 9 percent slopes
Observed soil series: none identified
Remarks: A1, A2 and Bt horizons contain 20 percent quartzite, serpentine and basalt gravels and cobbles

Profile "Conn Valley Road"

Fill - 0 to 5 inches, grayish brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) moist; massive; hard, slightly firm, slightly sticky and slightly plastic; no roots; very few very fine interstitial pores; medium acid (pH 5.6).

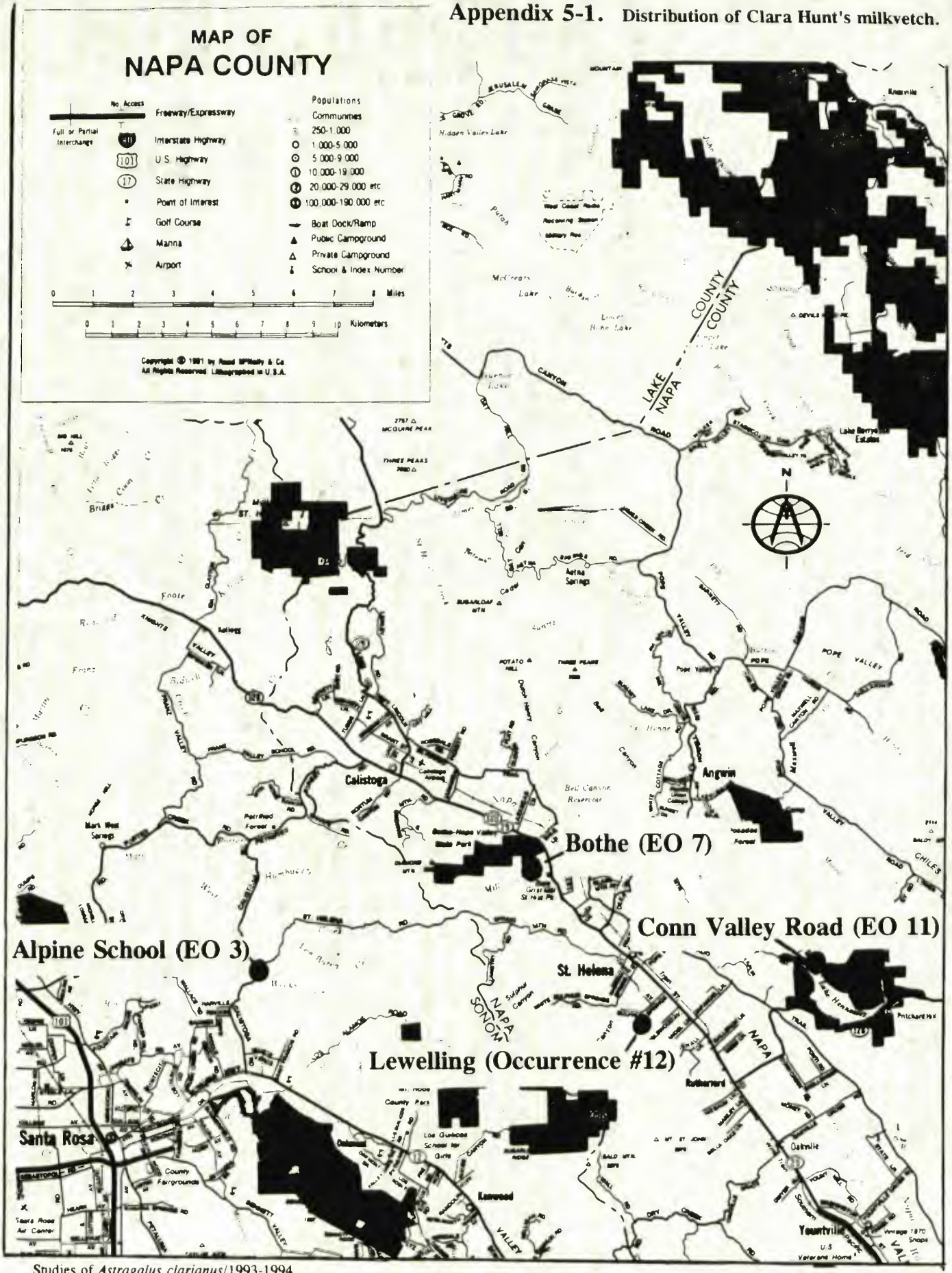
Parent material: mixed alluvium (?)

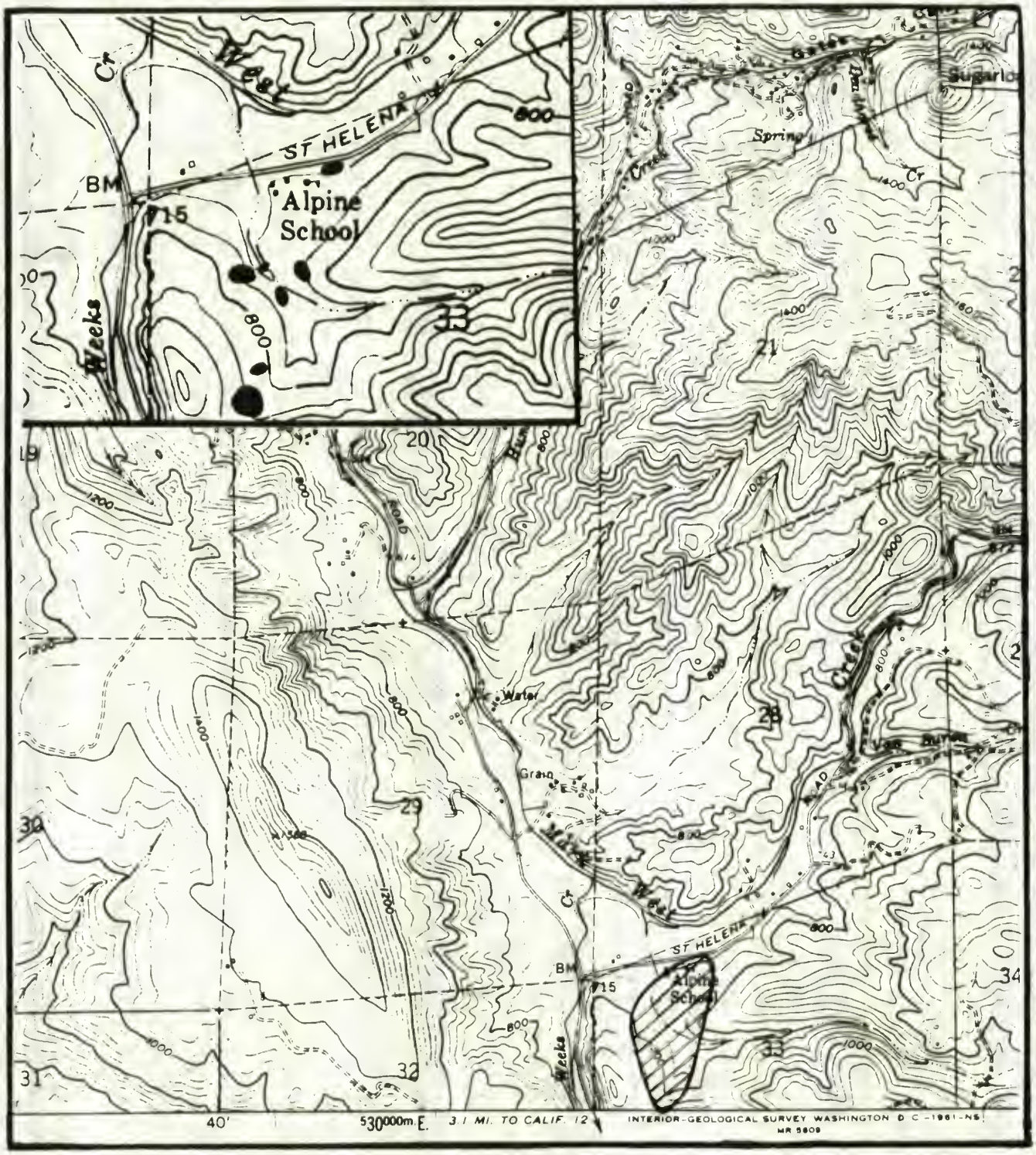
References:

Lambert, G. and J. Kashiwagi 1978. Soil Survey of Napa County, California. USDA Soil Conservation Service, in cooperation with the University of California Agricultural Experiment Station.

Miller, V.C. 1972. Soil Survey of Sonoma County, California. USDA Soil Conservation Service, in cooperation with the University of California Agricultural Experiment Station.

Appendix 5-1. Distribution of Clara Hunt's milkvetch.





Appendix 5-2. Alpine School (EO 3) 4-16-93

SCALE 1:24 000

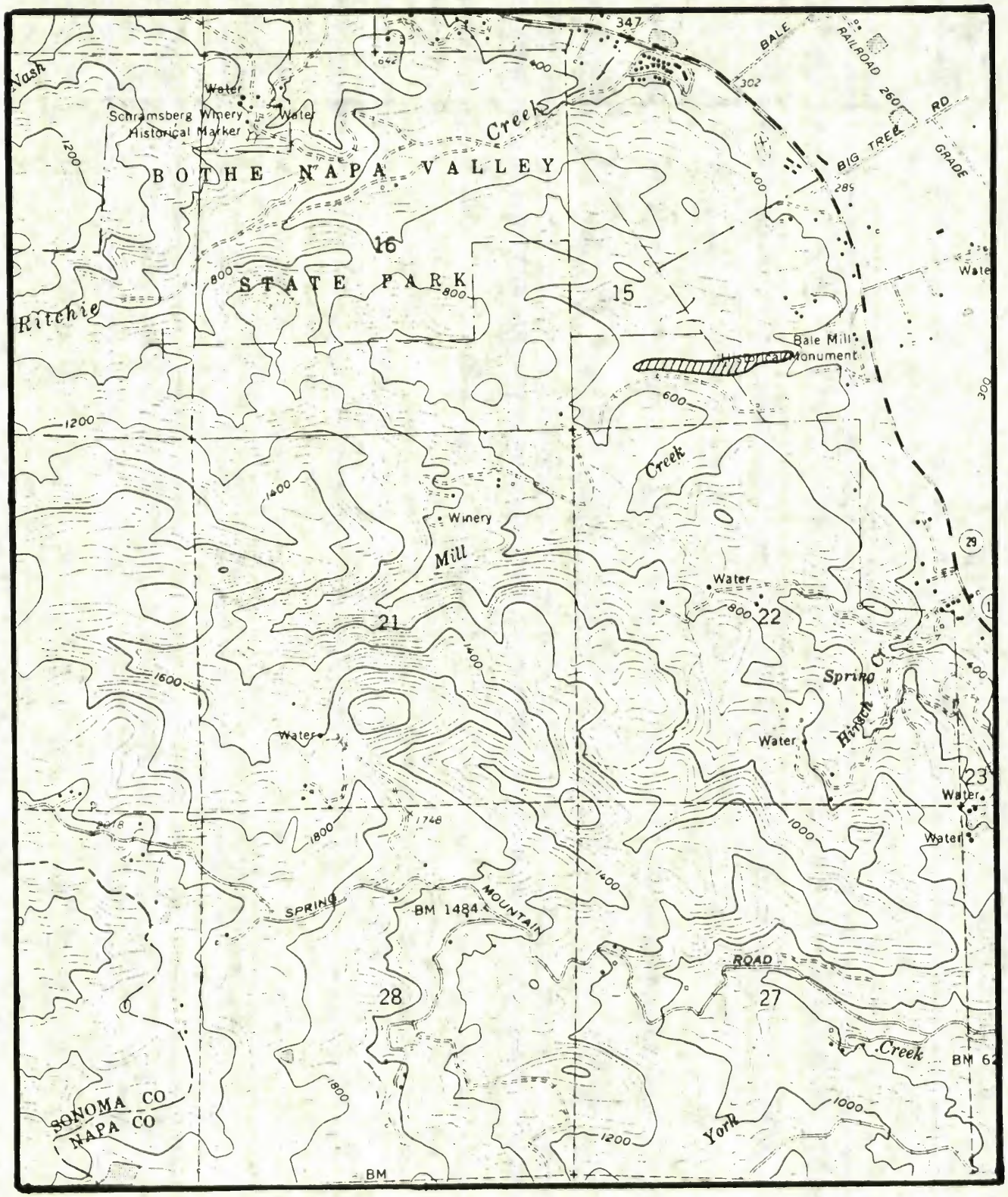
1 0 1000 0 1000 2000 3000 4000 5000

MARK WEST SPRINGS, CA

SW/4 CALISTOGA 15' QUADRANGLE

N3830—W12237.5/7.5

1958



Appendix 5-3. **Bothe (EO 7) 4-8-93**

SCALE 1:24 000

1 0 1/2

1000 0 1000 2000 3000 4000 5000

1 .5 0

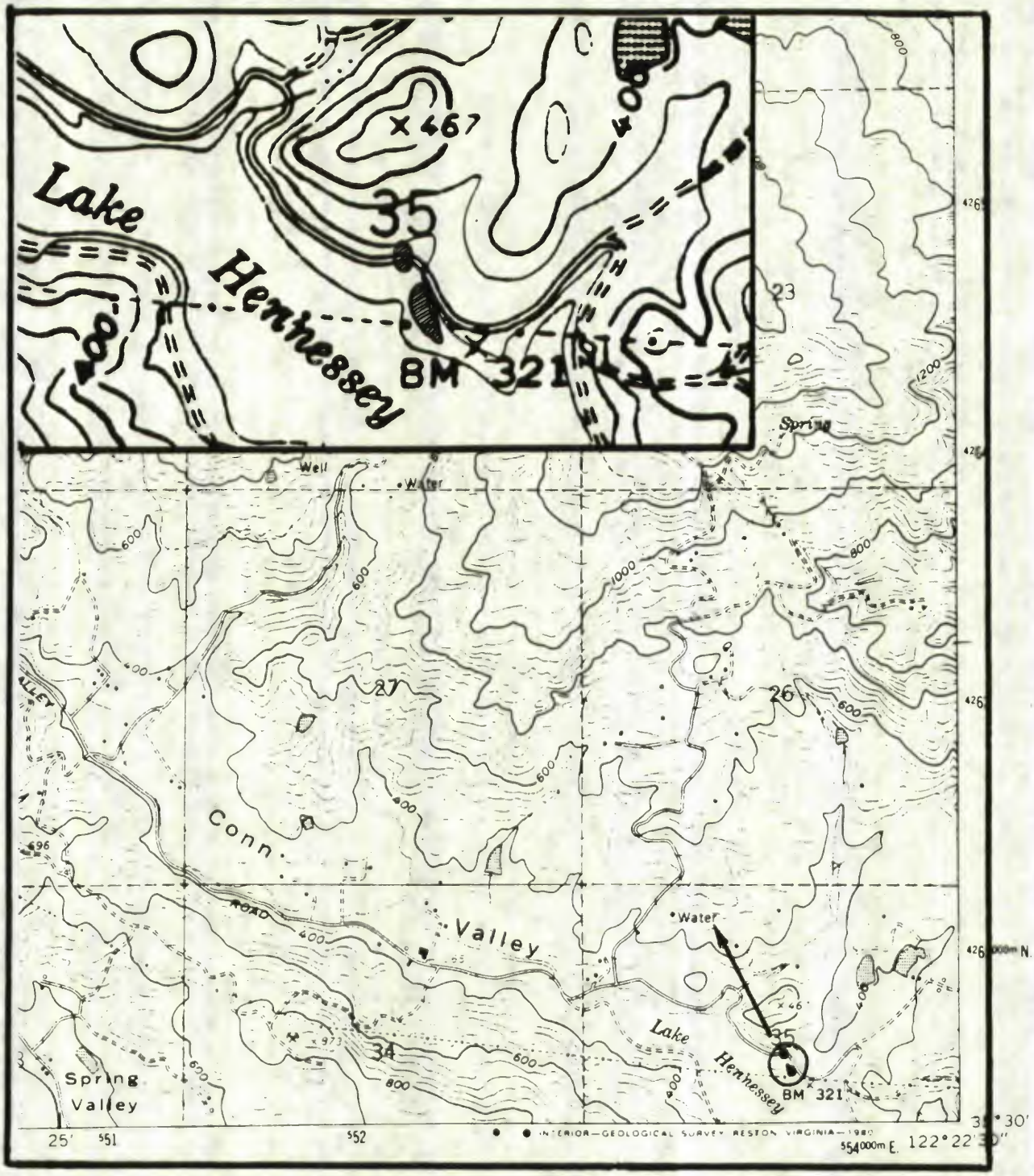
CALISTOGA, CALIF.

SE/4 CALISTOGA 15' QUADRANGLE

N3830—W12230/7.5

1958

AMS 1461 II SE—SERIES V895



Appendix 5-4. Conn Valley Road (EO 11) 4-1-93

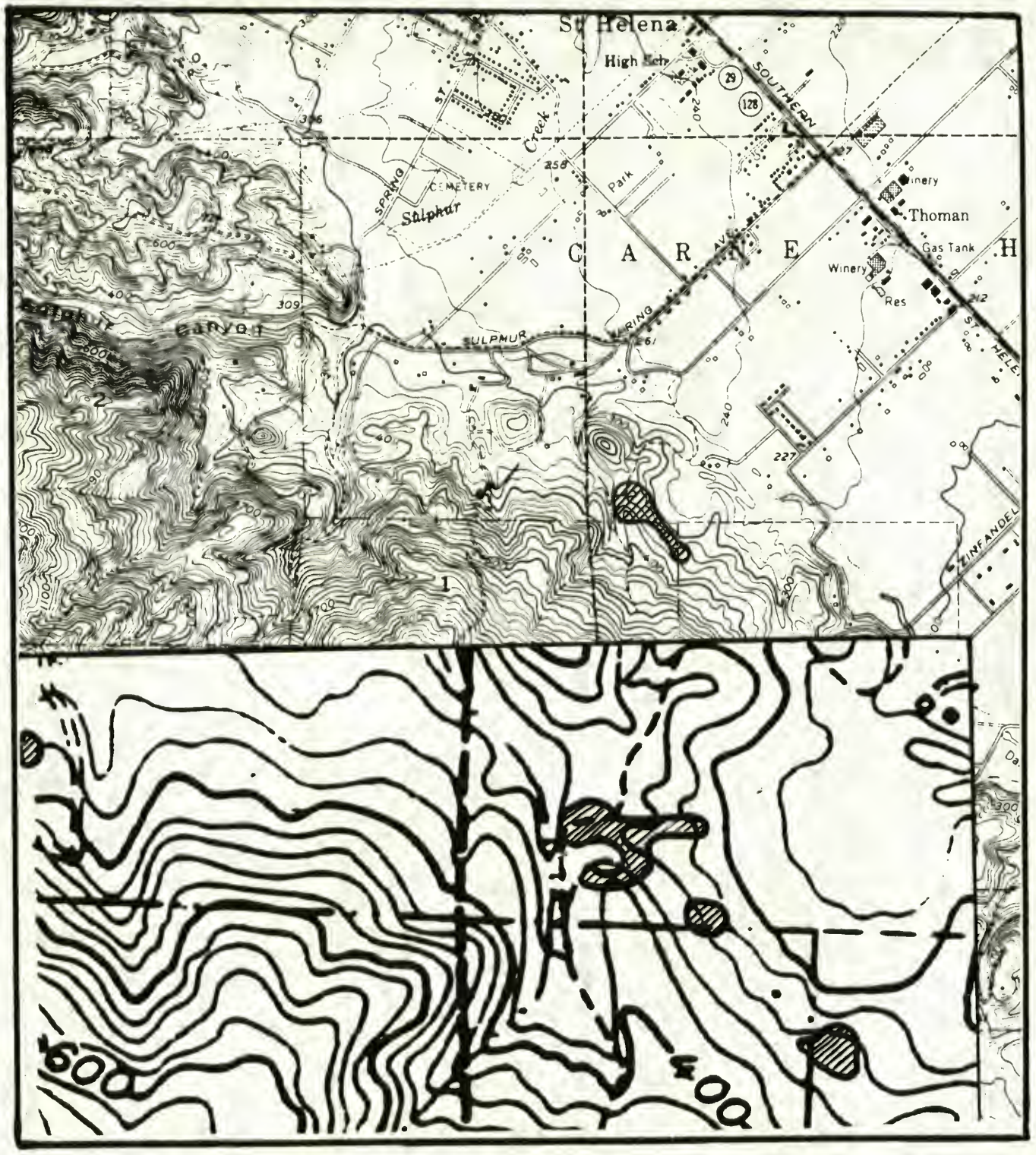
SCALE 1:24000

1000 0 1000 2000 3000 4000 5000

CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

ST. HELENA, CALIF.
SW/4 ST. HELENA 15' QUADRANGLE
N3830 – W12222.5/7.5

1960
PHOTOREVISED 1980



Appendix 5-5. Lewelling (Occ. 12) 4-10-93

SCALE 1:24000

1000 0 1000 2000 3000 4000 5000

CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

RUTHERFORD, CALIF.
NW/4 SONOMA 15' QUADRANGLE
N3822.5—W12222.5/7.5

1951
PHOTOREVISED 1968

Appendix 6.
Summary of *Astragalus clarianus* site searches.

EO #: 1 **Location Name:** St. Helena (Location not precisely described). This is the "type" locality. Geographic coordinates on NDDB summary report approx. Adams and Kearny St. **County:** Napa

Ownership: Unknown

First Reported: April, 1909

Habitat Description: "Field".

Elevation: 75 m (240 ft.) **Quadrangle:** St. Helena (presumed)

Major Associated Species: Not reported

Search History

Date	Reporter	# Patches	# Plants	Collected
4-1-1909*	Clara Adele Hunt	NR	"a mass"	Jeps./U.C.
4-19-1922	Mrs. D. O. Hunt (Clara)	NR	NR	CAS

Current Habitat Quality: Presumed destroyed; population extirpated. The city of St. Helena has expanded Hunt collections. Residential development is surrounded by agriculture (vineyard).

Occupied Habitat Area: Not reported

Knowledgable Persons:		Phone Number
Clara Hunt (deceased)		
Willis L. Jepson (deceased)		

Comments: Only two collections exist from this site. The type specimen was received (*) by W. L. Jepson on April 8, 1909 and is presumed to have been collected March 20 - April 1 and was marked "St. Helena". The second collection was marked "Near St. Helena". Manual of the Flowering Plants of California (Jepson, 1925) describes the habitat as "Rocky hillslopes, Napa Range"; Near St. Helena. This could describe EO 12.

EO #: 2 **Location Name:** Conn Schoolhouse, Conn Valley. The geographic coordinates on NDDB summary report gives location approx. .5 mi east of Rossi Rd. and 1 m west of L. Hennessey **County:** Napa

Ownership: unknown

First Reported: 1924

Habitat Description:

Elevation: 360 ft. **Quadrangle:** St. Helena

Major Associated Species:

Search History

Date	Reporter	# Patches	# Plants	Collected
1924	Milo Baker	NR	NR	Yes
4-19-1931	J. T. Howell	NR	NR	CAS

Current Habitat Quality: This site has been developed as orchard and is probably extirpated. (see below)

Occupied Habitat Area:

Knowledgable Persons:		Phone Number
Milo Baker (deceased)		
J. T. Howell		
Niall McCarten	consultant, research scientist, CH2M Hill	510-251-2426

Comments: This occurrence may be the same as EO 11. When Joe Callizo asked an old timer to point the site of the Conn Valley Schoolhouse, the man led him to the location of EO 11.

EO #: 3 Location Name: Alpine School, St. Helena Road.

County: Sonoma

Ownership: Wm. and C. O'Brien (private)

First Reported: April 19, 1931

Habitat Description: Woodland / Grassland mosaic dominated by Blue Oak with native and non-native grasses and forbs. Gradual to moderate slope on soil derived from volcanic parent material.

Elevation: 240-275 m (700-850 ft.) Quadrangle: Mark West Springs

Major Associated Species: Erodium botrys, E. cicutarium, Bromus hordeaceus, Dichelostemma pulchellum, Collinsia sparsiflora, Linanthus bicolor, Nasella pulchra, Trifolium depauperatum.

Search History

Date	Reporter	# Patches	# Plants	Collected
4-19-1931	John T. Howell	NR	NR	CAS
4-30-1954	R. C. Barneby	NR	NR	CAS
5-1985	Niall McCarten		Not Found	
4-16-1986	William T. Grummer	NR	17	PUC
3-19-1988	Grummer and Liston	NR	24	No
4-12-1990	Lynn Lozier	6	322	No
4-1992	Saxton Holt	7	4500	No
4-16-1993	Saxton Holt	7	2660	No
4-1994	Saxton Holt	8	994	No

Current Habitat Quality: Site in good condition. Being utilized to graze cattle.

Occupied Habitat Area: 900 m^2 (.2 acre)

Knowledgable Persons:		Phone Number
John T. Howell		
Aaron Liston	University of Oregon	503-737-5301
Lynn Lozier	The Nature Conservancy	415-777-0487
William Grummer	ranger, Bothe State Park	707-942-0136
Saxton Holt	volunteer, TNC, Landowner Protection Agreement	707-935-7788
Jake Ruygt	Napa, CA	707-253-1839

Comments: Grazing may play an important part in control of competing introduced grasses. This should be studied.

EO #: 7 **Location Name:** Bothe Napa Valley State Park, Old Bale Mill, north of Mill Creek.

County: Napa

Ownership: California Department of Parks and Recreation.

First Reported: 1980

Habitat Description: Blue Oak Woodland. Openings in woods with manzanita understory. Gradual slopes in soil formed from volcanic parent material.

Elevation: 130-185 m (400-580 ft.) **Quadrangle:** Calistoga

Major Associated Species: Erodium cicutarium, Linanthus bicolor, Lotus humistratus, Ranunculus occidentalis, Trifolium sp. and Nasella pulchra.

Search History

Date	Reporter	# Patches	# Plants	Collected
4-6-1980	William Grummer	NR	NR	PUC
4-5-1983	Grummer	2	120 (28)*	No
4-4-1984	Grummer	NR	142 (117)	No
4-3-1985	Grummer	NR	200 (161)	No
4-3-1986	Grummer	NR	53 (42)	No
4-2-1987	Grummer	NR	141 (64)	No
4-7-1988	Grummer	1	3	No
4-6-1989	Grummer	NR	110	No
4-5-1990	Grummer	NR	87	No
4-17-1991	Grummer	NR	11	No

Current Habitat Quality: Site in good condition but ageing woodland may be crowding out ASCL habitat by closing the canopy.

Occupied Habitat Area: 2,300 m^2 (.5 acre). Patches distributed in a 10 acre.

Knowledgable Persons:		Phone Number
William Grummer	park ranger, Bothe Napa Valley State Park	707-942-4575
Joe Callizo	CNPS, Napa Valley Chapter	707-965-2225
Jake Ruygt		707-253-1839
Aaron Liston	University of Oregon	503-737-5301
Niall McCarten	consultant, research scientist, CH2M Hill	510-251-2426
Ann Howald	Ecologist, Department of Fish and Game, Region 3	707-944-5529
Lynn Lozier	The Nature Conservancy	415-777-0487

Comments: This site is monitored by Mr. Grummer annually under the California Native plant Society's "Annual Plant Watch" activity. A quadrat has been established for this purpose. Site is protected.

* Numbers in parenthesis represent plants counted in a 3 m X 16 m quadrat at Bothe annually.

EO #: 7 (page 2) **Location Name:** Bothe Napa Valley State Park, Old Bale Mill

Search History

Date	Reporter	# Patches	# Plants	Collected
1992	Grummer, Howald	NR	34 (200),	No
4-8-1993	Grummer, Ruygt	NR	101 (12)	No
4-12-1994	Grummer, Ruygt, Howald and Mack	NR	7	No

EO #: 11 **Location Name:** Conn Valley Road, north side of Lake Hennessey. Conn Valley Schoolhouse.

County: Napa

Ownership: City of Napa, part in private ownership (Wilcox).

First Reported: 1984 , possibly same site as EO 02, 4-19-1931 (Howell #6442)

Habitat Description: Grassland at edge of Gray Pine Woodland, soil derived from serpentine parent material.

Elevation: 100-105 m (310-325 ft.) **Quadrangle:** St. Helena

Major Associated Species: Chlorogalum pomeridianum, Nasella pulchra, Linanthus bicolor, Lotus wrangelianus, Evax sparsiflora, Lasthenia californica, Lomatium utriculatum

Search History

Date	Reporter	# Patches	# Plants	Collected
3-21-1984	William Grummer	NR		Yes (PUC)
4-8-1984	Joe Callizo	2		Yes (PUC)
4-4-1985	Grummer	2	200	No
3-27-1986	Grummer	2	350	No
1987?	Aaron Liston ?			
3-19-1988	Liston		81	No
3-25-1989	Grummer	2	200	No
12-16-1990	Callizo (site disturbance)		0	
3-28-1991	Grummer, Morey, Callizo	2	10	No
3-28-1992	J. Ruygt, L. LeMaster	NR	325	No

Current Habitat Quality: Site disturbed in fall of 1989 by placement of topsoil stockpile measuring 200 ft. by 100 ft. and 10 ft. high. Most of stockpile was removed in 1990 through agreement between City of Napa, California Department of Fish and Game and private topsoil operators. Good recovery in 1992 reversed by weed invasion in 1993.

Occupied Habitat Area: 1,600 m^2 (.35 acre)

Knowledgable Persons:		Phone Number
William Grummer	Park ranger, Bothe Napa Valley State Park	707-942-4575
Joe Callizo	California Native Plant Society	707-965-2225
Sandra Morey	DFG, Natural Heritage Program	916-227-2309
Ann Howald	Plant Ecologist, DFG, Region 3	707-944-5529
Jake Ruygt		707-253-1839
Lucinda LeMaster	California Native Plant Society, Deer Park	707-963-9141
Aaron Liston	University of Oregon	503-737-5301
Don Ridenhour	City of Napa Public Works Department	707-257-9522

Comments: Site protected from vehicles by fenceing. City of Napa may consider raising dam at Lake Hennessey which would inundate most/all of this site.

EO #: 11 (page 2) **Location Name:** Conn Valley Road, north side of Lake Hennessey

Search History

Date	Reporter	# Patches	# Plants	Collected
4-1-1993	Ruygt, LaBarbera, Wickler	1	156	No
4-12-1994	Ruygt, Howald, Mack	1	9	No

EO #: 12 **Location Name:** Lewelling Ranch, Sulphur Springs Road, St. Helena

County: Napa

Ownership: private (Lewelling, Christian Brothers)

First Reported: April 1991 (seen by Alan Wight 1990, unreported)

Habitat Description: Mixed Woodland with Coast Live Oak, Valley Oak, Gray Pine, Ponderosa Pine, Douglas Fir with brushy understory of Toyon and Leather Oak.

Elevation: 300-360 ft. (95-115 m.) **Quadrangle:** Rutherford

Major Associated Species: Nasella pulchra, Plantago erecta, Dichelostemma pulchellum, Lomatium dasycarpum, Collinsia sparsiflora, Linathus bicolor, Agoseris heterophylla, Chlorogalum pomeridianum

Search History

Date	Reporter	# Patches	# Plants	Collected
4-12-1991	W. Grummer, S. Morey, J. Callizo		15	No
4-4-1992	Grummer, A. Wight, J. Ruygt		450	No
4-7-1993	Ruygt, LaBarbera, Leblanc, Giusto	4	2,238	No
4-5-1994	Ruygt, Howald, Steeck, McGuire	3*	6,192	Yes

Current Habitat Quality: Site in excellent condition at time of 1994 census: small part of habitat is grazed by cattle; majority of site is excluded from cattle. Pig rooting disturbed over 50 % of habitat in early June, 1994.

Occupied Habitat Area: 3,700 m^2 (.8 acre)

Knowledgable Persons:

		Phone Number
William Grummer	park ranger, Bothe Napa Valley State Park	707-942-4575
Alan Wight	member of Lewelling family, Lewelling Lane, St. Helena	707-763-8572
Jake Ruygt		707-253-1839
Sandra Morey	DFG, Natural Heritage Program	916-227-2309
Joe Callizo	California Native Plant Society	707-965-2225
Ann Howald	plant ecologist, DFG, Region 3	707-944-5529
Diane Steeck	Drought Contract Administrator, The Nature Conservancy	916-227-2313

Comments: Ranch managed by Doug Wight. A 1993 application to construct reservoir near ASCL population is being negotiated. This site is near St. Helena and on "rocky hillslopes" and potentially part of or near to the "type" locality.

* One subpopulation on Christian Brother's property, not censused in 1994. Site is unprotected. Owner willing to protect.

EO# 4 **Location:** Walter Springs, approximately 3.5 miles west of Lake Berryessa, Napa Co.

County: Napa

Comments: Plants collected from this location are Astragalus rattanii ssp. jepsonianus.

EO# 5 **Location:** 3 mi. east of Middletown, south side Butts Canyon Road, Lake Co.

County: Lake

Comments: Plants collected from this location are Astragalus rattanii ssp. jepsonianus.

EO# 6 **Location:** 3.9 mi. east of Middletown, serpentine hill.

County: Lake

Comments: Plants collected from this location are Astragalus rattanii ssp. jepsonianus.

EO# 8 **Location:** 1.3 mi. WNW of Knoxville.

County: Napa

Comments: Plants at this site are Astragalus rattanii ssp. jepsonianus.

EO# 9 **Location:** 2 mi. north of Knoxville on road to Lower Lake

County: Napa

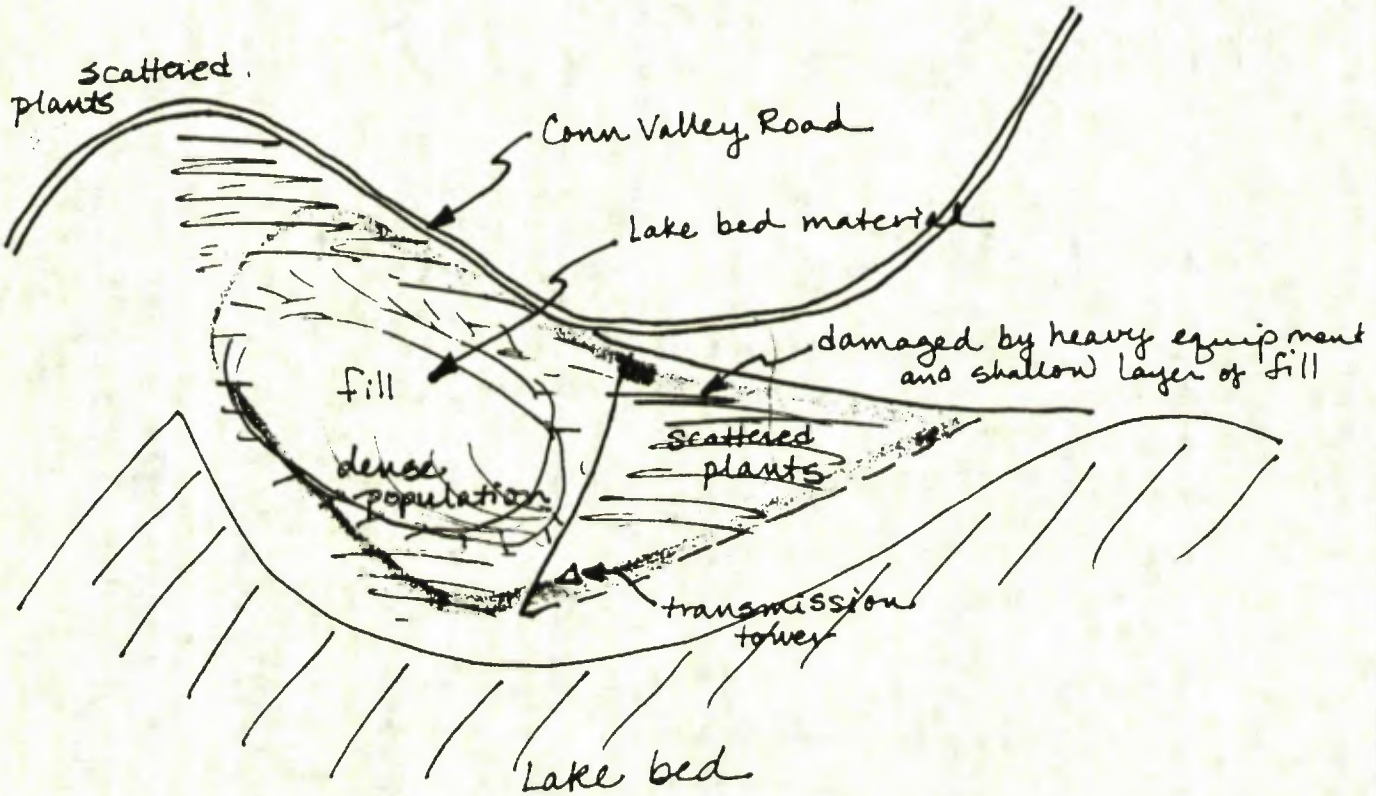
Comments: Last seen in 1936. Probable misidentification; Astragalus rattanii ssp. jepsonianus less than 1 mile from this site.

EO# 10 **Location:** near Zim-Zim Creek, 1 mile east of Devilhead Road.

County: Napa

Comments: Erroneous report according to California Native Plant Society (1981)

Appendix 7. Map of Conn Valley Road disturbance.



from Bill Grummer's 4/85 map
w/ Roxanne Bittman's 4/89 note

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