SHORT-TERM EFFECTS OF FIRE

ON WILD BLUE LUPINE (*Lupinus perennis perennis*)

IN THE ALBANY PINE BUSH PRESERVE

ALBANY, NEW YORK

Initial Draft Prepared by:
Beth Bidwell, Stephanie Gebauer-Gifford, and Amy Rudich
Albany Pine Bush Preserve Commission

Finalized by:
Neil A. Gifford, Preserve Ecologist
Albany Pine Bush Preserve Commission
108 Wade Road
Latham, NY 12110

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Thank you to everyone who participated in this ongoing investigation of fire effects on wild blue lupine in the Albany Pine Bush Preserve.

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INTRODUCTION

As the only known larval food plant of the federally-endangered Karner blue butterfly (*Lycaeides melissa samuelis),* wild blue lupine (*Lupinus perennis*) is critical to the butterfly's survival. Several studies (Smallidge and Leopold 1992; Boyonoski 1992) have suggested that lupine presence, density, and abundance are associated with relatively low canopy cover levels. Fire suppression over the past fifty years has resulted in increased canopy cover and has been suggested as one of the primary causes for the observed decline in the abundance of wild blue lupine in the Albany Pine Bush (Zaremba et al. 1991; Givnish et al. 1988). Because fire reduces the canopy cover of tall, woody plant species, prescribed burning may be an important management tool for enhancing and maintaining Karner blue butterfly habitat.

The historical role of fire in the Albany Pine Bush in creating and maintaining conditions favorable for lupine growth and reproduction suggests that fire may also have a positive effect on releasing dormant lupine plants and perhaps ungerminated seeds, allowing for the expansion of existing populations. In the spring of 1991, The Albany Pine Bush Preserve Commission conducted the first controlled burn in the Albany Pine Bush Preserve. Lupine was observed following prescribed burns in several areas not known to previously contain lupine. Whether these newly observed plants resulted from conditions created by the fire or were existing plants that had gone unnoticed before the burns is uncertain. Understanding the effects of fire on wild blue lupine in the Albany Pine Bush is a very important step in determining the feasibility of fire as a primary management tool and in formulating an effective plan for recovering the Karner blue butterfly to meet minimum viability criteria as determined by the New York State Karner Blue Recovery Team (Zaremba and O'Brien, 1996). If it is determined that fire cannot be used as a primary tool for enhancing and maintaining wild blue lupine, than other management practices must be explored in order to establish and expand suitable Karner blue habitat.

OBJECTIVES

The purpose of this study is to determine the effects of fire on the establishment and maintenance of three wild blue lupine populations located within the Albany Pine Bush Preserve and to explore potential relationships between lupine population condition and the composition and structure of the surrounding plant community. Specifically, this report will investigate:

1) changes in lupine vigor,
2) effects of fire on lupine reproduction,
3) changes in plant community composition and structure.

This report summarizes differences in pre-burn and one and two year post-burn lupine population and plant community status. However, in order to determine any meaningful effects of fire, data for several years following fire is necessary. Pending available resources, the Albany Pine Bush Preserve Commission anticipates continuing this study for at least five years following the first treatment of each site with fire.

Additionally, a study being conducted by SUNY-ESF in cooperation with Niagara Mohawk (Hudson, in prep.; Leopold, et al., 1993) will provide a comprehensive analysis of the data collected for this study to compare the effects of fire and several Powerline-Right-Of-Way management techniques on unoccupied Karner blue habitat. The SUNY-ESF study will provide recommendations regarding the most effective management practices for enhancing the size and vigor of wild blue lupine populations. The SUNY-ESF study is expected to be completed by the year 2003 (Leopold, et al., 1993).

METHODS

Study site selection

To determine the effects of prescribed burning on wild blue lupine, three lupine populations were sampled. These three represent the three largest, undisturbed, and unoccupied (by Karner blue butterflies) lupine populations in the Albany Pine Bush. Each site was sampled during the summer of 1995, 1996 and again in 1997. All three sites were subject to a prescribed burn during the spring of 1996. These sites, Willow Street Sandpit, Old State Road Sandpit, and Karner Barrens East are located in the Town of Guilderland and the city of Albany, respectively (Appendix A contains a map of these locations). These sites have not been subjected to a controlled burn or exposed to a wildfire, or otherwise disturbed within the past 15-20 years.

The wildfire history of the sites is not well known. Time since fire was estimated by knowledge about wildfire history within the Albany Pine Bush (Zaremba et al., 1991), age of pitch pine regeneration that likely resulted from previous disturbance and estimating the age of available firescars. Using this information, the following deductions about each site were made:

1) it is likely that the Karner Barrens East population last burned during the 1981 wildfire that swept through much of this region.
2) based on the age of pitch pine regeneration at the Old State Road population, this site likely last experienced fire or other forms of disturbance over 15 years ago.
3) evidence of recent fires at the Willow Street Sandpit population are absent, suggesting that this population has not experienced fire for at least 20 years.
4) since none of these three populations experienced fire or other forms of disturbance for at least 15-20 years before the inception of this study, it is unlikely that disturbance history will influence the response of lupine to a controlled burn.

Each site was sampled during the summer of 1995 to collect pre-treatment data and again in 1996 and 1997 after each site had burned.

Study design

Within each lupine population, a rectangular plot was located to include a majority of the lupine plants. Plot width was fixed at 20 meters, while plot length was determined by the maximum extent of the lupine population. The baseline was determined as the long axis of the plot and represented the line from which all sampling transects originated. Transects were set perpendicular to the baseline and were as long as the plot width (20m). Transect spacing varied depending on the type of data being collected. To sample a representative number of lupine clumps, population data transects were spaced according to lupine population density and were consistently spaced within any given plot. For example, at a sparsely populated site, transects would be spaced a minimum of 1m apart while at a densely populated site, transects would be spaced a maximum of 5m apart. The minimum number of lupine clumps to be sampled at a site was set at 10 and the transect spacing was determined to meet or exceed this goal. At the three populations sampled within the Albany Pine Bush, the lupine was relatively sparse, so population data was collected along transects spaced 1m apart. The number of transects sampled within a plot varied depending on plot length; within the Albany Pine Bush the number of transects sampled was either 20 or 30. Data collected along these population transects will be used to determine lupine clump vigor and wild blue lupine reproduction.

Community data transects were also established perpendicular to the baseline and were as long as the plot was wide. Community data transects were spaced 10m apart within each of the plots with two additional transects located 10m outside the plot (one on either end of the plot). The transects located outside the plot will provide important data when and if the lupine populations expand beyond their current location. The number of community data transects within a plot varied depending on the plot length, and within the Albany Pine Bush was either 6 or 7.

Two 5m x 5m subplots were located along each community data transect. From the baseline, each subplot was located at 2.5m and 12.5 with its right side along the transect. One 5m

x 5m subplot was sampled on each transect; sampling at 2.5m from the baseline on the first transect, and 12.5m from the baseline on the next transect. The data from these subplots was used to estimated canopy cover at the site.

Four 1m x 1m quadrats were located in each corner of each 5 m x 5 m subplot. The data from these quadrats was used to characterize the herbaceous vegetation of the site.

To assist in relocating the sites, plots, transects, subplots, and quadrats, a permanent stake (rebar) was set at each site. A sketch of each site includes a description of the rebar, plot, subplot, and quadrat locations. See Appendix B for maps of each site.

Sampling methods

Two types of data, lupine population data and plant community data, were collected at each site during the summers of 1995, 1996, and 1997.

Population data

Population data was collected to record various lupine morphological characteristics and several characteristics of the microsite around each the lupine clump. The data collected from each intercepted clump of lupine included: transect number, distance to baseline, intercept length, clump length, clump width, height of the tallest stem, number of lupine stems, number of flowering/fruiting stems, number of lupine germinates, percent bare ground, percent nonvascular and vascular cover, and percent lupine cover. The number of lupine germinates, percent bare ground, percent nonvascular and vascular cover, and percent lupine cover, were recorded for the area with the "dripline" of the clump foliage. All of the data was collected on standard data sheets (Appendix C). A lupine clump was defined as any group of lupine stems within 10 centimeters (cm) of each other at soil level, but greater than 10 cm from any adjacent stem. Only lupine clumps intercepted by a transect were sampled.

The first three parameters: transect number, distance to baseline, and intercept length, serve to relocate clumps for annual measurements. The height of the tallest stem, the number of lupine stems, and the number of flowering/fruiting lupine stems, measure vegetative reproduction and clump vigor. The number of lupine germinates provides a measure of sexual reproduction. The percent cover parameters describe clump microsite conditions, which are both favorable and unfavorable to clump vigor and reproduction.

Community data

Plant community data was used to evaluate the effect of fire on each species observed and to investigate plant community relationships, e.g. which species are positively and negatively associated with lupine.

Total percent woody cover was estimated for each 5m x 5m subplot. All woody stems within and outside the subplot that shaded the subplot and were 1cm or greater in diameter at breast height were included in this estimation. The number of stems was recorded by species for those stems located within the subplot.

Percent cover was recorded to characterize the herbaceous vegetation at each of the four quadrats within a subplot. Within each quadrat, the percent cover of each species present was recorded. Coverage of each species within a quadrat was estimated to the nearest 1 percent if total cover was less than 5 percent, and to the nearest 5 percent if total cover was estimated to be more than 5 percent. Woody species with a diameter of less than 1 cm at breast height were treated like herbaceous vegetation and assigned cover estimates by species for the quadrat. If lupine was present within a subplot, the number of stems was recorded. Community data was recorded on a standard "Community data" sheet (Appendix D).

Data Analyses

The response of wild blue lupine, microsite and plant community characteristics to controlled burning were evaluated by determining percent change for each variable before and after the controlled burn. For community data importance values for each species were

calculated. Changes in plant community species richness at each site will be used to evaluate changes in plant community composition. Changes in importance values for overstory and herbaceous species at each site will be used to evaluate changes in plant community structure.

RESULTS

Population data

The number of lupine clumps measured after one season following the spring burns decreased at the Willow street sandpit site and slightly increased at the Old State Road sandpit and Karner barrens east sites as compared to the number of clumps counted before the burns. The number of clumps measured at the Willow Street and Old State Road sites decreased after two seasons following the spring burns. Lupine population data was not collected at Karner barrens site in 1997 due to limited available resources prior to lupine senescence. All sites showed an increase in the average clump length and width, the average height of the tallest stem, and the average number of stems following the prescribed burns, except the Old State Rd. site which showed a slight decrease in the average height of the tallest stem. After two seasons following the prescribed burns the average clump length and width, and average height of the tallest stem increased slightly when compared to pre-burn data at the Willow Street and Old State Road sites. The average total number of stems counted two seasons following prescribed burns decreased at the Old State Road site, and slightly increased at the Willow Street site when compared to pre-burn data. At all sites, the number of flowering stems and the number of germinates was about zero both before and after the controlled burns.

At all three sites, percent bare ground and percent lupine increased during the 1996 growing season, while percent vascular species and non-vascular species decreased. 1997 data illustrate a decrease in the percent bare ground at the Old State Road site when compared to 1995 (-4%) and 1996 (-26%) data. Percent bare ground at the Willow Street site increased slightly in 1997 (+4%).

COMMUNITY DATA

Pre- and post-burn plant species composition and structure, were analyzed at all the three sites. Canopy and groundcover plant community composition and structure varied between the three sites before and following the prescribed fires.

Average percent canopy cover declined at all sites when compared to pre-burn data. Pre-burn, average percent canopy cover was 75% at the Willow Street, 58% at the Old State Road site, and 57% at the Karner barrens east site. Second year post-burn average canopy cover was 54% at the Willow Street Sandpit, 46% at the Karner barrens east site, and 35% at the Old State Road site. While the Karner barren east site did show a slight increase in percent canopy cover in the first post-burn growing season (from 57% to 60%), it was followed by a fairly large decrease the second year following the fire (from 60% to 46%).

Overstory species richness and composition varied between the three sites, and among years following prescribed fire. Pre-burn overstory species richness values were three at the Karner barren east site, five at the Old State Road site, and ten at the Willow Street sandpit site. At the Willow Street site species richness declined each year following the fire, with eight species observed in 1996, and six species observed in 1997. Similarly, species richness showed an overall decline at the Old State Road site two years following the fire, but increased from three to four species in 1997. Species richness increased at the Karner barrens east site, with three, five, and four species observed in 1995, 1996 and 1997, respectively. The increase at the Karner barrens east site was due to the presence of *Populus tremuloides* an *P. grandidenta* in 1996, and *Quercus rubra* in 1997. (It is likely that *P. tremuloides* and *P. grandidentata* sprouted from parent individuals located outside of the plot.)

Overstory structure also varied at each site. All three sites supported, *Pinus rigida* and *Quercus ilicifolia* both before and after the controlled burns. The importance values for these and other overstory species varied, however, at each site following the prescribed burns. *Pinus rigida,* and *Quercus ilicifolia* were the most important overstory species before and after the

controlled burns at the Karner barrens and Old State Road sites. Pre-burn importance values were higher for *Quercus ilicifolia* at the Karner barrens site and *Pinus rigida* at the Old State Road site. At the Willow Street Sandpit *Robinia pseudo-acacia* showed the highest pre-burn importance value (55.08). *Quercus ilicifolia and Pinus rigida showed* the fifth and seventh highest importance values of the ten species recorded in 1995 at the Willow Street site.

First year post-burn data at Willow Street showed *Pinus rigida* with the highest importance value (43.49) of eight species recorded. (This was likely a result of fire top-killing other canopy species, reducing their relative frequency and relative dominance at the site.) *R. pseudo-acacia* and *Q. ilicifolia* showed the third and fourth highest importance values for the same year. Second year post-burn data showed *Populus* grandidentata with the highest importance value (67.50). *P. grandidentata* showed the third highest importance value in 1995 and the second highest value in 1996.

Understory species composition and structure also varied between the three sites and within each site following the prescribed burns of 1996. The total number of associated plant species varied from 24 to 41 for the three sites before the controlled burns and from 20 to 39 after the burns. As in Grigore (1992), no trends in diversity between the sites before or after the burns were observed. *Aster linariifolius, Corylus americana, Uvularia perfoliata, Prunus virginiana,* and *Melampyrum lineare,* which were present in at least two out of the three sites before the burns, were absent from all three sites following the burns in 1996. Each of these species except *M. lineare* and *P. virginiana* were present in 1997. *Schizachyrium scoparium, Carex pensylvanica, Panicum spp., Urtica dioica, Monotropa uniflora,* and *Andropogon gerardii,* which were absent from all three sites before the burns, were present in at least two out of three sites following the fires.

Several species that were absent before the burns, were recorded at one of the sites following the burns. *Asclepias tuberosa* which was absent from all sites before and immediately following the burns, had the 15th highest importance value two years following the burn at the

Karner barrens east site. *Kalmia angustifolia* was recorded in 1997 at the Old State Road site, but was absent from all sites before the burns. *Vaccinium* spp., *Quercus alba*, and *Chimaphila umbellata*, were also recorded following the fire at the Willow Street site.

DISCUSSION

With only two years of post-burn data, it is inappropriate to identify trends in species composition and structure following the prescribed burns . However, an increase in the average lupine clump length and width, the average height of the tallest stem, and the average number of stems at all sites following the prescribed burns would suggest that clump vigor has improved. These results coupled with an increase in percent bareground and percent lupine and a decrease in percent vascular species and non-vascular species suggests that fire creates a macrosite more favorable for lupine growth. This is probably due to a decrease in interspecific competition and leaf litter, and an increase in available resources. Boyonoski (1992) concluded that treatments that remove litter cover and eliminate competing herbaceous vegetation, such as fire, promote seedling establishment. This data seems to support Boyonoski's conclusion.

With the number of flowering stems and germinates near zero at all sites (both pre- and post-burn), little was discovered about the effects of fire on reproductive success. Grigore (1992) found that lupine at burned sites produced significantly more seed pods and the flowering stems set more seed than lupine at unburned sites. However, she was not able to determine whether fire had a significant effect on the total number of flowering stems during the first growing season following a fire at a previously unburned lupine site. More data is needed to accurately assess lupine reproduction following fire in the Albany Pine Bush.

Upon analyzing the pre- and post-burn plant species present at the three sites, no trends in diversity between the sites were observed. More data would be helpful in evaluating each species response to fire, in determining which species are positively and negatively associated

with lupine, in characterizing the herbaceous vegetation of the site, and in identifying trends in diversity between the sites.

Finally, when considering fire as a tool for managing lupine, the timing of the burns is crucial. Grigore (1992) found that fire adversely affected recruitment in a lupine population by killing seeds on the soil surface and by killing newly germinated seeds. In order for lupine to benefit from the effects of fire, the controlled burns must be conducted in the spring, before the seedlings emerge. Grigore also suggests burning every other year instead of annually in order to minimize fire damage to seeds and seedlings. Although prescribed burning is probably an important management tool for enhancing and maintaining Karner blue butterfly habitat, it may be beneficial to use it in conjunction with other management practices.

CONCLUSION

While Fire/Weather Observation data sheets (Appendix G) show that fire behavior for all three 1996 controlled research burns were of low intensity, these fires had a positive effect on lupine and the surrounding plants communities. Each site is slated for another prescribed fire in 1998. Studying the cumulative short- and long-term affects of prescribed fire on these sites will aid in determining the effectiveness of prescribed fire as a tool to maintain, expand, and restore Karner blue butterfly habitat in the Albany Pine Bush, and throughout the Glacial Lake Albany Karner blue butterfly Recovery Unit.

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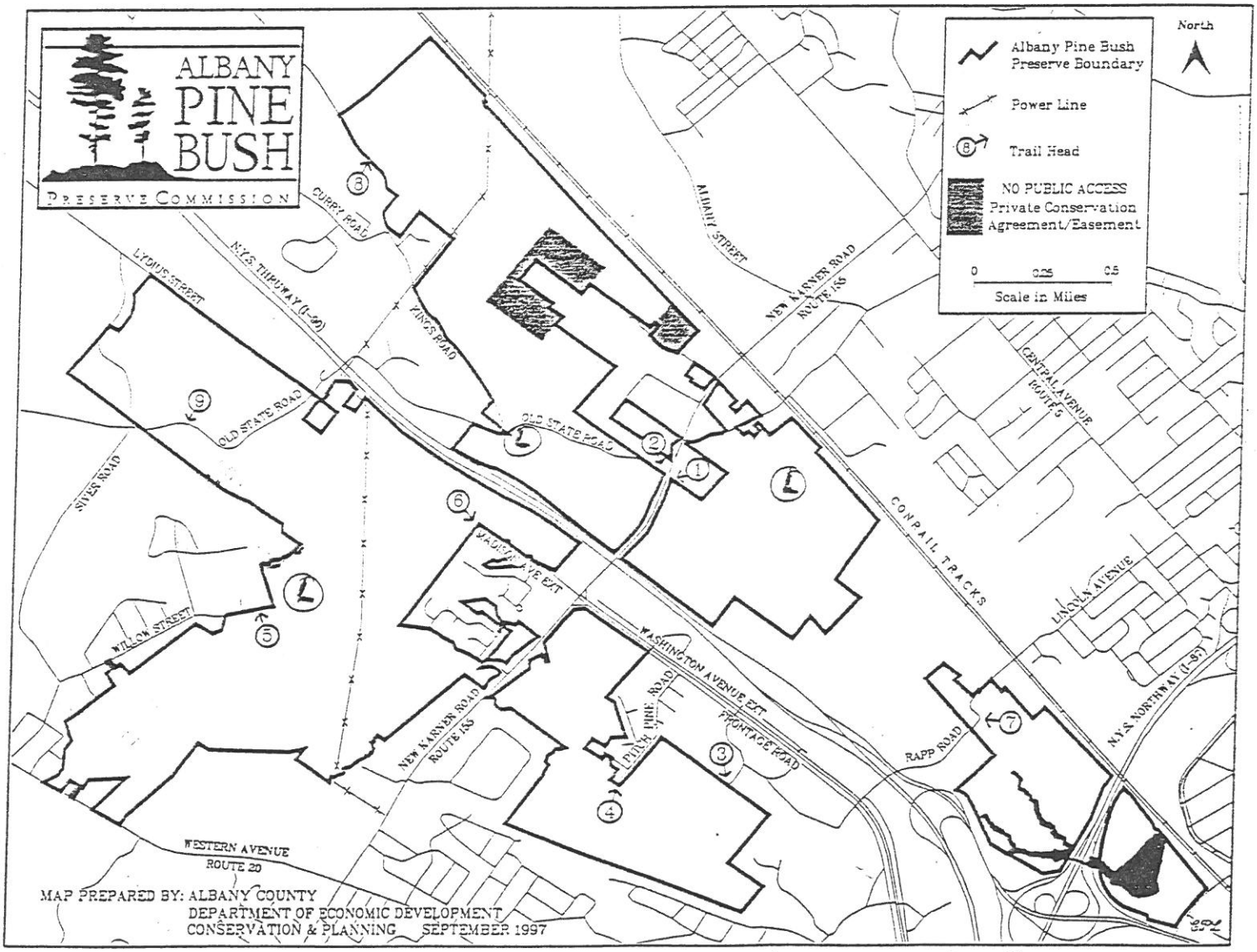
APPENDIX A. MAP OF THE ALBANY PINE BUSH PRESERVE WITH STUDY SITES



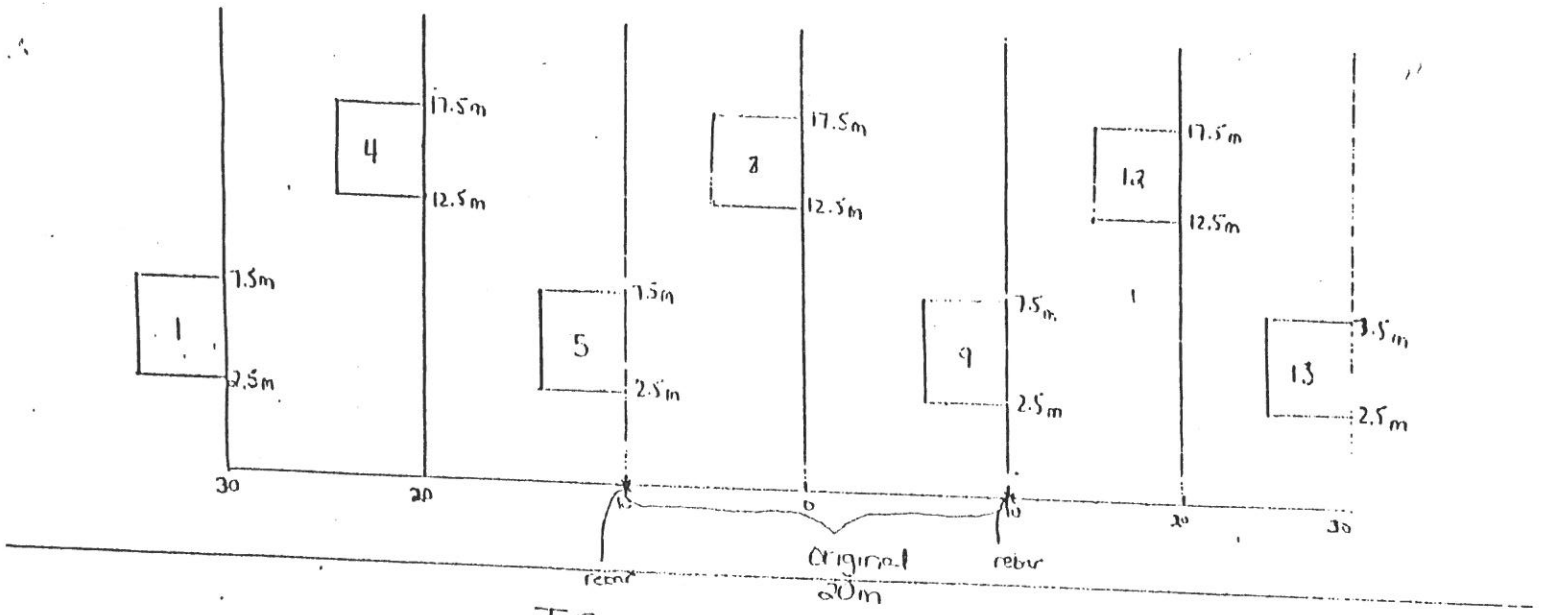
L = Lupine study site

APPENDIX B. MAPS OF EACH STUDY SITE

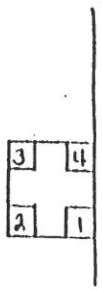
KARNER BARRENS EAST

Community Data Map

5m x 5m placement



1m x 1m placement



Clump Data Sheet

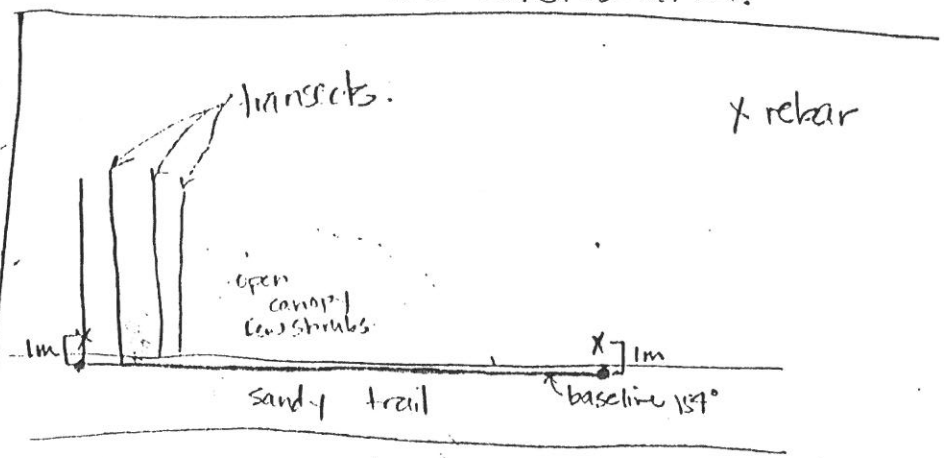
Location KBE | Date 7/12/15 | Row Width (m) NA | Path Width (m) NA | Interval Width (m) 1m

Recorder Bronson Gebauer Gifford | Row Bearing NA | P/T# | to P/T# | Transect Starts at the SW Corner of the Block

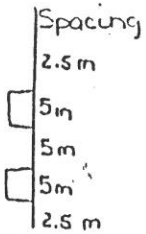
Clump #	0-1	2-1	2-2	3-1	3-2		4-1	5-1	5-2	6-1	8-1	8-2		9-1	13-1	13-2	14-1	14-2	14-3	17-1	18-1	19-1									
Dist. to Baseline (m)	0.8	5.2	5.6	0.9	3.7		2.9	11.1	5.4	5.1	3.0	4		8.3	3.1	3.9	4.6	4.9	5.3	4.4	0.8	4.4									
Intercept Length (cm)	20	41	41	3	2		10	3	4	1	10	1		4	7	8	3	41	6	9	10	2									
Length (cm)	21	7	7	8	12		18	42	10	19	21	18		14	22	14	18	19	14	17	13	10									
Width (cm)	15	3	5	10	11		7	17	3	7	20	13		13	19	8	8	7	9	10	10	5									
Height (cm)	11	15	3	3	14		19	31	9	14	28	12		15	14	12	5	20	13	12	17	8									
Total # of Stems	2	1	1	1	1		2	2	1	1	3	1		2	2	2	9	2	2	1	1	2									
# of Fl. Stems	0	0	0	0	0		0	1	0	1	2	10		0	0	0	6	1	0	0	0	0									
# of Germinates	0	0	0	0	0		0	0	0	0	0	0		0	0	0	0	0	0	0	0	0									
% Bare Ground	5	0	0	0	0		0	0	0	0	50	6		0	0	0	0	0	0	0	0	0									
% Non-Vascular	0	0	0	5	0		0	0	0	0	0	0		0	0	0	0	0	0	0	0	0									
% Vascular	15	50	10	10	10		10	40	5	10	10	50		30	30	15	50	20	30	10	10	15									
% Lupine	60	5	5	10	50		10	30	20	20	20	20		40	40	30	20	20	20	40	30	50									

Notes: Baseline bearing = 168° M/I declination = 13.5° 154°

In open area, but some also located in surrounding shrub-covered area.
Lupine moderately to largely screened.
Plot also overlaps with old HAL study.
Rebar located @ both ends of baseline 1m NE of trail edge so that it wouldn't be disturbed.



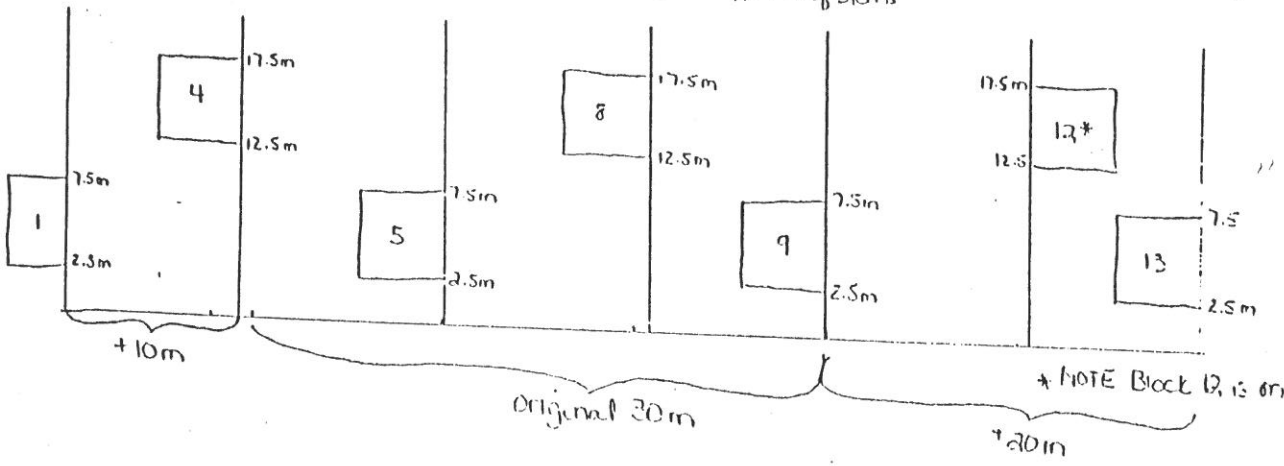
Population Data Map

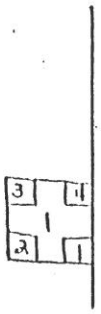


Willow Street Sandpit

NORTH

5m x 5m Placement :- woody plants : total % cover all woody stems in 5x5m + 1cm diameter at breast height (1%, 2, 3, 4, 5, 10, 15, 20, 25%, ...)
- List ea spp + # of stems





1m x 1m Placement
- w/in ea. 5x5m block → 4 - 1m x 1m blocks
- herbac. plants
  - spp + % cover of herbac. in ea. 1x1m block
  - * for lupine : % cover / # stems
  - woody plants < 1cm in diam at breast hgt are recorded as herbac.

Willow Street

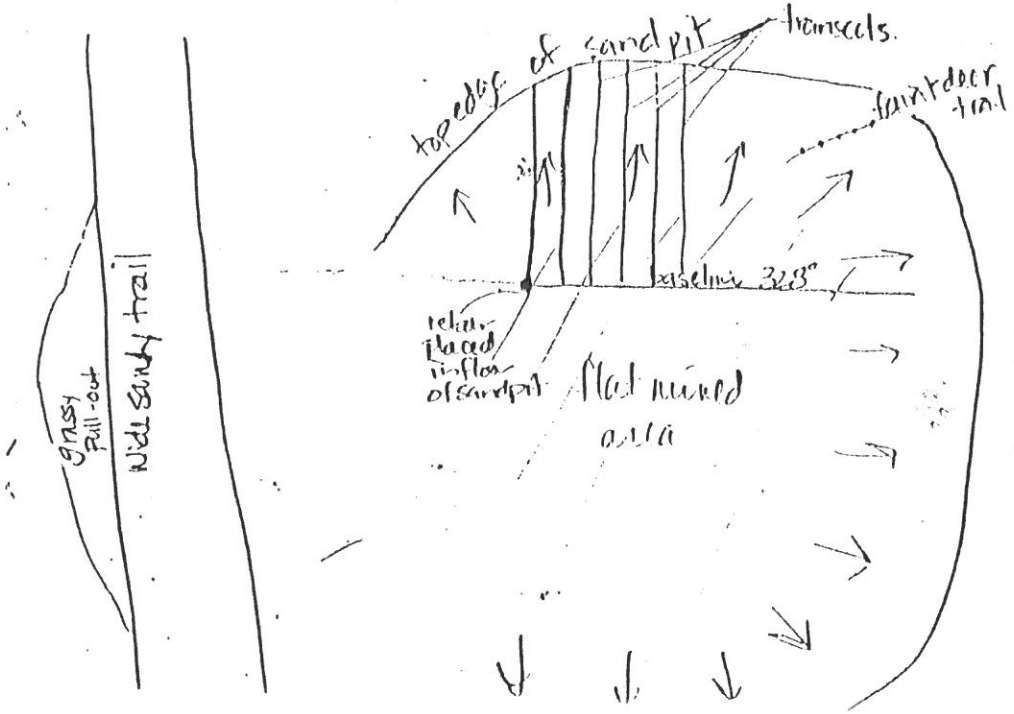
Clump Data Sheet

Location Sandpit | Date 95 | Flow Width (m) NA | Path Width (m) NA | Interval Width (m) | m

Recorder Gehrer, Sullivan | Flow Bearing | P/T# to P/T# | Transect Starts at the SW Corner of the Block

Clump #	3-1	6-1	8-1	11-1	11-2	16-1	16-2	18-1	20-1	25-1	25-2	30-1																
Dist. to Baseline (m)	2	3.8	6.6	1.5	8.2	5.6	8	5.3	9	1.3	8.6	11.1																
Intercept Length (cm)	5	3	12	>1	2	3	1	>1	3	1	6	5																
Length (cm)	11	12	21	30	29	10	9	9	17	13	10	16																
Width (cm)	6	5	10	13	17	5	1	3	17	1	10	11																
Height (cm)	10	6	5	14	20	7	1	4	10	6	8	15																
Total # of Stems	1	1	2	2	1	1	1	1	2	1	1	1																
# of Fl. Stems	0	0	0	0	0	0	0	0	0	0	0	0																
# of Germinates	0	0	0	0	0	0	0	0	0	0	0	0																
%, Bare Ground	0	0	0	0	5	0	0	0	0	0	0	10																
% Non-Vascular	0	40	0	0	5	0	0	0	0	0	0	0																
% Vascular	80	55	50	70	5	90	0	90	1	5	0	0																
% Lupine	70	55	50	25	40	60	90	25	60	50	60	50																

Notes: Bearing of baseline = 328° for N at declination of 13.5°

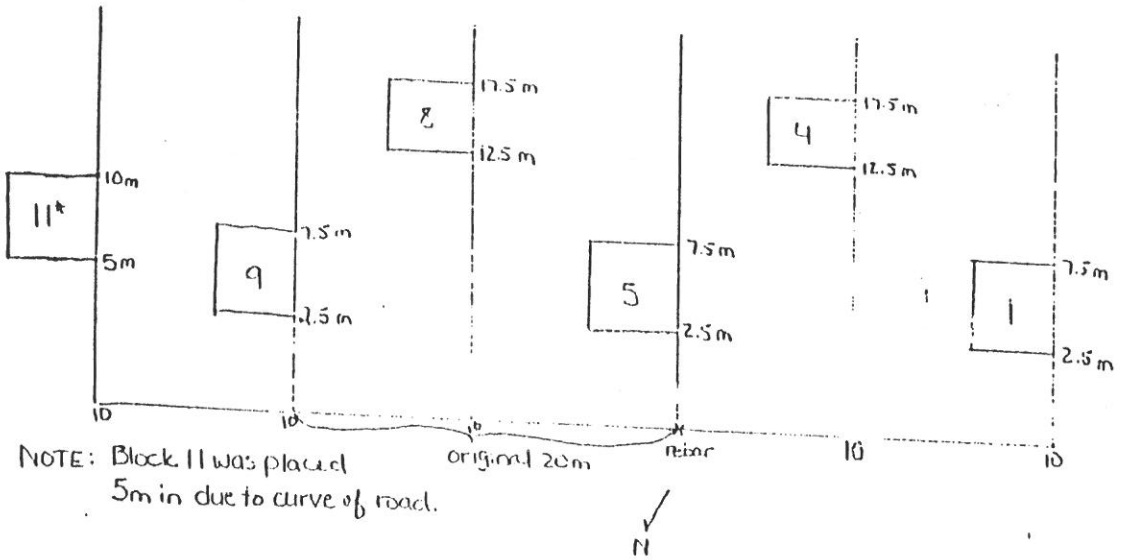


↑ points upslope

- slope is mostly open w/ low scattered sprawl rose & other herbaceous & woody plants. litter covers most of surface.
- flat floor of sandpit has sparse (10-15%) low cover of grass & sedges
- baseline ran across sandpit floor & transects go up slope
- lupine occurred both on slope & flat floor of sandpit, only

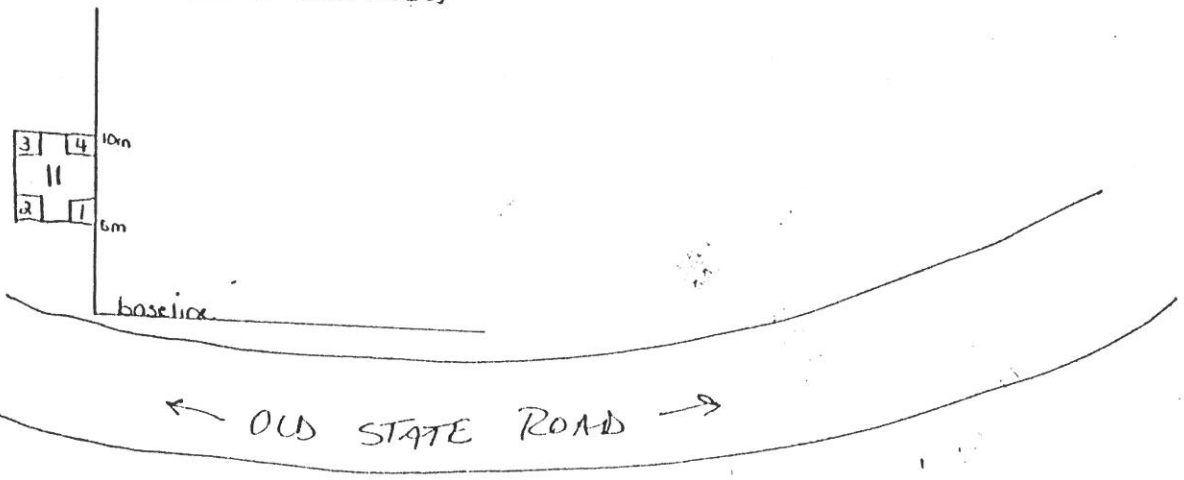
OLD STATE ROAD

Placement of 5×5m blocks



NOTE: Block 11 was placed 5m in due to curve of road.

Placement of 1×1m blocks



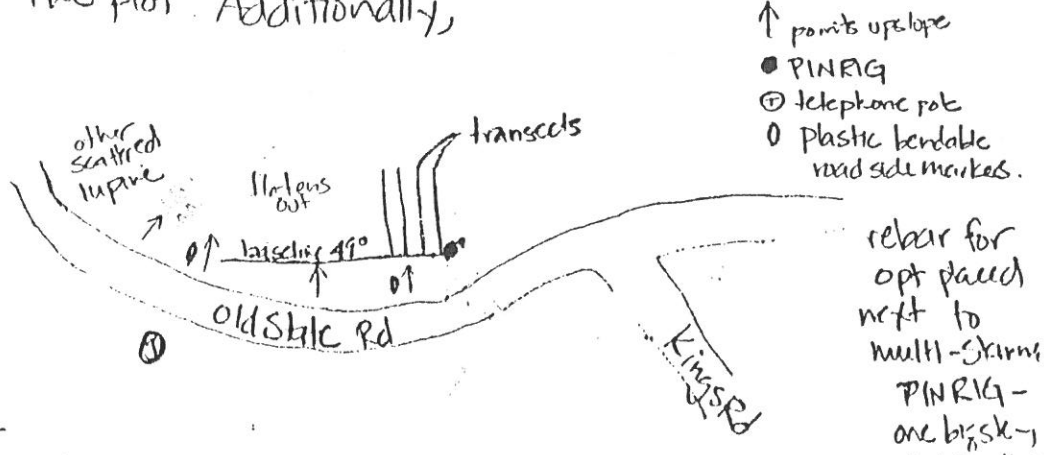
Clump Data Sheet

Location Old State | Date 7/13/19 | Row Width (m) NA | Path Width (m) NA | Interval Width (m) 1m.

Recorder Sullivan, Gebauer | Row Bearing | P/T# to P/T# | Transect Starts at the NW Corner of the Block

Clump #	6-1	7-1	9-2	9-1	9-2	9-3	9-1	13-1	15-1	5-2	18-1
Dist. to Baseline (m)	2.6	7.6	2.8	4.3	4.3	4.9	5.1	3.5	2.3	5.0	.1
Intercept Length (cm)	<1	10	1	8	1	>1	5	10	8	7	>1
Length (cm)	10	28	12	14	8	16	18	12	14	13	20
Width (cm)	1	16	6	6	1	15	17	4	11	7	13
Height (cm)	3	10	5	9	6	13	11	11	27	8	13
Total # of Stems	1	2	1	1	1	1	1	2	1	2	1
# of Fl. Stems	0	0	0	0	0	0	0	0	1	0	0
# of Germinates	0	0	0	0	0	0	0	0	0	0	0
% Bare Ground	5	>5	0	>5	0	5	20	0	0	0	0
% Non-Vascular	0	0	0	0	0	0	0	0	0	0	0
% Vascular	20	10	10	10	5	25	20	10	25	30	10
% Lupine	40	60	70	65	50	40	40	30	10	60	10

Notes: Baseline bearing = 49° E of N w/ declination of 13.5°. Most of the lupine was scattered on the slope & just above the slope along Old State Rd. There was some lupine located further east of the plot, but they were few & widely scattered. There was also a "buffer area" between these plants and the plot that was devoid of lupine so the eastern most plants were not included in the plot. Additionally, because of the location of the plot near a bend in the road, the straight baseline cut some of the lupine plants out of the plot (in other words there are a few plants between the baseline & rd.). The baseline was located slightly uphill slope so that it didn't run into the road and to avoid the unused area.



APPENDIX C. STANDARD LUPINE POPULATION DATA SHEET

Location | Date | Row Width (m) | Path Width (m) | Interval Width (m)

Recorder | Row Bearing | P/T# to P/T# | Transect Starts at the Corner of the Block

Clump #																														
Dist. to Baseline (m)																														
Intercept Length (cm)																														
Length (cm)																														
Width (cm)																														
Height (cm) / max d.																														
Total # of Stems																														
# of Fl. Stems																														
# of Germinates																														
% Bare Ground																														
% Non-Vascular																														
% Vascular																														
% Lupine																														

Notes:

APPENDIX D. STANDARD VEGETATION COMMUNITY DATA SHEET

KBE 8/25/96 Bidwell + Bidwell, baseline 154°, Transects begin in the NW corner 182

	1	1-1	1-2	1-3	1-4	4	4-1	4-2	4-3	4-4	5	5-1	5-2	5-3	5-4	8	8-1	8-2	8-3	8-4
Total woody & cover	90				95						40					85				
# stems / spp																				
QUEILI	18				15															
PINRIG	2										2									
% herbs																				
PARQUI																				
CNEAIB																				
ARRPEN			20								30							20		
PANICUM spp											2			15					2	
LYCQUA		10	10	2															3	
PTEAQU		2														5	5	40	30	
RHUGLA																	2		10	
QUEILI		50	15			30	10	40			10	15	50	40					50	90
CERAME		15									10	5								
DENGLE											5	2								
LONSPP											15	5		20					2	
SCHSCO			2																	
VITSPP			5	5																
QUESPP				30																
MONUMI				5																
SALSPP				10																
VETDIS											2		5							
CINVIL																				
ANDGER																5				

APPENDIX E. LUPINE POPULATION DATA AND ANALYSIS

Each # represents [illegible] of lupine

WILLOW ST SANDPIT	"7/13/95		Interval width: 1 meter																										
			Recorders: Gebauer, Sullivan, Gifford, Hopkins																										
			Transect started at SE corner.																										
			Baseline bearing: 328 E of N w/ declination of 13.5																										
Clump#	2-1	3-1	5-1	6-1	7-1	8-1	10-1	10-2	11-1	11-2	12-1	15-1	16-1	16-2	17-1	17-2	17-3	17-4	18-1	20-1	21-1	25-1	25-2	26-1	27-1	30-1	AVG	MIN	MAX
Dist to Baseline (m)	3.2	2	4.3	3.8	6.7	6.6	4.7	4.9	1.5	8.2	5.2	10.5	5.6	8	3.7	4.3	5.2	8.7	5.3	9	10.7	7.3	8.6	30.4	10.6	11.1	7.3115	1.5	30.4
Intercept Length (cm)	22	5	19	3	4	12	5	11	1	2	11	10	3	4	12	10	7	20	1	3	23	4	6	4	6	5	8.1923	1	23
Length (cm)	32	11	25	12	6	24	22	16	32	29	12	35	10	4	14	10	16	24	7	17	29	13	10	12	16	16	17.462	4	35
Width (cm)	19	6	9	5	4	18	9	12	13	17	8	14	5	4	15	6	8	20	3	17	17	4	10	6	10	11	10.385	3	20
Height (cm)	9	10	7	6	3	5	8	4	14	20	10	20	7	4	10	9	5	18	4	10	19	6	8	10	6	15	9.5	3	20
Total # of stems	1	1	1	1	1	2	1	1	2	1	1	5	1	1	2	1	1	2	1	2	2	1	1	1	1	1	1.3846	1	5
Number of fl. stems	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0.1538	0	2
Number of germinates	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent bareground	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1.3462	0	10
Percent non-vascular	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5769	0	10
Percent vascular	40	20	10	5	0	50	10	10	70	5	50	0	40	0	10	30	20	5	10	1	0	5	0	0	0	0	15.038	0	70
Percent lupine	10	70	30	55	90	50	25	40	25	40	40	40	60	90	30	30	30	50	25	60	75	50	60	30	50	50	46.346	10	90
WILLOW ST SANDPIT	"7/8/96		Interval width: 1 meter																										
			Recorders: Bidwell, McArthur																										
			Transect started at SE corner.																										
			Baseline bearing: 328 E of N w/ declination of 13.5																										
Clump#	5-1	6-1	11-1	11-2	13-1	14-1	15-1	17-1	17-2	19-1	21-1	21-2	26-1	30-1	AVG	MIN	MAX												
Dist to Baseline (m)	4.6	4.1	7.6	8.9	2	9.9	7.6	5.2	6.2	8.6	11.8	11.9	13.5	12.9	8.2	2	13.5												
Intercept Length (cm)	9	4	18	8	12	18	7	3	9	8	11	19	21	10	11.214	3	21												
Length (cm)	17	14	22	18	14	21	14	8	12	11	24	36	34	15	18.571	0	36												
Width (cm)	9	6	12	11	6	21	4	4	10	10	15	20	21	15	11.714	4	21												
Height (cm)	15	13	15	11	8	21	12	4	8	10	14	38	23	11	14.5	4	38												
Total # of stems	1	2	3	3	1	3	2	1	2	2	2	1	4	2	2.0714	1	4												
Number of fl. stems	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0												
Number of germinates	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												
Percent bareground	30	40	10	20	40	40	50	60	40	50	30	20	50	60	30.571	10	60												
Percent non-vascular	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0												
Percent vascular	5	40	40	0	0	0	5	3	10	0	1	5	3	0	8	0	40												
Percent lupine	60	20	50	80	60	60	30	30	50	50	60	70	40	40	50	20	80												
WILLOW ST SANDPIT	"8/12/97		Interval width: 1 meter																										
			Record Guido																										
			Transect started at SE corner.																										
			Baseline bearing: 328 E of N w/ declination of 13.5																										
Clump#	6-1	21-1	22-2	27-1	30-1	AVG	MIN	MAX																					
Dist to Baseline (m)	3.2	8.1	8.8	10.25	10.01	8.072	3.2	10.25																					
Intercept Length (cm)	8	12	15	20	20	15	8	20																					
Length (cm)	12	15	15	30	20	18.4	12	30																					
Width (cm)	10	12	14	20	16	14.4	10	20																					
Height (cm)	2	10	25	15	10	12.4	2	25																					
Total # of stems	1	1	2	3	1	1.6	1	3																					
Number of fl. stems	0	0	1	0	0	0.2	0	1																					
Number of germinates	0	0	0	0	0	0	0	0																					
Percent bareground	0	25	60	85	45	43	0	85																					
Percent non-vascular	0	0	0	0	0	0	0	0																					
Percent vascular	15	0	0	30	70	23	0	70																					
Percent lupine	15	30	20	35	45	29	15	45																					

OLD STATE RD	"7/31/95		Interval width: 1 meter																												
			Recorders: Sullivan, Gebauer, Gifford, Hopkins																												
			Transect started at NW corner																												
			Baseline bearing: 49 E of N w/declination of 13.5																												
Clump#	4-1	5-1	5-2	6-1	7-1	7-2	8-1	8-2	8-3	8-4	9-1	9-2	9-3	9-4	10-1	11-1	11-2	12-1	13-1	15-1	15-2	17-1	18-1	19-1	19-2	19-3	19-4	AVG	MIN	MAX	
Dist to Baseline (m)	6.7	3.9	6.6	2.6	1.6	2.8	1.5	2.5	3.9	6.7	4	4.3	4.9	5.1	3.2	2.1	2.6	4.3	3.5	2.3	5	0.3	0.4	0.6	1	1.5	2.3	3.1556	0.3	6.7	
Intercept Length (c	7	1	1	1	10	4	7	4	6	7	2	4	1	5	6	16	1	6	10	8	7	2	1	5	1	2	7	4.8889	1	18	
Length (cm)	11	17	20	10	28	12	18	7	10	15	14	8	16	18	14	16	23	21	12	14	13	32	20	43	40	24	7	17.815	7	43	
Width (cm)	5	7	14	1	16	6	9	5	6	7	6	4	15	17	6	9	13	9	4	11	7	14	13	21	25	10	5	9.8148	1	25	
Height (cm)	12	11	25	3	10	5	6	10	23	8	9	6	13	11	6	11	15	13	14	27	8	16	13	25	20	25	10	13.148	3	27	
Total # of stems	1	2	1	1	2	1	2	2	2	1	1	1	1	1	1	1	3	1	2	1	2	5	1	3	7	2	1	1.8148	1	7	
Number of fl. stems	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	2	2	2	0	0.3333	0	2	
Number of germinat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.037	0	1	
Percent bareground	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	0	0	6.4815	0	80	
Percent non-vascul	0	0	0	5	5	0	5	10	0	80	5	0	5	20	10	10	0	0	0	0	0	0	0	0	5	0	0	0.3704	0	5	
Percent vascular	10	5	20	20	10	10	20	0	10	0	10	5	25	20	25	10	20	15	10	25	30	30	40	35	50	20	20	18.333	0	50	
Percent lupine	60	35	10	40	60	70	25	60	25	10	65	50	40	40	25	30	25	20	30	10	60	25	40	25	40	25	25	35.926	10	70	
OLD STATE RD	"7/8/96		Interval width: 1 meter																												
			Recorders: Bidwell, McArthur																												
			Transect started at the NW corner																												
			Baseline bearing: 49 E of N w/declination of 13.5																												
Clump#	2-1	3-1	3-2	4-1	4-2	5-1	6-1	6-2	7-1	7-2	7-3	8-1	8-2	9-1	10-1	10-2	11-1	12-1	13-1	14-1	14-2	14-3	14-4	14-5	15-1	15-2	16-1	16-2	16-3	AVG	MIN	MAX
Dist to Baseline (m)	3.3	1.2	1.9	0.4	3.1	4.6	0.7	5.2	1.5	5.7	6.6	2.7	9.4	6.3	4	8.3	6.4	1.8	1.2	1	1.2	1.9	2.1	5.6	1.7	1.9	1.8	2.2	3.1	3.3379	0.4	9.4
Intercept Length (c	12	9	5	19	7	17	10	6	5	13	4	6	8	10	14	13	12	10	5	11	5	3	3	9	15	9	13	11	19	9.7586	3	19
Length (cm)	15	16	19	23	12	27	18	19	18	23	17	35	18	16	28	18	15	10	16	13	22	21	20	26	19	19	18	13	26	19.31	10	35	
Width (cm)	8	11	10	17	9	18	8	12	10	15	8	17	10	15	19	14	14	6	15	13	6	18	11	17	13	11	13	5	16	12.379	5	19	
Height (cm)	8	13	15	9	11	14	14	11	10	11	9	11	10	13	19	9	12	14	11	12	9	12	10	11	11	13	12	10	20	11.862	8	20	
Total # of stems	2	1	3	4	2	2	1	2	3	2	1	2	3	2	3	1	2	2	2	2	3	5	4	4	2	1	3	2	4	2.4138	1	5	
Number of fl. stems	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Number of germinal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Percent bareground	40	20	70	20	60	30	40	50	40	20	10	30	30	10	10	10	20	10	60	20	60	10	40	10	30	50	20	10	10	28.966	10	70	
Percent non-vascul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Percent vascular	2	10	5	2	2	5	4	5	1	1	50	20	30	5	20	10	40	40	1	4	3	10	5	40	1	5	5	60	10	13.655	1	60	
Percent lupine	50	70	20	70	30	60	50	40	50	70	40	50	30	80	70	80	40	50	30	70	30	70	50	50	60	40	70	30	70	52.414	20	80	
OLD STATE RD	"8/12/97		Interval width: 1 meter																												
			Recorders Guido																												
			Transect started at the NW corner																												
			Baseline bearing: 49 E of N w/declination of 13.5																												
Clump#	8-1	9-1	10-1	10-2	10-3	11-1	13-1	16-1	AVG	MIN	MAX																				
Dist to Baseline (m)	3.45	3.05	2.45	5.93	6.15	4.5	6.75	2.1	4.2975	2.1	6.75																				
Intercept Length (c	12	5	15	10	4	12	32	30	15	4	32																				
Length (cm)	33	14	15	23	4	31	34	40	24.25	4	40																				
Width (cm)	22	14	8	10	3	12	17	33	14.875	3	33																				
Height (cm)	20	11	21	12	5	7	18	13	13.375	5	21																				
Total # of stems	1	1	1	1	1	2	1	4	1.5	1	4																				
Number of fl. stems	0	0	1	0	0	0	0	0	0	0	0																				
Number of germinal	0	0	0	0	0	6	0	0	0.75	0	6																				
Percent bareground	0	0	10	2	0	0	4	5	2.625	0	10																				
Percent non-vascul	0	0	0	0	0	0	0	0	0	0	0																				
Percent vascular	2	1	1	1	1	1	10	35	6.5	1	35																				
Percent lupine	20	5	53	15	50	5	15	40	25.375	5	53																				

Karner Barrens East	07/12/95		Interval width: 1 meter																						
			Recorders: Bronson, Gebauer, Gifford																						
			Transect started at NW corner																						
			Baseline bearing: 154 declination of 13.5																						
Clump#		2-1	2-2	3-1	3-2	4-1	5-1	5-2	6-1	8-1	8-2	9-1	13-1	13-2	14-1	14-2	14-3	17-1	18-1	19-1	AVG	MIN	MAX		
Dist to Baseline (m)	0-1	5.2	5.6	0.9	3.7	2.9	4.4	5.4	5.1	0.8	4	8.3	3.1	3.9	4.6	4.9	5.3	4.4	0.8	4.4	3.925	0.8	8.3		
Intercept Length (cm)	2	1	1	3	2	10	3	4	1	10	1	4	7	6	3	1	6	9	10	2	4.4	1	10		
Length (cm)	21	7	7	8	12	18	42	10	19	27	16	14	22	14	18	19	14	17	13	10	16.5	7	42		
Width (cm)	15	3	5	10	11	7	17	3	7	20	13	13	19	8	8	7	9	10	10	5	10	3	20		
Height (cm)	11	15	3	3	14	19	31	9	14	28	12	15	14	12	5	20	13	12	17	8	13.75	3	31		
Total # of stems	2	1	1	1	1	2	2	1	1	3	1	2	2	2	9	2	2	1	1	2	1.95	1	9		
Number of fl. stems	0	0	0	0	0	0	1	0	1	2	0	0	0	0	0	1	0	0	0	0	0.25	0	2		
Number of germinates	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Percent bareground	5	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	2.75	0	50		
Percent non-vascular	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	5		
Percent vascular	15	50	10	10	10	10	40	5	10	10	50	30	30	15	50	20	30	10	10	15	21.5	5	50		
Percent lupine	60	5	5	10	50	10	30	30	30	20	20	40	40	30	20	20	20	40	30	50	28	5	60		

KARNER BARRENS EA	07/03/96		Interval width: 1 meter																						
			Recorders: Bidwell, McArthur																						
			Transect started at NW corner																						
			Baseline bearing: 154 w/ declination of 13.5																						
Clump#	0-1	1-1	1-2	1-3	1-4	3-1	3-2	4-1	4-2	4-3	5-1	6-1	7-1	7-2	7-3	8-1	9-1	13-1	13-2	14-1	15-1	16-1	AVG	MIN	MAX
Dist to Baseline (m)	5	1.4	1.7	2.5	4.6	2.4	4.8	1.7	1.9	2	2.8	3.3	2.2	2.9	3.5	0.5	0.2	1.5	1.7	1.7	1.4	1.1	2.3090909	0.2	5
Intercept Length (cm)	9	19	13	1	15	14	15	4	10	21	17	11	19	19	5	15	4	1	11	16	16	13	12.181818	1	21
Length (cm)	20	21	16	23	19	17	16	16	19	21	20	22	23	20	12	43	10	15	15	21	28	17	20	12	43
Width (cm)	12	18	13	14	15	15	5	12	16	16	17	20	15	19	7	19	11	10	12	14	17	11	14	5	20
Height (cm)	10	10	20	8	10	14	8	13	16	16	12	16	22	18	10	19	15	14	11	14	21	12	14.227273	8	22
Total # of stems	3	2	1	3	3	1	3	2	2	1	4	3	2	3	2	3	1	3	1	3	3	2	2.4090909	1	4
Number of fl. stems	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of germinates	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent bareground	30	30	20	40	30	50	10	50	40	50	30	50	20	30	40	30	20	20	50	20	30	30	32.727273	10	50
Percent non-vascular	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percent vascular	5	5	10	5	5	5	5	5	5	5	5	5	5	1	2	30	5	2	2	1	2	0	5.2272727	0	30
Percent lupine	60	60	70	50	60	40	80	40	50	40	60	40	70	60	50	40	60	70	40	70	60	70	58.363636	40	80