




CRESCENT CITY MARSH WILDLIFE AREA

DEL NORTE COUNTY, AND

TABLE BLUFF ECOLOGICAL RESERVE

HUMBOLDT COUNTY, CALIFORNIA

CALIFORNIA DEPARTMENT OF FISH AND GAME

2000 STATUS REPORT
WESTERN LILY VEGETATION STRATEGY

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Prepared Under Interagency Agreement
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Cover illustrations: (Upper left) CCMWA South Marsh, showing western lily, Ledum glandulosom, Veratrum californicum, and other marsh species; (Upper right) western lily at TBER; species present at CCMWA, including (left to right) Helenium bolanderi, Viola palustris, Rhododendron occidentale, and Menyanthes trifoliata,.

1.0 INTRODUCTION

This report includes the 3rd year monitoring results, and a summary of the first 2 years of results for all tasks included in the Western Lily (*Lilium occidentale*) Vegetation Strategy Project, implemented in June 1998. The 1998 and 1999 results were reported in detail previously (Imper and Sawyer 2000a). Current funding (through Section 6 Endangered Species Act) for this project has been extended through March 2002. Since many elements of the study involve long term processes (e.g., western lily recruitment, gradual modification of habitat), extended monitoring is necessary in order to gain meaningful information. As a result, the study was designed to continue well beyond the current schedule, perhaps for a decade or more.

Tasks completed over the past 2 years include data collection from previously established sample plots and transects, as well as a new sample protocol intended to further our understanding of the ecology of the western lily, and assess the efficacy of manual treatment and cattle grazing for maintaining its habitat at the Table Bluff Ecological Reserve (TBER) and Crescent City Marsh Wildlife Area (CCMWA). Data files generated as part of this report are included as Attachment 5.

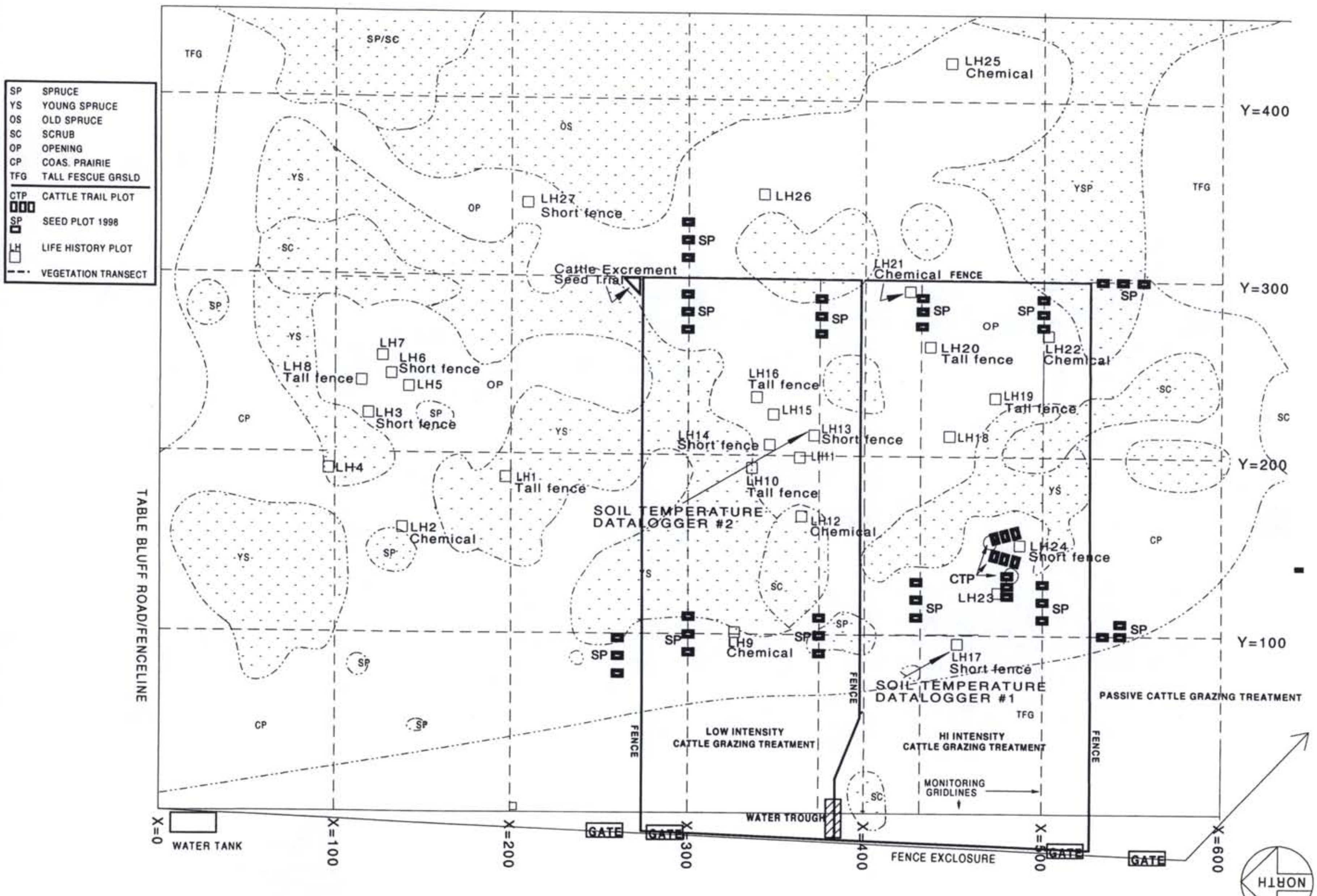
2.0 BACKGROUND AND STUDY OBJECTIVES

2.1 TABLE BLUFF ECOLOGICAL RESERVE

Formal monitoring of the western lily population at the TBER began in 1987 (Map 1). Annual monitoring at this and other sites on Table Bluff documented often severe browsing by deer or small mammals, resulting in loss of 50% or more of the reproductive effort in some years. Although no quantitative data are available, natural browsing may be a factor affecting mortality of the lily. With the exception of limited monitoring at the Christensen and Barry sites on Table Bluff in the early 1990's, and monitoring conducted by The Nature Conservancy at their Bastendorf Reserve near Coos Bay, Oregon, there has been no intensive effort to determine the actual annual loss to deer and small mammals, or to investigate methods for discouraging mammal depredation. The ability of this plant to remain dormant for one or more years complicates investigation of browsing impacts. As a result, investigation intended to model the population demographics and various external factors affecting survival must necessarily track the life history of a large number of seedlings throughout the growing season, and over multiple years.

The monitoring at TBER since 1987 also documented an increasing threat to the lily as a result of plant growth following removal of cattle. At the same time, removal of approximately 50% of the spruce forest encouraged plant growth on the forest floor, exacerbating the need for vegetation management. Although the removal of spruce allowed many juvenile lily plants to mature, the release caused by tree canopy removal also appeared to eliminate many preexisting lily plants

We also did not know whether lily recruitment at the TBER was adequate to maintain, or expand the population. Seed plots established in fall 1993 as part of the Experimental Habitat Manipulation Project exhibited virtually no survival of seedlings in the *Coastal prairie*, and relatively low survival in the *Spruce forest*. In contrast, abundant seedlings have been documented growing in pedestrian



SCALE: 1" = 80'

MAP 1. CURRENT VEGETATION, LIFE HISTORY PLOTS (LH1-27), CATTLE TRAIL PLOTS, SOIL TEMPERATURE LOGGERS, SEED PLOTS, SEASONAL GRAZING TREATMENTS, LH PLOT TREATMENTS, AND VEGETATION TRANSECTS, TBER 2000

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and cattle trails at the reserve, and in old cattle trails at another site on Table Bluff. We do not know if these seedlings eventually will mature. There is evidence, however, that exclusion of cattle from the lily habitat between 1987 and 1996 negatively impacted both lily recruitment and the longevity of mature plants. Passive cattle grazing has been introduced into the entire lily habitat at TBER for the past 3 years. Other than vegetation transect data collected prior to reintroduction of grazing, and data collected in this study, there has been no quantitative study of the impacts of cattle grazing on vegetation, soil compaction, or lily recruitment.

The investigation at TBER is generally aimed at quantifying both the beneficial and negative impacts of cattle grazing applied at varying intensities and duration, as a method for maintenance of vegetation in western lily habitat. That information is critical to development of a formal grazing plan for the TBER, and should be applicable to many other western lily sites throughout the range.

The principle study objectives at the TBER are to:

- assess the impacts of cattle grazing applied at different intensities and durations upon vegetation composition and structure, soil compaction, and recruitment by the lily, and
- determine quantitative impacts of natural browsing on the western lily, and the effect of deer and small mammal fencing and chemical inhibitors in reducing natural browsing.
- Secondary objectives include further definition of the life history of the lily, and determination of whether cattle ingestion of the lily seed, under controlled conditions, is a successful mode of recruitment.

2.2 CRESCENT CITY MARSH WILDLIFE AREA

Formal monitoring of the western lily population in the north part of the CCMWA ("North" and "South" marshes, Map 2; Imper and Sawyer, 1992, 1997) was implemented in 1997. The CCMWA population is unquestionably the largest population known, containing more than 5,000 plants, yet is one of the least studied. Until this study, there had been no detailed investigation of the life history, recruitment and population demographics, and browsing impacts for the western lily at any of the populations near Crescent City. The critical importance of the CCMWA population in particular (50% or more of all known flowering plants) warrants a greater understanding of natural browsing impacts, as well as the general life history of this population.

Past monitoring at sites on Table Bluff and in southern Oregon indicate the principal threat to the western lily is encroachment by trees and shrubs (Guerrant et al. 1997). At the CCMWA, even a slow growth rate may be cause for alarm, due to the exponential relationship between lateral growth and aerial cover, particularly in light of the literally 1000's of expanding "islands" (seedlings and saplings) of shrubs and trees now scattered throughout the marsh.

The principal objectives of this investigation at CCMWA are therefore to:

- characterize the current state of the western lily population and its habitat,
- monitor the rate of vegetation encroachment and its impact on the lily,
- determine the efficacy of manual vegetation for maintaining the habitat in a suitable condition for the lily,

MAP 2. 1996 AERIAL PHOTO OF THE STUDY AREA, SHOWING ACCESS TRAIL, NORTH AND SOUTH MARSHES, AND SAMPLE TRANSECTS; SCALE: 1" = 200'.

TABLE 1. LOCATIONAL COORDINATES OF LIFE HISTORY PLOTS (LH), CATTLE TRAIL PLOTS, SEED PLOTS AND VEGETATION TRANSECT (MAP 1) AND PHOTOPOINTS, TBER.

Location	Plot ID	Cattle grazing treatment	LH Plot treatment	X/Y Coordinates		
Life	1	passive	Tall fence	200/184		
History	2	passive	Chemical	141/156		
Plots	3	passive	Short fence	123.5/219		
(SW corner)	4	passive	Tall fence	99/188		
	5	passive		145/234		
	6	passive	Short fence	135/241		
	7	passive		130/251		
	8	passive	Tall fence	118/237		
	9	no. enclosure	Chemical	329/98		
	10	no. enclosure	Tall fence	339/190		
	11	no. enclosure		366/196		
	12	no. enclosure	Chemical	367/163.5		
	13	no. enclosure	Short fence	374/208.5		
	14	no. enclosure	Short fence	349/203		
	15	no. enclosure		351/220		
	16	no. enclosure	Tall fence	341.5/229.5		
	17	so. enclosure	Short fence	455/92		
	18	so. enclosure		450.5/208.5		
	19	so. enclosure	Tall fence	476/230		
	20	so. enclosure	Tall fence	439.5/258.5		
	21	so. enclosure	Chemical	428/290		
	22	so. enclosure	Chemical	505.5/265.5		
	23	so. enclosure		477.5/121		
	24	so. enclosure	Short fence	490/148		
	25	passive	Chemical	451/418.5		
	26	passive		345.5/344		
	27	passive	Short fence	212/338		

Location	Plot ID	Cattle Grazing Treatment		X/Y Coordinates		
Seed Plots						
(NW corner)		so. enclosure		430/110	430/120	430/130
		so. enclosure		430/280	430/285	430/290
		so. enclosure		500/110	500/120	500/130
		so. enclosure		500/274	500/280	500/288
		no. enclosure		300/90	300/100	300/110
		no. enclosure		300/270	300/279	300/290
		no. enclosure		375/90	375/100	375/110
		no. enclosure		375/270	375/282	375/290
		passive		260/80	260/90	260/100
		passive		300/310	300/320	300/330
		passive		535/300	540/300	550/300
		passive		535/100	540/100	540/105
Cattle Trail	#1	so. enclosure		479/130		
Plots	#2	so. enclosure		477/142		
(SW corner)	#3	so. enclosure		478/155		

Notes: Coordinates fo Life History Plots = SW corner (rebar @ diag. corners); for Cattle Trail Plots = SW corner (rebar @ diag. corners) of center 3' x 3' plot; lateral 3' x 3' plots are oriented relative to center plot as follows:#1-90d;#2-20d;#3-356d.

Coordinates for Seed Plots = NW corner (rebar stake) of 12" x 12" plot, 50 seed planted ea. plot 10/6/98.

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TABLE 1. CONTINUED

Vegetation Transects	Cattle Grazing Treatment	X/Y Coordinates
(General habitat	passive	Y=100; X=0-270, 530-600
and grazing trtmt	passive	Y=200; X=0-270, 530-600
characterization)	passive	Y=300; X=0-270, 530-600
	passive	Y=400; X=0-600
	passive	X=100; Y=0-450
	passive	X=200; Y=0-450
	passive	X=300; Y=300-450
	passive	X=400; Y=300-450
	passive	X=500; Y=300-450
	no. enclosure	Y=100; X=270-400
	no. enclosure	Y=200; X=270-400
	no. enclosure	X=300; Y=0-300
	no. enclosure	X=375; Y=0-300
	so. enclosure	Y=100; X=400-530
	so. enclosure	Y=200; X=400-530
	so. enclosure	X=400; Y=0-300
	so. enclosure	X=430; Y=0-300

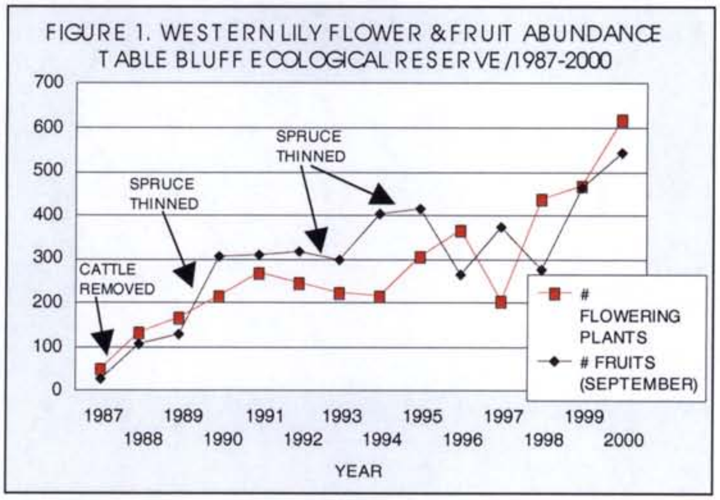
Photopoints	Cattle Grazing Treatment	Orientation	X/Y Coordinates	
General habitat		S	00/00	
(historical photopts)		S	00/50	
		E,S	200/100	
		S,W	400/100	
		E,N	470/100	
		E	125/200	(north glade)
		E,S,N	200/200	
		E,S	200/300	
		S,W	400/200	
		S,W	400/300	
		S,W	200/400	
		S,W,N	400/400	
		E,W	350/200	(south glade)
		E	170/35	1994 mow trtmt)
		E	235/30	1994 grzg trtmt)
		E	305/40	burn trtmt-unburned)
Grazing treatments	no. enclosure	S	270/100	
(added 10/8/98)	no. enclosure	S	270/200	
	no. enclosure	W	300/300	
	no. enclosure	W	360/300	
	no./so. enclos.	N,S	400/200	
	no./so. enclos.	N,S	400/100	
	no. enclosure	E	330/0	
	so. enclosure	E	460/0	
	so. enclosure	N	530/100	
	so. enclosure	N	530/200	
	so. enclosure	W	470/300	

- assess the historical impact of cattle grazing in western lily habitat on the reserve, and
- determine the relative impacts of natural browsing and the effect of deer and small mammal fencing in reducing natural browsing.
- A secondary objective is to increase our knowledge of the life history of the largest known population of western lily and develop a quantitative estimate of current recruitment.

3.0 TABLE BLUFF ECOLOGICAL RESERVE

3.1 Western Lily Population Status

A census of the entire population was conducted at the TBER between 1987 and 1992, after which the annual census has generally been limited to flowering plants (Imper and Sawyer, 2000b). The number of flowering plants at the reserve has increased from about 50 in 1987 to over 620 in 2000 (Figure 1). The principal factors responsible are removal of cattle during the growing season, and removal of approximately 50% of the spruce stand, which had shaded much of the population. While the total population has not been censused since 1992, nearly 1,200 plants were mapped and recorded this year as part of this study, occupying 970 square feet (sf) of the 5 acres of habitat. Although the sample plots were subjectively located in high density areas for the plant, we can assume the total population easily exceeds 5,000. However, more than half of the plants recorded in the sample plots were single leaf seedlings, which are subject to high mortality. At least 160 additional plants have been established at 4 colonies located elsewhere on the reserve, using bulbs propagated in the greenhouse (Imper and Sawyer, 2000b).



3.2 Experimental Restrictions on Natural Browsing and Seasonal Cattle Grazing

Fencing and Browsing Inhibitor Treatments: In June, 1998, twenty seven 6ft^2 plots, referred to as "Life History (LH) Plots", were permanently marked, allocated equally among the 3 seasonal cattle grazing treatment areas described below (Table 1, Map 1). The southwest and northeast corner of each plot was staked with rebar; plot identification, grazing treatment and grid coordinates of the southwest corner are indicated in Table 1. In order to coincide with the overall grid coordinate system for the reserve, the X/Y coordinates recorded on the data sheets for each plot (Attachment 1) utilized the northwest corner as the origin. Within each grazing treatment, the plots were located so as to maximize the number of mature (i.e., multi-leaved) lilies and seedlings (single leaf), and still provide representation throughout the treatment areas. In March 1999 and March 2000, prior to emergence of the lily, the 27 plots were treated as follows:

#Plots	Name	Treatment
7	Deer exclosure	60 inch chickenwire, corner staked
7	Small mammal exclosure	18 inch x 0.5 inch mesh fence, corner staked
6	Deer chemical inhibitor	Coyote urine vial placed at one corner, recharged 30 day intervals
7	Control	No treatment

The fencing and chemical vials were removed in September of 1999 and 2000, and will continue to be reinstalled in March, and removed each fall to avoid interfering with the cattle grazing treatments.

The LH plots were initially monitored in June, 1998, and were monitored on 4 dates between March and June of 1999 and 2000. All mature lilies were inventoried and mapped. For single-leaf seedlings, subunits of each plot were successively inventoried until not less than 20 single-leaf were recorded; for the purpose of seedling inventories, the sample plot is considered to be the portion of the original $6ft^2$ plot sampled to achieve 20 or more seedlings (or the total present in the 6 foot square plot, whichever is less), as indicated in the population maps for each plot (Appendix A). All mature lilies were characterized as to height, extent of browsing or disease, and flowering status. Cover and height of all associated plants were described in 1998.

Seasonal Cattle Grazing Applications: All the occupied western lily habitat (~5 acres) at the reserve was opened to passive winter grazing by cattle in 1997. Cattle were able to freely enter the ~35 acre rare plant exclosure generally between November and early March. Actual grazing impact, however, has been generally low due to the intermittent, or limited periods during which cattle have been available on the reserve for introduction into the rare plant exclosure.

As part of this study, two 1 acre active grazing treatments were implemented in winter 1998-99, referred to as the northern, or "low intensity-long duration" treatment cell, and southern, or "high intensity-short duration" treatment cell (Map 1). A 1,000 gallon water tank, and a float-controlled water trough serving the 2 enclosures were installed. The grazing periods to date have been flexible, and based on the following subjective measures: maximum reduction of shrub cover and establishment of cattle trails within shrub canopies; reduction of the majority of *Calamagrostis nutkaensis* culms to between 6 and 12 inches height; minimal disruption of soil more than one inch deep, particularly in areas known to support the lily.

1998: Although opened to cattle on December 1, the passive-grazed habitat was only utilized by cattle between about January 21 and March 7, 1999 due to scheduling problems with the former grazing lessee. Overall, the intensity of use was less than desired, but was substantial in some areas, particularly along the fences where the cattle created mud trails. Two cows were confined in the north enclosure for 20 days, beginning January 4, and 11 cows were confined in the south enclosure for 5 days, beginning January 21, 1999. Additional grazing would have been beneficial, but the cattle were removed at the request of the lessee.

1999: Last winter, the new grazing lessee (Clint Victorine) confined his entire herd of 68 cows within the passive-treated habitat for 3 days, beginning on February 12, 2000. The herd was then allowed to enter the habitat passively. The gates were closed on about March 1. Two cows were enclosed in the low intensity treatment cell for 28 days (total 56 animal days), and 12 adults and 13 calves were held in the high intensity treatment area for 6 days (total 72 adult days; 78 calf days), both treatments beginning January 18, 2000.

2000: This winter, the herd of 68 cows was allowed into the entire exclosure passively beginning on February 2, 2001. The gates are scheduled to be closed on March 2, when the herd will be moved to another area of the wildlife area. Twelve adults cows were held in the high intensity treatment area for 5 days (total 60 adult days), and 2 cows were held in the low intensity treatment cell for approximately 21 days (total 42 animal days); both treatments began February 2, 2001.

3.3 Vegetation Characterization and Results of Seasonal Grazing

Overall Habitat: General habitat monitoring was conducted across the entire monitoring grid (4650' transect) in October, 1998, following the standard protocol (Imper *et al.*, 1987), and compared to (pre-experimental grazing) habitat data collected in 1989, 1993 and 1996 (Imper and Sawyer, 2000b). In general, cover by typical *Coastal prairie* increased significantly after removal of cattle in 1987, but has since stabilized. The *Sweet vernal grassland*, dominated by *Holcus lanatus* and various other "pasture" species decreased soon after removal of grazing (i.e., converted to *Coastal prairie* or blackberry) but increased since 1993 in response to thinning of the spruce stand. The *Young spruce forest* (i.e., the dense spruce vegetation type, as opposed to individual trees) declined from 32% cover to 7% in 1998 as a result of thinning (largely converted to *Sweet vernal grassland*). Combined cover of *Rubus ursinus* and *R. spectabilis* increased from 13% to 31% by 1998, one of the principal reasons for implementing this study.

Effects of Seasonal Grazing on Vegetation: It appeared that all of the grazing treatments conducted last winter (passive throughout exclosure, and 2 confined treatments) were at least moderately successful at maintaining vegetation. Informal observation suggets that impacts produced by a large number of cattle confined for a short period (high intensity-short duration treatment) are more evenly distributed, and cause fewer trails and less severe soil disruption than in the low intensity area. The two cows in the low intensity treatment have tended to use the same pathways repeatedly, and concentrated grazing impacts in smaller areas, resulting in rather extensive soils disruption within the "south glade" lily habitat in the north enclosure (Map 1).

In order to provide better sample coverage of the north and south cattle enclosures, two additional vegetation transects were added to the existing network in October 1998 (i.e., X=375/Y=0-300 - north enclosure; X=430/Y=0-300 - south enclosure), and the resulting data for all transects were segregated according to grazing treatment (transect segments allocated to each treatment indicated in Table 1). These transects were resampled in September of 1999 and 2000 (2000 field data - Attachment 2). Those results will be summarized and reported in the 2001 status report.

Effects of Seasonal Grazing on Western Lily: The number of seedlings and mature plants both increased in all cattle grazing treatments between 1998 and 1999 (15-62% and 31-70%, seedling and mature plants respectively), and again between 1999 and this year (96-110% and 10-13%, respectively) (Table 2). The one exception was number of mature plants in the high intensity treatment declined by 3% this year. Number of flowering plants has also increased steadily (10-60% between 1998 and 1999; 9-32% between 1999 and 2000). Although it is probably too early to draw any firm conclusions regarding the response of the lily directly to seasonal grazing, the results suggest that, at the least, seasonal cattle grazing is not detrimental to seedling establishment, and is more likely beneficial. The explanation for the general increase in abundance of mature and flowering plants could be related to several factors other than enhanced seedling establishment, including the effects of a more conducive habitat (as a result of logging and vegetation removal, partly by cows) conducted over the past decade, or multi-year dormancy. However, the increase in mature and flowering plants again suggests seasonal grazing is not immediately detrimental to the lily.

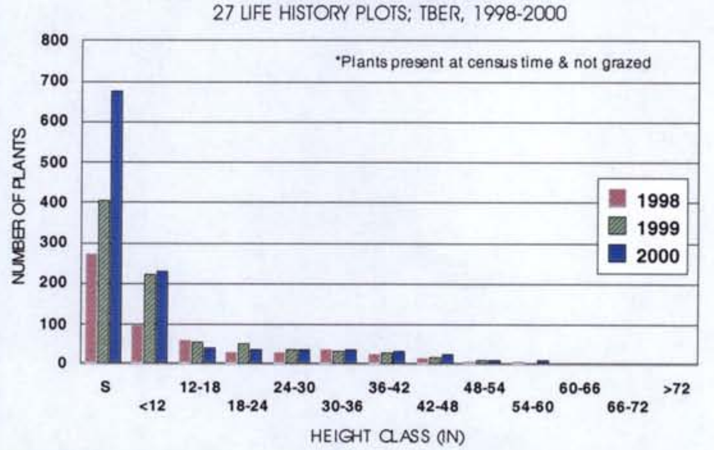
The increase in seedling abundance appeared equally high in all treatments. The increase in mature plants and flowering was greatest in the passive and low intensity grazed plots, even though plants within the high intensity treatment area have shown greater average growth (6.4 inches growth since 1998, compared to +0.7 inches and –1.9 inches change in the other treatments; Table 2). However, it remains too early to draw firm conclusions regarding lily response to grazing intensity and duration.

Photomonitoring: Photomonitoring has been conducted during the annual flowering plant census at 25 permanent photopoints since 1987; an additional 3 photopoints were established in 1994, focused on the 3 vegetation treatment areas included in the Experimental Habitat Restoration Study (one slide set submitted with Imper and Sawyer, 2000b). In 1998, 13 additional photopoints were established to monitor the impact of cattle grazing in the north and south cattle enclosures (locational coordinates and declinations indicated in Table 1). Photographs were taken in June 2000 (Attachment 5), and will continue to be taken annually during the annual plant census.

3.4 Western Lily Life History/Browsing Inhibitor Plot Results

Plant density and growth: Various growth characteristics of the sample populations are compared for the 3 years in Table 2; maps of all plants emerging in 2000 are included as Appendix A. The 2000 field data sheets are included as Attachment 1.

FIGURE 2. WESTERN LILY HEIGHT CLASS DISTRIBUTION; 27 LIFE HISTORY PLOTS; TBER, 1998-2000



Some 274 seedlings and 314 mature lilies were recorded in 1998, 467 seedlings and 496 mature plants in 1999, and 689 seedlings and 502 mature plants this year, for an overall increase of 151% and 60% in seedlings and mature plants, respectively. Number of flowering plants increased from 106 in 1998 to 165 this year, reflecting the trend seen in the overall population (Figure 1). Seedlings comprised the largest size class during all three years (Figure 2), ranging from 46-58% of the plants recorded. No incidence of disease was observed.

Emergence: Emergence was somewhat earlier this year than last: in 1999, 52% of the seedlings and 36% of the mature plants had emerged by April 15, while this year 86% of seedlings and 68% of the mature plants emerged by April 15. Only 3% of mature plants emerged after May 13 this year, compared to 24% of mature plants emerging after May 7 last year. The advanced phenology was expected based on the established relationship between phenology and temperature (5 inches less spring rainfall [7.4 vs. 12.5], and higher average spring temperature

TABLE 2. SUMMARY STATISTICS FOR WESTERN LILY IN 27 LIFE HISTORY PLOTS
TABLE BLUFF ECOLOGICAL RESERVE
SAMPLED BY DAVID IMPER, JOHN MCRAE, JUNE 16-18, 1998, JUNE 12-15, 1999, JUNE 14-15, 2000.

OVERALL LIFE HISTORY (LH) PLOTS (27-6' sq.; 972 sf))	1998	1999	2000
Total LIOC seedlings sampled (single leaf)	274	467	689
#LIOC seedlings sampled per sf*	0.3	0.5	0.7
Total non-seedling plants sampled	314	496	503
Mean ht non-seedling (non-grazed) plants (in)	21	17	20
% incidence mammal grazing (plts still visible at census)	3	4	4
% incidence insect/slug grazing (plts still visible at census)	4	0	0
% incidence disease (plts still visible at census)	0	0	0
Total %plants missing at census time		11	2
#Seedlings missing at census		91	13
%Seedlings missing at census		19	2
#Mature plants missing at census		12	5
%Mature plants missing at census		2	1

Emergence		1999	2000	1999	2000
	%Seedlings	3/20-4/2	PRIOR 3/17	0	9
		4/2-4/16	3/17-4/15	52	77
		4/16-5/7	4/15-5/13	39	11
		5/7-6/18	5/13-6/14	9	2
	%Mature plants	3/20-4/2	PRIOR 3/17	1	2
		4/2-4/16	3/17-4/15	35	66
		4/16-5/7	4/15-5/13	41	29
		5/7-6/18	5/13-6/14	24	3

FLOWERING PLANTS ALL LH PLOTS		1998	1999	2000
Total LIOC flowering		106	132	165
Mean #flowers		2.3	3.0	2.8
Maximum #flwrs		13	12	18
Maximum ht (in)		66	61	66
	DATE	6/18/98	7/8/99	6/14/00
Phenology (%total flowering population)	Bud	93	53	86
(from complete population census data)	Flower	6	41	14
	Fruit	0	6	0

COMPARISON AMONG FENCING/INHIBITOR TREATMENTS (LH PLOTS)

Treatment	*Tall fence*	*Short fence*	*Chemical*	*Control*
1998 (pre-treatment)				
#seedling (present at census)	65	71	64	67
#mature plants (present at census)	77	102	42	91
#mature plants mammal grazed	1	10	4	3
1999				
#seedling (present at census)	57	87	87	145
#seedling (total emerging)	105	127	90	145
#mature plants (present at census)	110	149	48	177
#mature plants (total emerging)	113	150	50	183
#mature plants mammal grazed	3	16	8	18
#mature plants missing at census time or grazed	6	17	10	24
2000				
#seedling (present at census)	173	238	133	232
#seedling (total emerging)	173	238	140	238
#mature plants (present at census)	114	177	47	183
#mature plants (total emerging)	115	177	48	186
#mature plants mammal grazed	4	18	9	26
#mature plants missing at census time or grazed	5	18	10	29

COMPARISON AMONG GRAZING TREATMENTS (~1 acre cells)

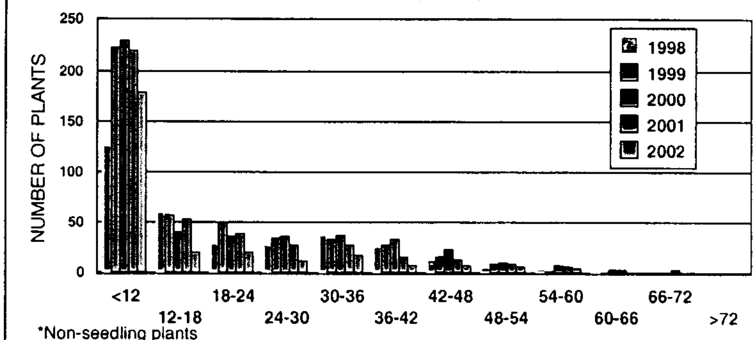
Treatment	*Passive grazing*	*Lo Intensity*	*Hi Intensity*
1998 (treatments not yet implemented)			
#seedling (present at census)	100	65	109
#mature plants (present at census)	116	122	89
#flowering plants	41	25	40
Mean ht mature plants (not grazed)	22.8	17.5	16.2
1999			
#seedling (present at census)	162	88	126
#seedling (total emerging)	167	89	211
#mature plants (present at census)	160	207	117
#mature plants (total emerging)	163	212	121
#flowering plants	47	40	44
Mean ht mature plants (not grazed)	20.1	14.6	21.3
2000			
#seedling (present at census)	341	171	264
#seedling (total emerging)	348	174	267
#mature plants (present at census)	181	227	113
#mature plants (total emerging)	181	231	114
#flowering plants	70	53	48
Mean ht mature plants (not grazed)	23.5	15.6	22.6

# Plots	Name	Treatment
7	Deer Exclosure:"Tall-Fence"	60 inch chicken wire, corner staked
7	Small Mammal Exclosure: "Short-Fence"	18 inch x 0.5 inch mesh fence, corner staked
6	"Chemical" Deer Inhibitor	Coyote urine vial placed at one corner, recharged at 30 day intervals
7	Control	No treatment

The fencing and chemical vials were removed in September of each year and reinstalled the following March in order to avoid interfering with the cattle grazing treatments.

The LH plots were initially monitored in June, 1998, and subsequently have been monitored on 4 dates between March and June from 1999 to 2002 (Table 2A). Single-leaf seedlings were inventoried, mapped, and characterized as to emergence date, extent of browsing or disease, and whether still present at June census. Mature lilies were also inventoried, mapped, and characterized as to emergence date, height, extent of browsing or disease, flowering status, and whether present at census. Presence at census is an indicator of "seasonal success" (or mortality), since plants that are grazed or senesce before census do not necessarily die, but may go dormant for the remainder of the season and then reappear the following year. Maps of all plants emerging in LH plots at TBER during 2002 are included as Appendix A.

FIGURE 2. WESTERN LILY HEIGHT CLASS DISTRIBUTION; 27 LIFE HISTORY PLOTS; TBER, 1998-2002



*Non-seedling plants at June census not grazed

Seasonal Cattle Grazing Applications: All the occupied western lily habitat (~5 acres) at the reserve was opened to passive winter grazing by cattle in 1997. Cattle were able to freely enter the ~35 acre rare plant exclosure each year generally between November and early March.

As part of this study, two 1 acre active grazing treatments were implemented in winter 1998-99, referred to as the North or "low-intensity/long duration" treatment cell, and South, or "high-intensity/short duration" treatment cell (Map 1). A 1,000 gallon water tank and a float-controlled water trough serving the 2 enclosures were installed. The grazing periods to date have been flexible, and based on the following subjective measures: maximum reduction of shrub cover and establishment of cattle trails within shrub canopies; reduction of the majority of *Calamagrostis nutkaensis* culms to between 6 and 12 inches in height; minimal disruption of soil not more than one inch deep, particularly in areas known to support the lily.

1998: Although opened to cattle on December 1, the passively grazed habitat was only utilized by cattle between about January 21 and March 7, 1999 due to scheduling problems with the former grazing lessee. Overall, the intensity of use was less than desired, but was substantial in some areas, particularly along the fences where the cattle created mud trails. Two cows were confined in the North enclosure for 20 days, beginning January 4, and 11 cows were confined in the South enclosure for 5 days, beginning January 21, 1999. Additional grazing would have been beneficial, but the cattle were removed at the request of the lessee.

1999: The new grazing lessee (Clint Victorine) confined his entire herd of 68 cows within the passively treated habitat for 3 days, beginning on February 12, 2000. The herd was then allowed to enter the habitat passively. The gates were closed on about March 1. Beginning on January 18, 2000, two cows were enclosed in the low-intensity treatment cell for 28 days (total 56 animal days), and 12 adults and 13 calves were held in the high-intensity treatment area for 6 days (72 adult days; 78 calf days).

2000: The herd of 68 cows was allowed into the entire exclosure passively beginning on February 2, 2001. The gates were closed on about March 2, when the herd was moved to another area of the wildlife area. Twelve adult cows were held in the high-intensity treatment area for 5 days (60 adult days), and 2 cows were held in the low-intensity treatment cell for approximately 21 days (42 adult days); both treatments began February 2, 2001.

2001: The herd of approximately 70 cows was allowed into the entire exclosure passively between January 7 and late March, when the herd was moved to another part of the wildlife area. Beginning on January 7, 12 adult cows were held in the high-intensity treatment area for about 8 days (96 adult days), and 2 cows were held in the low-intensity treatment cell for approximately 30 days (60 adult days).

2002: This winter, the passive exclosure was opened to the entire herd of adult and young cows for approximately 30 days during February and March. Beginning on January 25, 10 cows were placed in the high-intensity exclosure until February 2 (90 adult days), and two cows were contained within the low-intensity treatment cell until February 24 (31 adult days).

3.3 Vegetation Characterization and Results of Seasonal Grazing

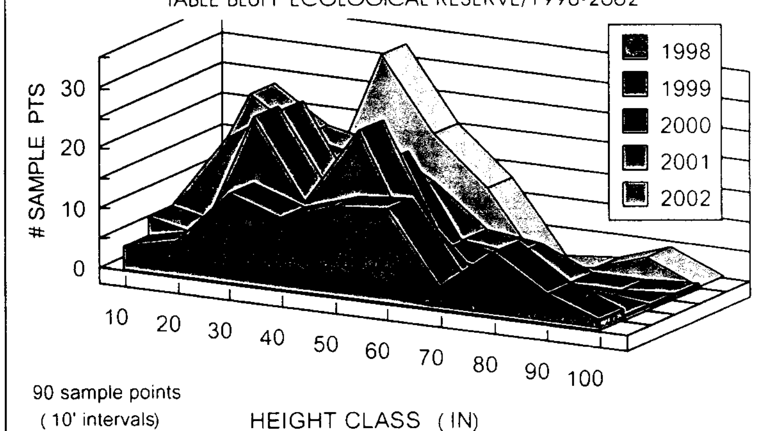
Overall Habitat: Following the standard protocol, general habitat monitoring was conducted across the entire monitoring grid (a total of 4,650 ft. of transects) in October 1998 (Imper *et al.*, 1987). Results were compared to (pre-experimental grazing) habitat data collected in 1989, 1993, and 1996 (Imper & Sawyer, 2001). In general, cover by typical *Coastal prairie* increased significantly after removal of cattle in 1987, but has since stabilized. The *Sweet vernal grassland*, dominated by *Holcus lanatus* and various other "pasture" species, decreased soon after removal of grazing (i.e., converted to *Coastal prairie* or blackberry), but has increased since 1993 in response to thinning of the spruce stand. The *Young spruce forest* (i.e., the dense spruce vegetation type, as opposed to individual trees) declined from 32% cover to 7% in 1998 as a result of thinning (largely converted to *Sweet vernal grassland*). Combined cover of *Rubus ursinus* (blackberry) and *R. spectabilis* (salmonberry) increased from 13% to 31% by 1998, one of the principal reasons for implementing this study.

In 1998, transects were segregated according to the three grazing treatments (passive, low-intensity, and high-intensity) in order to compare the vegetation structure between grazing treatments, and to track the yearly change in vegetation within a grazing treatment (Table 2B; transect segments allocated to each treatment given in Table 1). At each sample point, transect data included %hemispheric cover and height of dominant understory species. Two additional vegetation transects were added to the existing grid network in October 1998 (X=375/Y=0-300 [North enclosure]; X=430/Y=0-300 [South enclosure]) to allow for better representation within the cattle enclosures (low- and high-intensity grazing treatments). Transects within low- and high-intensity grazing treatments were resampled in September 1999, 2000, and 2001; the entire monitoring grid was resampled in September, 2002 (Attachment 1).

Effects of Seasonal Grazing on Vegetation: Despite the differences in duration and intensity of the grazing regimes, after 5 seasons, the mean %hemispheric cover of vegetation (taken 3 ft. above the ground) still remains nearly equal between treatments, probably within the range of sampling variation (Table 2B). The most noticeable decline in %hemispheric cover occurred within the high-intensity grazing cell after the first year of monitoring in 1998 (69% to 62%). Both the low-intensity and high-intensity grazing cells have maintained an average %hemispheric cover of 62-63% since 1998, before increasing slightly this year back to near the original 1998 level. A small decline in %hemispheric cover has also been seen in the passively grazed areas since 1998. Although the mean %hemispheric cover may remain relatively constant, the high standard deviation indicates wide variation within the habitat. Hemispheric cover is heavily influenced by tree cover, which has not materially changed since 1998. There fore, this variable does not necessarily reflect actual change in canopy cover impacting the lily.

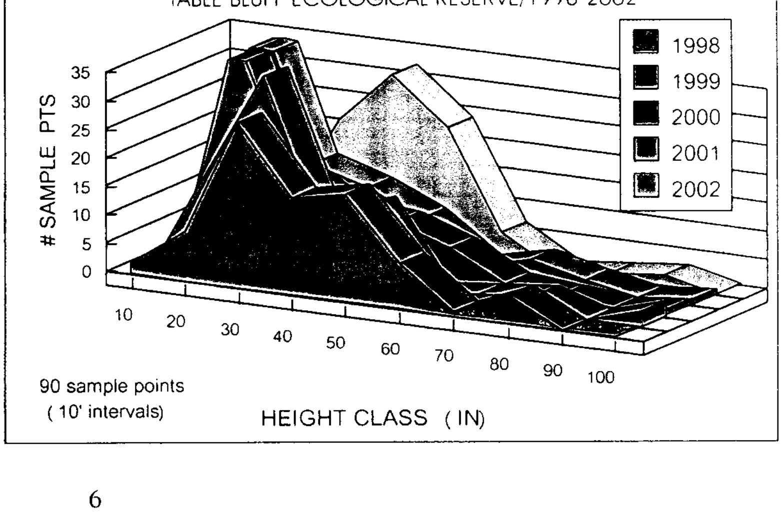
In 2002, the mean vegetation height was not substantially different between the three grazing treatments (Table 2B). Surprisingly since 1999, the high-intensity treatment cell has exhibited the tallest mean vegetation (probably reflecting higher cover by *Rubus* spp.), with the 2002 season recording the peak height since 1998 (39"). More importantly, within the high-intensity cell, the mean vegetation remains 7" below the initial 1998 level, and last year was 16" less than 1998. In contrast, within the low-intensity and passive cells, average vegetation height this year was similar to 1998. These results suggest that high-intensity grazing may be more effective in maintaining reduced vegetation height than the passive or low-intensity grazing, although, test applications of Roundup on *Rubus* spp., particularly in the South (high-intensity) enclosure, may have contributed to the reduction.

FIGURE 3A. VEGETATION HEIGHT IN HIGH INTENSITY (SOUTH) GRZG TRTMT
TABLE BLUFF ECOLOGICAL RESERVE/1998-2002



The profiles of the vegetation structure within the high- and low-intensity treatment cells indicate a noticeable shift in the dominant size classes (Figures 3A and 3B). Until 2001, the majority of sample points recorded in both cells was ≤40"; this year, most sample points were generally ≥40". These shifts are reflected in the increase in the mean vegetation height for 2002 within both the high- and low-intensity cells (+8" in the low-, and +9" in the high-intensity), and also likely due to the increased cover of *Rubus spectabilis* and *R. discolor* (Table 2B). In general, the high standard deviation for all treatments reveals a trend toward development of a mosaic pattern of taller vegetation "islands" within the habitat (i.e., spruce or *Rubus* thickets), and maximizing "edge", which is thought to benefit the lily by providing protection from deer browsing.

FIGURE 3B. VEGETATION HEIGHT IN LOW INTENSITY (NORTH) GRZG TRTMT
TABLE BLUFF ECOLOGICAL RESERVE/1998-2002



It appears that all of the grazing treatments conducted over the past 4 winters (passive throughout exclosure, and 2 confined treatments) were at least moderately successful at maintaining vegetation. Informal observations suggest that impacts produced by a large number of cattle confined for a short period (high-intensity, short duration treatment) are more evenly distributed, and cause fewer trails and less severe soil disruption than in the low-intensity area. The two cows in the low-intensity treatment have tended to use the same pathways repeatedly, and have concentrated grazing impacts in smaller areas, resulting in greater soils disruption within the "south glade" lily habitat in the North enclosure (Map 1).

The %cover of the broad-scale, general habitat types has remained relatively stable within grazing treatments from 1998 to 2001 (Table 2B). *Sweet vernal grassland* remains the dominant habitat type within the passive and low-intensity treatment areas, while in the high-intensity cell, *Coastal prairie* is dominant. The %cover of *Willow scrub* and *Young spruce* have remained constant within treatments, suggesting this vegetation is relatively stable, or is maintained by seasonal grazing.

A more detailed sampling of the %cover of the principal species occurring in lily habitat indicates that the high-intensity grazing cell has a greater mean cover of salmonberry (*Rubus spectabilis*), himalayan berry (*R. discolor*), and barren understory than the low-intensity and passive cells (Table 2B). In contrast, %cover of trailing blackberry (*R. ursinus*) was reduced in the high-intensity grazing cell by 11% since 1998, compared to little change in the low-intensity and passive cells. These results suggest that the high-intensity, short duration grazing regime may be more effective at controlling blackberry than the woody *Rubus* spp. *Calamagrostis nutkaensis* cover (the leading indicator species for *Coastal prairie*) was the highest in both the high- and low-intensity cells since the 1998 monitoring; however, within the passively grazed area, this native grass has been reduced by nearly half.

FIGURE 4A. FLOWERING LILY INCIDENCE BY GRAZING TREATMENT ENTIRE FLOWERING POPULATION; TBER, 1997-2002

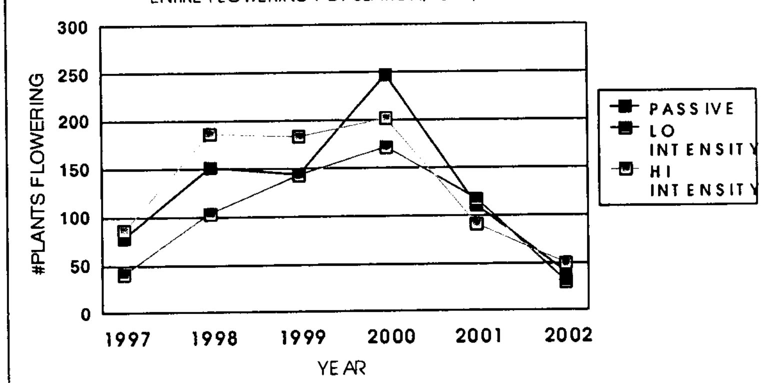
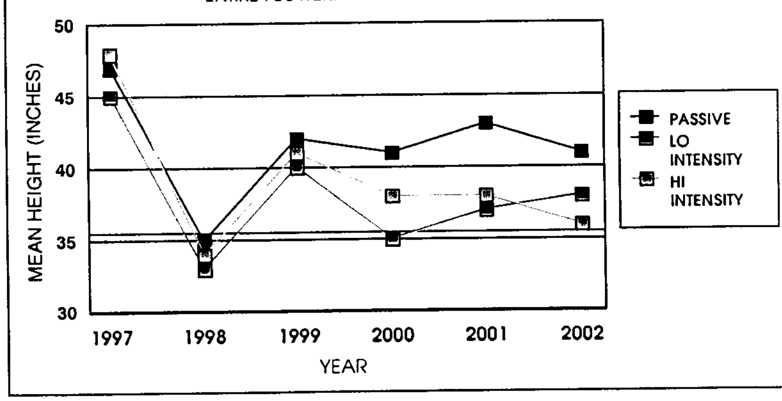
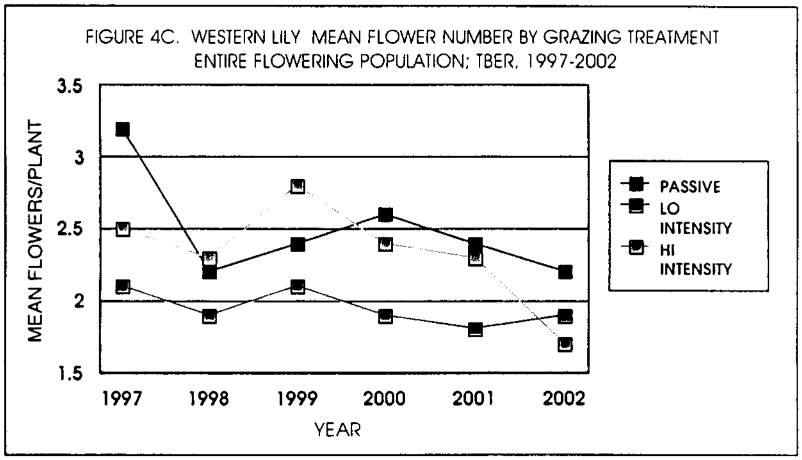


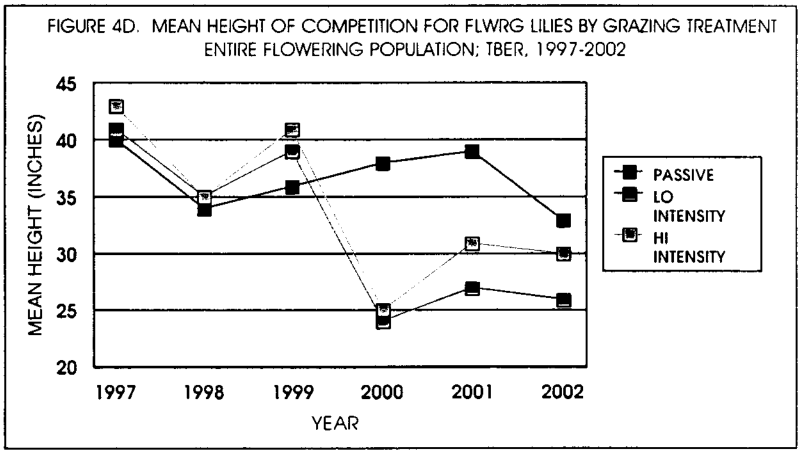
FIGURE 4B. WESTERN LILY MEAN HEIGHT OF FLOWERING LILIES BY GRAZING TREATMENT ENTIRE FLOWERING POPULATION; TBER, 1997-2002



Effects of Seasonal Grazing on Western Lily: Since 2001, the total number of flowering plants present at census in all grazing treatments has dramatically declined due to deer browsing (Figure 4A, Table 2A). In 2002, the number of flowering plants was generally evenly distributed across grazing treatments, as most plants were located within Tall-Fence plots where they were protected from grazing. Thus, the location of flowering plants during the extreme browsing years of 2001 and 2002 was primarily an indicator of the effectiveness of the Tall-Fence browsing inhibitor treatment and not a particular grazing regime. Prior to 2001, the number of flowering plants has increased steadily in all treatments.

Following a dramatic decline in the mean height of flowering lilies, from >45" in 1997 to <35" in 1998, mean heights have remained relatively constant within treatments after rebounding to ~40" in 1999 (Figure 4B, Table 2A). This decline was likely a response to the initial thinnings and reintroduction of cattle during 1997. In 2000, the difference in mean height of flowering plants between treatments began to appear, the tallest plants being located within the passive treatment area. However, the distinction in heights during 2001 and 2002 are unreliable due to the influence of severe deer browsing. The mean number of flowers per plant has also been greatest in the passive treatment, although this variable is highly correlated with height, and thus is also influenced by deer browsing (Figure 4C). These results give some indication that the passively grazed area (with no specified duration or intensity) is more conducive to robust plant growth, however, the data is biased due to browsing.





The mean height of flowering lilies has generally paralleled the changes in height of the competing vegetation (Figures 4B and 4D). Although severe browsing prevents making a direct correlation between the mean height of flowering lilies and the mean height of the competing vegetation, the overall reduction in flowering plant height in all treatments is consistent with the reduction in height of competing vegetation in all treatments. The passively grazed area has exhibited the tallest mean heights, while the actual treatments (low- and high-intensity) have shorter vegetation on average.

Results from the LH plots indicate that generally the greatest increase in seedlings emerging occurs within the passive treatment area (Table 2A). Since 1998, the greatest percent increase has occurred within the passive treatment (480%), followed by low-intensity (434%) and high-intensity (236%). The consistent increase in number of seedlings emerging for all treatments over the past 5 years is consistent with the increase in flowering and fruit production until 2000 (Figure 1).

This year, the percentage of seedlings still present at June census is substantially lower than in previous years. This decline in seasonal survival for seedlings does not appear associated with an increase in small mammal activity, given the decline in seasonal survival for all treatments in the browsing inhibitor plots (described below). In 2002, the percentage of seedlings present at June census was generally equal between treatments. Although the passively grazed area exhibited the lowest average seasonal survival in 2002, given the high number of seedlings initially, this area overall had the greatest number of seedlings still present at census.

Although the number of emerging mature plants declined only slightly from 2001, overall, the total number of mature plants has gradually increased since 1999 for all treatments (Table 2A). Since 1998, the overall percent increase in emerging mature plants has been greatest in the passively grazed area (13%), followed by the high-intensity treatment (10%) and the low-intensity treatment (3%).

Similar to seedlings, the percentage of mature plants still present at June census declined significantly for all treatments in 2002 (to ~50%), likely due in part to the high level of deer browsing, and perhaps weather extremes that may have also contributed to desiccation of seedlings. For 2002, the seasonal survival of mature plants was generally equal between treatments, indicating that factors other than grazing treatment are likely responsible for the apparent loss of plants.

Although we have no non-grazed treatment, in general, seasonal cattle grazing has been associated with an increase of seedlings and mature plants over time (Table 2A). Low to moderate grazing intensity (passive and low-intensity treatments) seems to have allowed a greater increase in seedling establishment than the high-intensity treatment, possibly due to a greater likelihood of trampling by cattle. However, there has been no significant difference in the increase in mature plants among grazing treatments since 1999. Therefore, while seedling establishment may be greater in the low to moderate intensity grazing regime, it is too early to determine whether that affect carries on into the mature population.

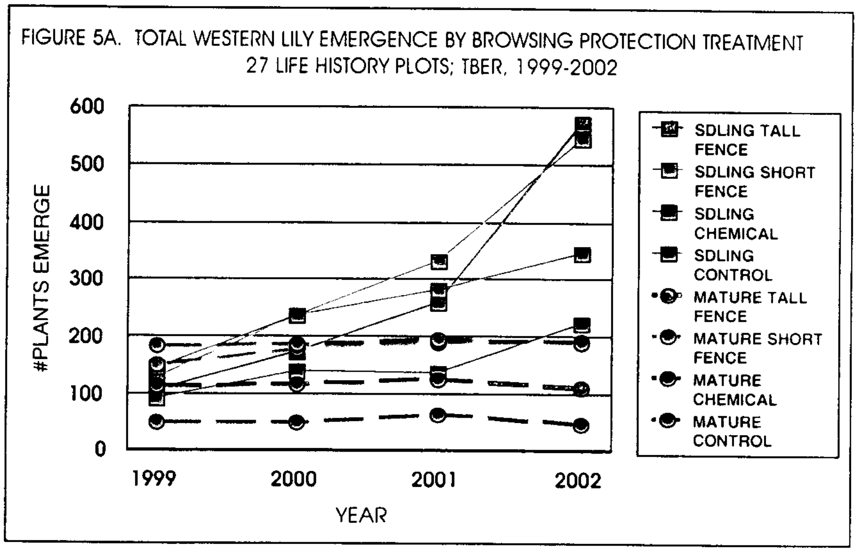
Photomonitoring: Beginning in 1987, photomonitoring was conducted during the annual flowering plant census at 25 permanent photopoints. An additional three photopoints were established in1994, which focused on the three vegetation treatment areas included in the Experimental Habitat Restoration Study (since abandoned). In 1998, 13 additional photopoints were established to monitor the impact of cattle grazing in the North and South cattle enclosures (location coordinates and declinations indicated in Table 1). The photomonitoring was most recently conducted in October 2001; no photomonitoring was conducted in 2002. The photomonitoring provides a visual record of the quantitative data recorded.

3.4 Western Lily Life History/Browsing Inhibitor Plot Results

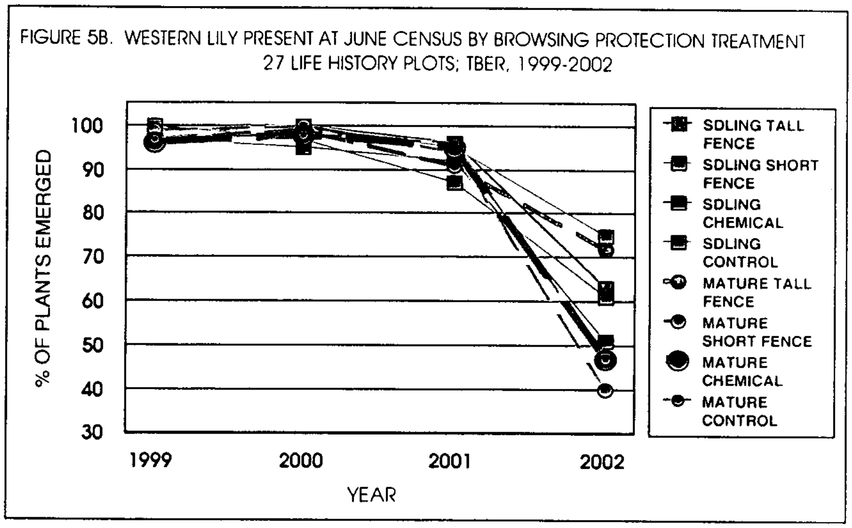
Plant Density and Growth: Various growth characteristics of the population are compared for the previous 5 years in Table 2A. In 2002, seedlings accounted for 76% of the total number of individuals in LH plots, although 35% of these were missing at the time of the June census. Mature plants were far fewer in number (24%) and suffered a higher rate of seasonal mortality (51%) than seedlings, likely due to heavy deer browsing during the growing season. The LH plots only contained 65 of the total 120 flowering plants recorded during the 2002 annual census (54%). Based on the LH plot data, about 3% of the overall lily population at TBER in 2002 were flowering individuals, and approximately 21% were non-flowering, multi-leaved individuals. Over half of the mature, ungrazed plants were 12" tall or less (Figure 2). Although the total number of mature plants in each size class varies somewhat between years, the juvenile, non-flowering, sector of the population consistently remains the dominant size class following seedlings. This demographic pattern seems to be typical for long-lived perennial plants.

Results of Browsing Inhibitor Treatments: Since 1998, the total number of seedlings emerging in all treatments has been steadily increasing (Table 2A, Figure 5A). The annual increase in total number of seedlings had been relatively constant from 1999 to 2001, but in 2002, there was a substantial increase, especially within the Tall-Fence and Short-Fence plots. The greatest percent increase in emerging seedlings since 1998 has occurred within the Tall-Fence plots (~550%), followed by Short-Fence (~430%), Chemical (~250%), and Control plots (~230%).

Until 2001, the percentage of seedlings still present in June in all treatments averaged above 90%; however, in 2002, the seasonal survival of seedlings had dropped to an average of 63% for all treatments. This decline in seedlings was generally evenly distributed across browsing inhibitor treatments. In 2002, although the total number of seedlings was greatest within the Tall-Fence plots, the highest percentage of seedlings still present at June census was found within the Short-Fence plots (Table 2A, Figure 5B). These results indicate that fencing is beneficial for seedling recruitment, shown by the Tall-Fence plots that receive no deer grazing, and the Short-Fence plots that receive deer browsing but deter predation by small mammals and slugs. The number of seedlings in Control and Chemical plots continued to increase, but at a smaller rate.



In general, the number of mature plants emerging within each treatment has remained consistent since 1999 (Figure 5A, Table 2A). Overall, and including 2002, the Short-Fence and the Control plots have had the greatest number of emerging mature plants, unexpected given that these plots allow for the greatest deer browsing opportunities. The percent change in number of mature plants has been slight since 1998, ranging from an overall increase of 28% for Short-Fence plots to an overall decrease of 10% for Chemical plots (Table 2A). Tall-Fence plots have had only a 1% increase in the number of mature plants since 1998. An increase in the vegetation cover within Tall-Fence plots, due to complete lack of browsing during the entire growing season, could explain the lower number of emerging mature lilies found there. The number of mature plants emerging in the Short-Fence plots is more than 4 times greater than the Chemical plots, which suggests either that the coyote urine may not work at all in deterring deer browsing, or, that repelling deer is indirectly reducing browsing of competing vegetation, and thus inhibiting emergence of mature plants.



From 1998 until 2001, the seasonal survival of mature plants has averaged above 90% for all treatments (Table 2A, Figure 5B). However in 2002, the percentage of mature plants still present at June census had significantly dropped for all treatments, most dramatically within the Short-Fence, Control, and Chemical plots (to less than 50%). For 2002, the highest seasonal survival was found within the Tall-Fence plots (72%).

The primary browser of mature plants in all years appears to be deer, which were best deterred by the Tall-Fence exclosures. Mature lilies located outside the Tall-fence plots that escaped deer browsing were generally camouflaged by dense vegetation. Most of these lilies were stunted in growth, and produced fewer flowers and fruits (Bencie and Imper, 2003). The Chemical plots had the same percent seasonal survival as Control plots for mature plants, and thus offered no additional protection against deer browsing.

3.5 Western Lily Recruitment Studies

3.51 Western Lily 1998 Seed Plots

As part of the current study, twelve 1 ft^2 seed plots were established in each of the three grazing treatment areas (Map 1). A short rebar stake was placed at the northwest corner of each plot. Location coordinates and grazing treatment for each Seed Plot are given in Table 1. On October 6, 1998, 50 visibly healthy seeds were planted in each test plot prior to introduction of cattle. A total of 600 seedlings were planted per treatment.

In July 2002, the number of seedlings and multi-leaved individuals were counted. Overall, survival after 4 years was 15.1% for all plots, with the greatest percent survival occurring within the high-intensity plots (9.8%) and the lowest within the passively grazed area (0.3%). The greatest number of seedlings occurred in plots located within the high-intensity enclosure (54 seedlings). The low-intensity plots had less than half as many seedlings (25), while the passive treatment plots contained only 2 seedlings. The number of multi-leaved individuals was equal in both the high- and low-intensity treatments (5), but no multi-leaved plants were found within the passively grazed area. Plots located in the passive area seemed disproportionately impacted by heavy cattle traffic, which may have lowered the survival rate of seedlings. Regardless of the possible bias, these data suggest that seasonal grazing is compatible with seedling recruitment.

Examining these data according to habitat type, the results are consistent with data collected from the 1993 Seed Plots (described below). *Spruce forest* plots had an overall survival rate after 4 years of 8.6%, twice the rate of the *Coastal prairie* plots (4.3%). Overall survival for the *Coastal Prairie* plots is greater here than in the 1993 Seed Plots, likely due to most of the plots being located within occupied lily habitat where a suitable moisture regime is present.

In fall 1993, a total of 48 plots in *Spruce forest* and *Coastal prairie* were planted with 100 seedlings each as part of a habitat manipulation study. In 1999, a total of 27 seedlings and 3 multi-leaved individuals were found within the *Coastal prairie* plots, giving an overall survival rate of 1.2% after 5 years; seedlings in *Coastal prairie* were not counted during 2002. Within the *Spruce forest* plots in 2002, a total of 84 seedlings and 61 multi-leaved plants (including 12 flowering) were recorded. This data gives an estimate of an overall survival rate for seedlings and mature plants in *Spruce forest* of only 6.0%, down from 8.4% in1999. These results provide the minimum estimate given the impacts of deer and cattle grazing, and indicate that survival of seedlings and mature plants is greater in *Spruce forest*.

3.52 Western Lily Seed (Cow) Ingestion Study

On January 18, 1999, 500 healthy western lily seeds were fed to a cow, provided by the grazing lessee, confined in a pen at his ranch near Loleta. The cow was initially deprived of food for 24 hours in order to encourage consumption of the grain. The seed was then added to several pounds of grain, and fed to the cow (confined by a stanchion). The excrement was collected every 12 hours thereafter for 36 hours, and transported to TBER, where it was placed in a fenced area near grid coordinates 270/300 (Map 1).

As of this year, no seedlings have emerged. These results are unexplained, but suggest either the excrement was not collected for a long enough period after the seed was fed to the cow, or complete mortality occurred, perhaps due to the altered diet of the cow prior and during the period the excrement was collected. Based on these results, this monitoring should be discontinued.

3.53 Western Lily Recruitment in Cattle Trails

In June, 1998, three 3 ft^2 plots (CTP #1-3; Map 1) were permanently marked in existing cattle trails located within the south enclosure, in order to monitor lily seedling density and fate, and soil compaction in trails created during the past 2 years of passive winter cattle grazing (and likely impacted by human traffic). Location coordinates are given in Table 1. For each plot, a rebar stake was placed at the southwest and northwest corners. In June or July of each year since 1998, all western lilies were recorded and mapped within the plot (centered on the cattle trail) and also within two 3 ft^2 plots adjoining the central plot on both sides of the trail. In 1998, 1999, and 2000, soil core samples were collected between 4 and 10 inches below the ground surface from each center plot and one of the adjacent plots. Samples were retrieved by driving a 1.37" diameter x 4 inch thinwall brass tube, sharpened on the leading edge. Each sample was immediately labeled and sealed with duct tape until weighed to the nearest gram. Samples were then extruded and dried to oven dry weight at 105 degrees Celsius, then reweighed to calculate bulk density and %moisture.

Soil Compaction: No bulk density samples were collected in 2001 or 2002 due to the potential cumulative impacts of the destructive soil sampling on the surrounding lily population. We suggest collecting the bulk density samples not more than once per 3 years for these plots. Bulk density and %moisture results for each plot from 1998 to 2000 are given in Table 3. Average soil bulk density for the 6 samples (3 trail, 3 adjacent) in 2000 was 54 pounds per cubic foot (pcf), ranging from 54-62 pcf in the trail plots, and 46-54 pcf in the adjacent plots (Table 3). Those data were similar to 1998, when average bulk density for all 6 samples was 58 pcf (ranging 50-61 in trail and 54-59 in adjacent plots). The sample sizes are too small to enable meaningful statistical comparison; however, the observed trends suggest shallow soil bulk density may be higher within the trails compared to adjacent soils, but there has been no obvious increase from year to year.

Seedling Fate: The results from monitoring seedling and mature plants within cattle trail plots are summarized in Table 3. As expected given the seasonal impacts on the trails from cattle, occurrence of seedlings, and to a lesser extent mature plants, within the plots was highly variable from year to year. The observed number of seedlings in 2002 was the lowest recorded since 1999, and the number of mature plants in 2002 was the lowest since 1998. This indicates an overall decrease of 22% in the number of seedlings since 1998, and an overall decrease of 50% for mature plants since 1998. Although subject to error due to variability in actual emergence location, difficulty in distinguishing the same plants each year, and the potential for multi-year dormancy, evidence indicates a high rate of turnover in seedlings from year to year (i.e., few seedlings survive more than 1-2 years). There is to date almost no evidence (3 questionable plants) of development of seedlings into multi-leaved plants occurring within the 5 year period.

In some cases, the trails have wandered or expanded over the years outside the initial trail center plot into the adjacent plots. Where this has happened, the number of seedlings in the adjacent plots have tended to increase, sometimes substantially (e.g., plots 1 west, 2 south). The appearance of several mole hills in several plots has confounded these results.

3.6 Soil Compaction Characterization

In October 1998, and September 1999 to 2002, between 5 and 7 soil cores were sampled at random locations within each of the three grazing treatments. Sample methodology and preparation were as described above.

Average dry bulk density for the 15 core samples in 2002 was 58 pcf, comparable to the 2001 level (57 pcf), but less than previous years ranging from 62 to 64 pcf (Table 3). The range in bulk density

TABLE 3. SOIL BULK DENSITY AND MOISTURE RESULTS, SEP 99, OCT 98, SEP 2000 - 2002.

		1998			1999				2000				2001				2002			
	Sample	Moisture	B. Dens.	Group B.D.	Sample	Moisture	B. Dens	Group B.D.	Sample	Moisture	B. Dens	Group B.D.	Sample	Moisture	B. Dens	Group B.D.	Sample	Moisture	B. Dens	Group B.D.
Location	ID	(%)	(#/cf)	Means	ID	(%)	(#/cf)	Means	ID	(%)	(#/cf)	Means	ID	(%)	(#/cf)	Means	ID	(%)	(#/cf)	Means
So. Grazing		35	54			26	64		11	23	56		1	34			1	22	47	
Trtmnt		45	49			28	61		12	22	59		2	30	54		2	21	54	
Cell		37	61			30	69		13	26	64		3	35	59		3	32	52	
		36	55			28	61		14	23	68		4	34	46		4	23	50	
		34	63	56		28	64		15	19	73	64	5	32	54	58	5	26	65	64
						39	51						6	32	60					
						30	64	62												
								2 sided t test 1998-99 P>0.1				*1998-2000 P=0.08*				*1998-2001 P>0.1*				*1998-2002 P>0.1*
No. Grazing		36	65			25	66		6	16	63		13	31	65		6	28	62	
Trtmnt		46	63			25	63		7	24	67		14	28	58		7	32	56	
Cell		26	64			33	60		8	20	65		15	43	52		8	19	63	
		42	67			51	50		9	20	65		16	30	59		9	37	56	
		33	58	63		26	52		10	24	53	63	17	33	45	56	10	29	59	59
						54	60						18	29	56					
						33	63	59												
								t statistic 1998-99 P>0.1				*1999-2000 P>0.1*				*1998-2001 P=0.04*				*1998-2002 P=0.1*
Passive		31	65			36	50		1	18	65		7	37	61		11	25	63	
Grazing		30	58			22	64		2	17	66		8	19	65		12	24	63	
Trtmnt		25	63			30	69		3	14	63		9	26	52		13	29	61	
			64			24	74		4	22	63		10	25	60		14	24	59	
		21	74	65		24	63		5	16	62	64	11	29	61	59	15	30	56	61
						27	64	64					12	26	56					
								t statistic 1998-99 P>0.1				*1999-2000 P>0.1*				*1998-2001 P=0.1*				*1998-2002 P>0.1*
Cattle Trail	1ctr	46	60			28	61		16	38	62									
Seed	1east	45	49			32	59		17	21	54			NOT				NOT		
Plots	1west																			
	2ctr	21	74			35	55		18	14	54			SAMPLED				SAMPLED		
	2north	39	58			29	57		19	14	51									
	2south																			
	3ctr	46	52			33	50		20	13	58									
	3north	44	52			30	54		21	21	46									
	3south			58				56				54								
								t statistic 1998-99 P>0.1				*1999-2000 P>0.1*								
Overall Mean		36	60			31	60			20	61			31	57			27	58	

Notes:

Soil bulk density values are dry weight; samples = 1.37" dia. x 4" or 6" brass tubes driven into soil between 4 and 10" below surface, oven-dried @ 105d C. to constant weight.

Cattle trail plots = 3' x 3', centered on cattle trails in optimum LIOC habitat.

TABLE 3 (CONTINUED). LIOC CENSUS RESULTS IN CATTLE TRAIL PLOTS, TBER, JUN/JUL 1998-2002.

WESTERN LILY IN CATTLE TRAILS

Cattle Trail	1998		1999		2000		2001		2002		NOTES
Plots	#sdlings*	#mature	#sdlings	#mat	#sdlings	#mat	#sdlings	#mat	#sdlings	#mat	
1ctr	20	0	11	0	7	0	7	0	2	0	'98-Trail thru ctr of 1CTR; '00-trail shift to w. into 1W (~30%); 01-2 molehills in CTR, 1 in 1W plot
1east	2	3	1	2	1	1	3	2	0	0	
1west	2	0	3	0	5	0	9	0	1	0	
2ctr	49	9	50	15	88	14	111	10	66	8	'98-Trail thru ctr of 2CTR; '00&'01-trail expand into 2N & 2S (~40% ea plot); '01-1 molehill in 2N and 2CTR
2north	10	6	4	8	3	7	3	1	0	1	
2south	11	9	13	11	45	10	32	11	7	2	
3ctr	19	3	14	4	16	6	20	6	10	4	'98-Trail thru ctr of 3CTR plot; '00&'01-1 molehill in CTR plot; no chge in trail since '98
3north	2	2	4	1	10	3	9	4	2	0	
3south	1	1	5	3	3	1	7	1	7	1	
Totals	116	33	105	44	178	42	201	35	95	16	

WESTERN LILY PERSISTENCE IN CATTLE TRAILS (#YEARS OBSERVED)

	1 YEAR		2 YEARS		3 YEARS		4 YEARS		5 YEARS				
	#sdlings*	#mature	#sdlings	#mat	#sdlings	#mat	#sdlings	#mat	#sdlings	#mat	#SDLGS OBSERVED ADVANCING TO MATURE STAGE (ANY YEAR IN 3)		
1ctr	14	0	2	0	3	0	1	0	2	0	0		
1east	3	1	2	0	0	1	0	1	0	0	0		
1west	5	0	4	0	1	0	1	0	0	0	0		
2ctr	86	9	0	5	58	3	6	1	5	5	3?		
2north	13	4	2	1	1	4	0	0	0	1	0		
2south	71	4	8	3	0	2	4	3	0	2	1?		
3ctr	43	3	6	0	1	5	4	0	2	1	1?		
3north	16	1	3	0	2	1	0	2	0	0	0		
3south	8	1	0	0	5	1	0	0	0	0	1?		
Totals	259	23	27	9	71	17	16	7	9	9	6	EST'D TOTAL UNIQUE PLANT	429
%TOTAL SDLG/ MATURE PLANTS	60	5	6	2	17	4	4	2	2	2			

* Seedlings = single leaf; mature = multi-leaved.

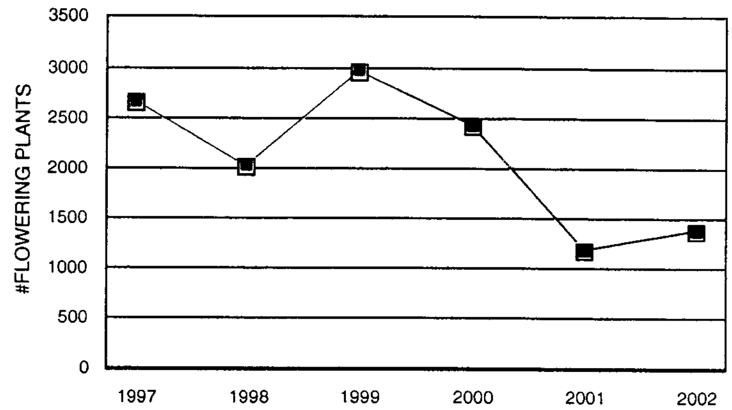
samples this year was 47-65, compared with 45-65 in 2001, 46-73 (2000), 50-74 (1999), and 49-74 (1998). These results correlated well with the mean density for samples collected in the *Coastal prairie* in 1992 (59 pcf; n=4) and 1994 (63 pcf; n=6). For comparison, the mean bulk density measured in the nearby *Tall fescue grassland* soils (unsuitable lily habitat) was 70 pcf (n=4) in 1992 (Imper and Sawyer, 1994). In 2002, samples from the passively grazed area had the greatest average bulk density. Statistical comparison (Student's t-test) between the overall means, and the group means for bulk density for each grazing treatment between 1998 and 2002 showed no significant differences ($P \geq 0.10$). There is no indication to date that the grazing regimes are causing an increase in bulk density.

4.0 CRESCENT CITY MARSH WILDLIFE AREA

4.1 Western Lily Population Status

Due to the large and widely distributed western lily population at the CCMWA, no complete flowering census has been conducted to date. The population monitoring protocol implemented in 1997 incorporated a series of 12 foot x 20 foot belt transects in the North Marsh, and 12 foot diameter circular plots in the South Marsh, systematically located and permanently marked for reference each year (Imper and Sawyer, 1997; Maps 2, 3, and 4). All flowering plants and a portion of the vegetative plants were recorded within an area of 8,650 square feet (sf). Based on the number of flowering plants counted in the North and South Marshes (80 and 130, or 2.2 and 3.0 plants/100 sf, respectively), and the estimated square footage of equivalent high density occupied habitat in each marsh (26,400 and 69,400 sf, respectively), the entire flowering population in 1997 was estimated to be about 2,660 (not counting some 580 flowering and non-flowering plants estimated to occupy "low density" habitat that year).

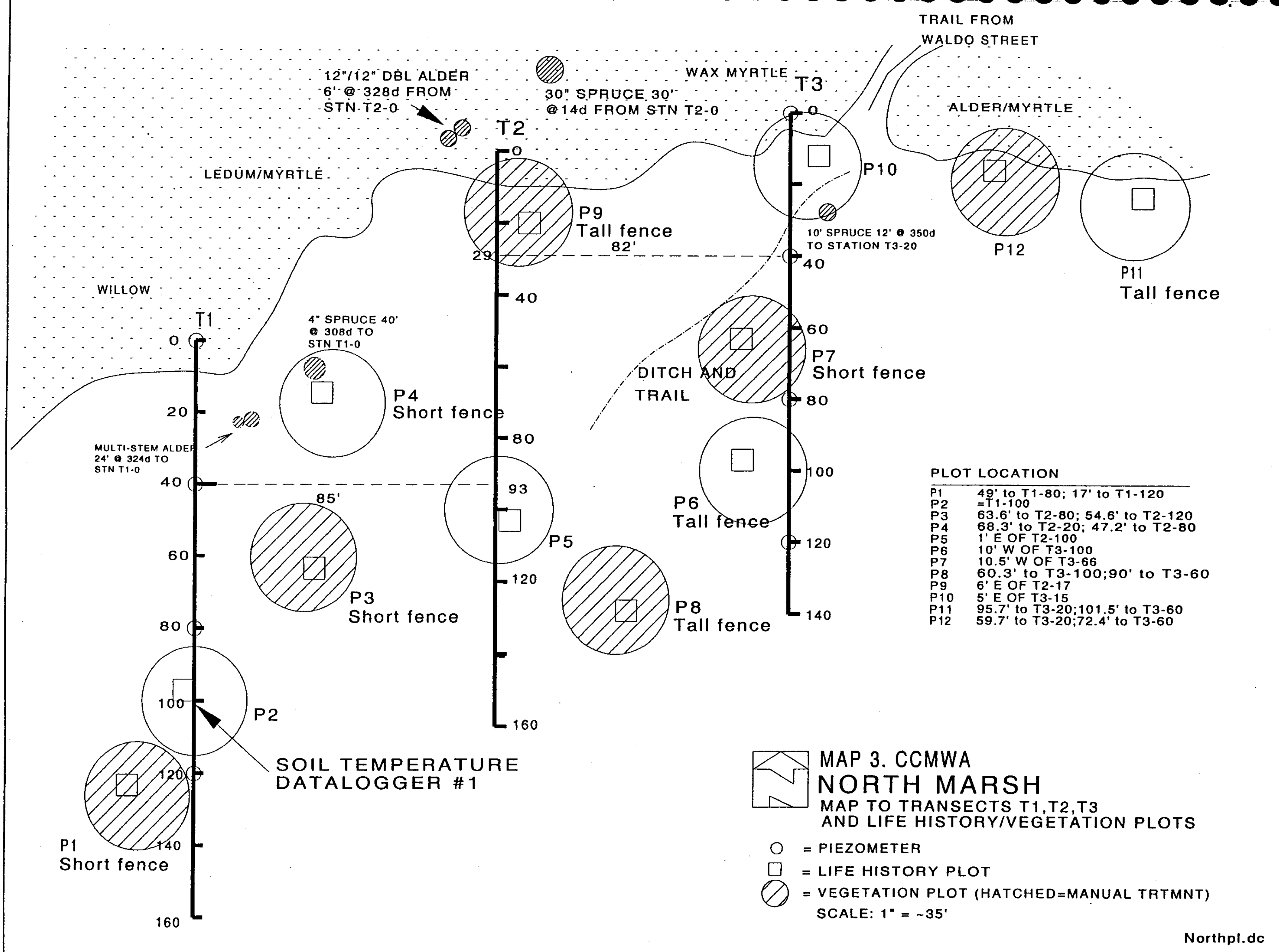
FIGURE 6. ESTIMATED WESTERN LILY FLOWERING PLANT ABUNDANCE CCMWA/1997-2002



*Hi density habitat only
Based on census 8650 sf (1997) and 16,956 sf (1998-2001)

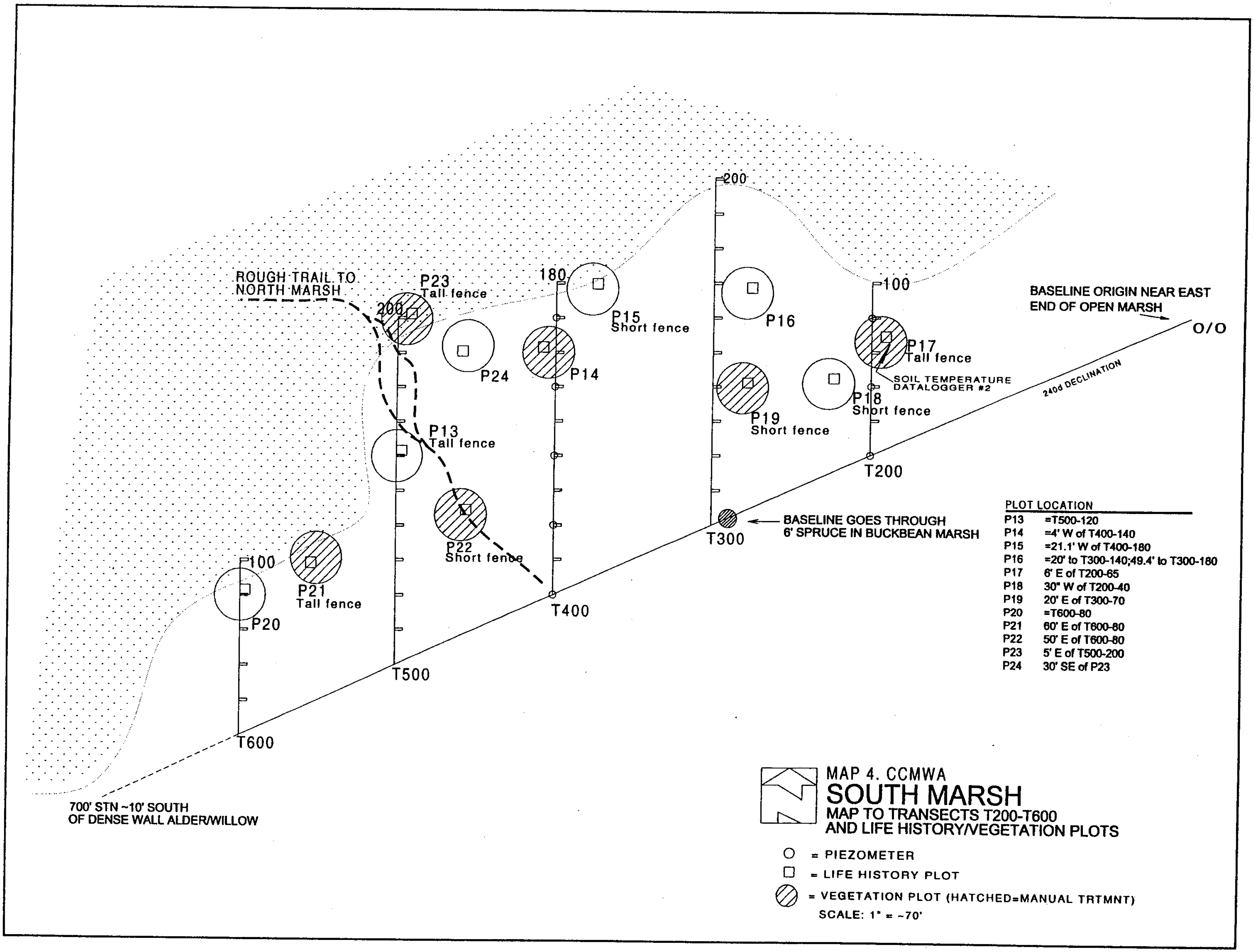
The revised protocol implemented in 1998 for this study included a flowering census based on twenty-four 30 ft. diameter circular plots, for a total sample area of 16,956 sf. All flowering lilies within each plot were recorded and mapped in July from 1998-2002 (2002 maps are given in Appendix B). Assuming the 8,478 sf sampled in each marsh qualifies as "high density" habitat defined in 1997, the estimated total number of plants flowering in 2002 was 1,377 (2,016 in 1998, 2,996 in 1999, 2,430 in 2000, and 1,186 in 2001; Figure 6; Table 4). These estimates do not include a small number of plants located on private property west of the 2 marshes, or habitat considered to have plants at low density. The (non-statistical based) estimates suggest that 1997 and 1999 were peak population years, while 2001 and 2002 were poor years for flowering lilies. The sharp decline in population size in 2001 remains unexplained.

Based on the ratio of flowering to vegetative plants observed emerging in the LH plots this year at CCMWA, the total population likely exceeded the flowering population by a factor of ~9, indicating a total estimated population size of ~12,000 individuals occupying high-density habitat. In 2002, the



PLOT LOCATION

P1	49' to T1-80; 17' to T1-120
P2	=T1-100
P3	63.6' to T2-80; 54.6' to T2-120
P4	68.3' to T2-20; 47.2' to T2-80
P5	1' E OF T2-100
P6	10' W OF T3-100
P7	10.5' W OF T3-66
P8	60.3' to T3-100;90' to T3-60
P9	6' E OF T2-17
P10	5' E OF T3-15
P11	95.7' to T3-20;101.5' to T3-60
P12	59.7' to T3-20;72.4' to T3-60



ROUGH TRAIL TO NORTH MARSH
P23 Tall fence
200
180
P15 Short fence
200
P16
100
BASELINE ORIGIN NEAR EAST END OF OPEN MARSH
O/O
P17 Tall fence
SOIL TEMPERATURE DATALOGGER #2
240d DECLINATION
P24
P14
P19 Short fence
P18 Short fence
P13 Tall fence
T200
P22 Short fence
BASELINE GOES THROUGH 6' SPRUCE IN BUCKBEAN MARSH
T300
100
P21 Tall fence
P20
T400
T500
T600
700' STN ~10' SOUTH OF DENSE WALL ALDER/WILLOW
PLOT LOCATION
P13 =T500-120
P14 =4' W of T400-140
P15 =21.1' W of T400-180
P16 =20' to T300-140;49.4' to T300-180
P17 6' E of T200-65
P18 30" W of T200-40
P19 20' E of T300-70
P20 =T600-80
P21 60' E of T600-80
P22 50' E of T600-80
P23 5' E of T500-200
P24 30' SE of P23
MAP 4. CCMWA
SOUTH MARSH
MAP TO TRANSECTS T200-T600 AND LIFE HISTORY/VEGETATION PLOTS
= PIEZOMETER
= LIFE HISTORY PLOT
= VEGETATION PLOT (HATCHED=MANUAL TRTMNT)
SCALE: 1" = ~70'

TABLE 4. SUMMARY STATISTICS FOR WESTERN LILY IN 24 LIFE HISTORY AND VEGETATION PLOTS,
CRESCENT CITY MARSH WILDLIFE AREA
SAMPLED BY R. BENCIE, K. WEAR, JULY 1998-2002

OVERALL LIFE HISTORY PLOTS (24-6 ft sq.)	NORTH MARSH					SOUTH MARSH				
BY MARSH	1998	1999	2000	2001	2002	1998	1999	2000	2001	2002
Total area sampled (sf) :	432	432	432	432	432	432	432	432	432	432
Total LIOC seedlings sampled (single leaf)	43	102	148	72	53	179	194	217	131	200
#LIOC seedlings sampled per sf	0.10	0.24	0.34	0.17	0.12	0.41	0.45	0.50	0.3	0.46
Total LIOC non-seedling sampled	81	137	139	64	67	74	79	87	30	41
Mean ht non-seedling plants (in)	33	23	19	17	18	35	29	20	19	19
% incidence mammal grazing (plts still visible at census)	3	2	0	0	9	1	0	1	1	1
% incidence insect/slug grazing (plts still visible at census)	1	0	0	0	6	0	0	0	0	0
% incidence disease (plts still visible at census)	0	0	0	0	0	0	0	0	0	0
MARSHES COMBINED										
Total %plants missing at July census; both marshes combined							15	19	24	20
#Seedlings missing at census; both marshes combined							57	77	41	47
%Seedlings missing at census; both marshes combined							19	21	20	19
#Mature plants missing at July census; both marshes combined							19	35	30	27
%Mature plants missing at census;both marshes combined							9	15	32	25

Emergence:		1999	%	2000	%	2001	%	2002	%
(both marshes combined)	%Seedlings	PRIOR TO 3/26	0	PRIOR TO 4/1	2	PRIOR TO 4/5	20	PRIOR TO 4/17	14
		3/26-4/24	62	4/1-4/29	63	4/5-5/20	72	4/17-5/11	51
		4/24-5/22	27	4/29-5/26	28	5/20-7/24	8	5-11-6/8	28
		5/22-7/21	11	5/26-7/14	7			6/8-7/13	7
	%Mature plants	PRIOR TO 3/26	0	PRIOR TO 4/1	1	PRIOR TO 4/5	1	PRIOR TO 4/17	11
		3/26-4/24	24	4/1-4/29	30	4/5-5/20	88	4/17-5/11	33
		4/24-5/22	48	4/29-5/26	56	5/20-7/24	12	5-11-6/8	35
		5/22-7/21	28	5/26-7/14	13			6/8-7/13	21

OVERALL VEGETATION PLOTS (24-30 ft dia.)		NORTH MARSH					SOUTH MARSH				
		1998	1999	2000	2001	2002	1998	1999	2000	2001	2002
Total area sampled (sf) :		8478	8478	8478	8478	8478	8478	8478	8478	8478	8478
Total LIOC flowering		133	268	248	135	151	199	266	204	93	113
#LIOC flowering per sf		0.016	0.032	0.029	0.016	0.018	0.023	0.031	0.024	0.011	0.013
Mean #flowers		1.6	1.7	1.4	1.5	1.7	1.5	1.6	1.7	1.4	1.3
Maximum #flwrs		5	6	6	5	5	7	8	7	4	4
Mean ht (in)		47	46	42	49	45	46	46	43	47	43
Maximum ht (in)		72	88	78	80	72	70	74	72	68	69
Phenology (%plts sampled)	Date:	07/16/1998	************	07/14/2000	************	07/13/2002	************	07/21/1999	************	07/24/2001	************
	Bud	68	56	52	21	77	63	48	53	24	67
	Flower	29	40	42	53	23	32	47	38	44	33
	Fruit	4	4	6	26	1	4	4	9	32	0
	(Infl. Grazed)	0	0	0	0	0	1	0	0	0	0
% incidence mammal grazing (plts still visible at census)		2	0	0	0	1	1	0	1	0	0
% incidence insect/slug grazing (plts still visible at census)		2	0	0	3	5	1	1	0	0	0
% incidence disease (plts still visible at census)		0	0	0	0	0	0	0	0	0	0

COMPARISON OF CLEARED/UNCLEARED TREATMENTS	1998		1999		2000		2001		2002	
	cleared	*uncleared*	*cleared*	*uncleared*	*cleared*	*uncleared*	*cleared*	*uncleared*	*cleared*	*uncleared*
Total sdlgs (LH plots)	122	100	173	123	210	155	111	92	167	86
Total mature plts (LH plots)	83	72	132	84	134	92	52	42	58	50
#flowering plants (veg plots)	208	122	324	210	301	151	141	87	168	96

t test significance results (paired; 2 tailed)		1998-1999		1999-00 (1998-00)		2000-01 (1999-01)		2001-02 (1998-02)	
LH Plots		*cleared*	*uncleared*	*cleared*	*uncleared*	*cleared*	*uncleared*	*cleared*	*uncleared*
All seedlings: #seedlings differ	P =	0.01	0.36	0.21 (0.02)	(0.12)	0.01 (0.03)	(0.27)	0.16 (0.14)	(0.50)
All mature plts: #mature plts differ	P =	0.07	0.24	0.92 (0.13)	(0.04)	0.03 (0.03)	(0.02)	0.65 (08)	(0.23)
Seedlings present at census: #seedlings differ	P =	0.54	0.89	0.16	0.56	0.04 (0.18)	(0.23)		
Mature plants present at census: #mat plts differ	P =	0.25	0.34	0.35	0.39	0.05 (0.02)	(0.01)		
Vegetation Plots									
Flowering plts present at census: #plts differ		0.03	0.003	0.75 (0.11)	(0.43)	0.00 (0.00)	(0.00)	0.38 (0.18)	(0.50)

COMPARISON OF FENCING TREATMENTS	*Tall fence*	*Short fence*	*Control*
1998 (pre-treatment)			
#seedling (present at census)	100	70	52
#mature plants (present at census)	56	59	40
#flowering plants	30	29	22
#plants mammal grazed	2	3	2
1999			
#seedling (total emerging)	102	123	71
%seedling present at census	88	75	80
#mature plants (total emerging)	58	105	53
%mature plants present at census	95	90	89
#flowering plants	31	35	22
%mature plants mammal grazed	3	2	0
%plants missing at census time or grazed	26	39	38
2000			
#seedling (total emerging)	119	143	103
%seedling present at census	92	66	81
#mature plants (total emerging)	70	115	41
%mature plants present at census	87	83	83
#flowering plants	34	24	16
%mature plants mammal grazed	0	1	1
%mature plants missing at census time or grazed	18	68	28
2001			
#seedling (total emerging)	59	74	70
%seedling present at census	76	81	81
#mature plants (total emerging)	17	60	17
%mature plants present at census	88	58	76
#flowering plants	7	9	6
%mature plants mammal grazed	0	0	6
%mature plants missing at census time or grazed	94	65	94
2002			
#seedling (total emerging)	95	111	47
%seedling present at census	91	77	74
#mature plants (total emerging)	17	73	18
%mature plants present at census	71	68	83
#flowering plants	7	20	9
%mature plants mammal grazed	0	7	6
%mature plants missing at census time or grazed	29	32	17

estimated population size has continued to decline compared with estimated population sizes of ~15,000 in 2001 and more than 17,000 in 1999 (Imper and Sawyer, 2002). This year's results indicate a population decline of ~30% since 1999. The explanation for this decline is not evident, although apparently disease and predation from grazers (deer, slugs, and small mammals) are not important factors.

4.2 Depth to Water Table

Formal monitoring of the water table depth in the North and South marshes was begun in 1997. A portion of the PVC pipe used to mark sample plots that year were modified to serve as informal piezometers, enabling measurement of depth to the water table across the occupied lily habitat. Piezometers were installed at 40 ft. intervals along transects T1 and T3 in the North Marsh, and at 40 ft. intervals along transect T200 and T400 in the South Marsh (Maps 3 and 4). The piezometers consisted of 6 ft. sections of ¾" PVC pipe, saw cut in the lower half, capped at the bottom, and pushed at least three feet into the peat substrate. Measurements made on July 28, 1997 ranged between 9 and 36 inches below the surface in the South Marsh, and from 10 to greater than 35 inches in the North Marsh. The correlation between vegetation type and height, and depth to water was evident in the South Marsh, with an average depth of 12 inches recorded in the *Low Labrador tea marsh* (N=4), and 29 inches in the *Tall Labrador tea marsh* (N=4). In particular, measurements in that marsh taken along transect T400 exhibited a sharp drop in the water table moving north, corresponding to a sharp increase in height of the *Labrador tea marsh*. Average depth to water is less in both the *Buckbean marsh* and *Carex marsh*, located south of the transect baseline, which often contains standing water. Water table measurements taken in the North Marsh were more varied. Average depth to water table measured there in the *Calamagrostis marsh* was 20 inches (N=5), while the average measurement along the edge or outside of that habitat exceeded 28 inches (N=3).

Measurements to the water table were made again on July 15, 2002, July 24, 2001, July 13, 2000, and July 21, 1999 at the following stations (2002, 2001, 2000, 1999, and 1997 depths below surface indicated; ND = no data): **North Marsh:** T1-0' (8 inches ND, ND, ND, 8"); T1-40' (11,11,ND,ND,ND); T1-80' (8,10,9,8,27); T1-120' (8,6,8,11,10); T3-0' (ND,ND,4,ND,>35); T3-40' (10,7,7,ND,18); T3-80' (10,10,9,ND,25); T3-120' (4,9,3,ND,33); **South Marsh:** T200-0' (3,5,ND,ND,ND); T200-40' (5,9,6,6,9); T200-80' (12,14,10,ND,15); T400-0' (8,ND,2,ND,10); T400-40' (4,5,8,ND,22); T400-80' (8,5,ND,ND,ND); T400-120' (8,6,ND,8,36); T400-160' (7,7,ND,8,31). The relative measurements indicate that on nearly the same date in each year, the water table was generally within several inches. Based on the Crescent City weather station, spring rainfall (March-June) was 13.4, 12.5, 16.7, 14.1, and 16.2 inches in 2002, 2001, 2000, 1999, and 1997, respectively. It is possible the water table had not yet equilibrated inside the piezometers in 1997, which were installed only 24-48 hours prior to marking the measurements.

On October 30, 2002, two formal continuous-recording pressure transducers were installed in the vicinity of the piezometers at LH Plot #2 in the North Marsh and LH Plot #17 in the South Marsh. The transducers were installed in a 2" x 0.010 slot well screen, and set ~4-5 ft. into the marsh surface. The built-in dataloggers will record depth to the water table continuously for about 18 months, at which time the batteries should be replaced.

4.3 Manual Vegetation Removal and Fencing Treatments

Twelve 30 ft. diameter Vegetation plots, each enclosing a 6ft^2 Life History (LH) plot, were permanently marked in both the North and South Marshes in July, 1998 (Maps 2-4). Since a comprehensive grid coordinate system has not been developed for the CCMWA population, the Vegetation and LH plots were mapped relative to the existing framework for both marshes (Maps 3 and 4). The plots were marked as follows: a 4 foot rebar stake was placed at one corner of the square plot, corresponding to the center point for the surrounding 30 ft. diameter Vegetation Plot. A 4 ft. PVC pipe marker was placed at the diagonal corner of the LH plot. The plots were subjectively located so as to provide a comparison between manual removal of vegetation and no treatment in similar vegetation, as well as, to contain at least some mature lilies, maximize the number of seedlings in the LH plots, and provide space between adjoining Vegetation plots. The manually treated plots are indicated in Maps 3 and 4.

In both the North and South Marshes, one-half of the Vegetation plots were cleared of all tree and selected shrub cover in October 1998. Trees and shrubs were removed at the base. Target species included: *Alnus rubra*, *A. viridus*, *Lonicera involucrata*, *Malus fusca*, *Myrica californica*, *Picea sitchensis*, *Rhamnus purshiana*, *Salix hookeriana*, *S. lasiolepis*, *Spiraea densiflorus*, and in some cases, *Ledum glandulosum* and *Rubus ursinus*. Past observations have indicated that in most cases the lily is able to tolerate high cover from most of the above shrub and tree species, but the lily rarely occurs in dense stands of *Spiraea*.

The LH plots at CCMWA were monitored on 4 dates between April 1 and July 13, 2002 using the same methodology as the LH plots at TBER (described in Section 3.2). Maps of all plants emerging in LH plots during 2002 are included as Appendix B. Vegetation plots were monitored in mid July; data collected included mean height and cover class for all species, %cover of the overhead canopy, and a map of the vegetation cover. Data sheets and maps of the Vegetation plots are included as Attachment 2. Browsing Inhibitor Plots were established as described for TBER, although there are no Chemical treatment plots at CCMWA.

4.4 Western Lily Characteristics and Vegetation and Life History/Browsing Inhibitor Plot Results

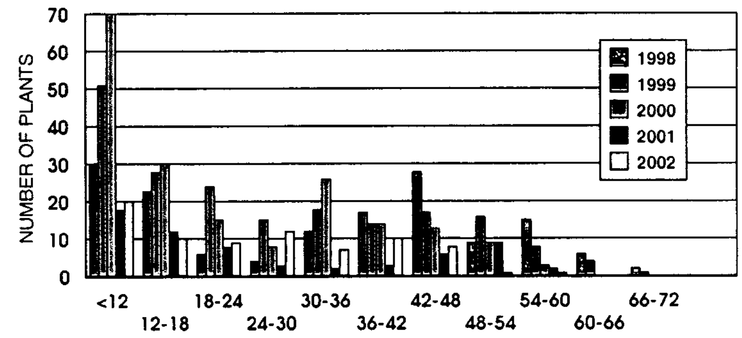
Lily Density and Growth: Various growth characteristics of the population are compared for the previous 5 years in Table 4. Since 1999, there has been an overall decline in the number of seedlings (15%) and mature (multi-leaved) plants (50%) within LH plots in both Marshes. In 2002, the decline in seedlings was greatest in the North Marsh (down 65% since 2000), and was greatest for mature plants in the South Marsh (down 55% since 2000). These data correspond with the overall reduction in number of flowering plants within the Vegetation plots (down 71% since 2000, and down 51% since 1999; Figure 6).

Although the number of seedlings in the South Marsh increased in 2002 to near the peak seen in 2000, the number of seedlings in the North Marsh and the total number of mature plants in both the North and South Marshes are still less than 50% of the 2000 totals. Mature and flowering plants are generally more numerous in the North Marsh, while seedlings have been consistently more abundant in the South Marsh (Table 4). Seedling density in the South Marsh is nearly 4 times that of the North Marsh; mature and flowering plant density is ~30% greater in the North marsh.

In general, the percent seedlings still present at July census in both Marshes has remained relatively consistent since 1999 (~20%), however, for mature plants, the seasonal loss has increased to 25% since 1999 (albeit the loss is slightly lower this year than in 2001) (Table 4). Incidence of disease or insect and slug predation was negligible. For the first time since monitoring was initiated, mammal grazing is an important factor impacting lilies in the North marsh (9%).

The mean height of mature plants within the LH plots has consistently declined since 1998, with the greatest reduction occurring the season following the vegetation clearing in 1998 (Table 4). Overall, plant vigor seems to have declined along with the decline in lily flowering abundance. This season, the mean height of 18.5" is approximately half the mean height recorded in 1998. In 2002, the largest size class was <12" tall, and approximately one-third of the mature plants were <24" tall (Figure 7). Since 1998, the largest size class for mature (multi-leaved) plants has remained the <12" class, however, seedlings consistently out-number mature plants, especially in the South marsh.

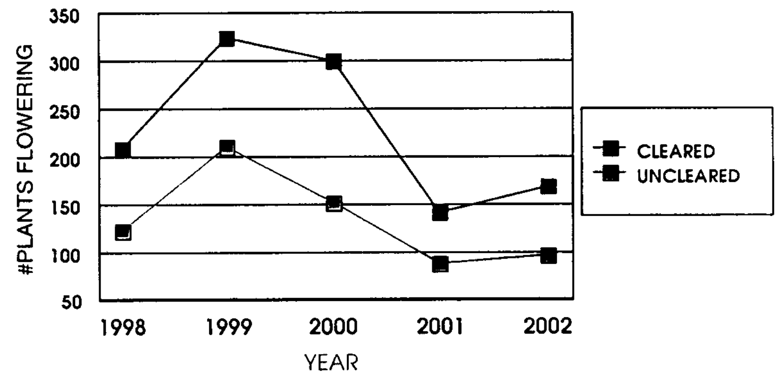
FIGURE 7. HEIGHT CLASS DISTRIBUTION
24 LIFE HISTORY PLOTS; CCMWA, 1998-2002



*census time & not grazed

Results of Browsing Inhibitor Treatments: In all years, the greatest number of emerged seedlings have been located within Short-Fence plots, although overall since 1999, there has been a 10% decrease in seedlings within these plots (Figure 9A, Table 4). The Tall-Fence plots have also maintained a relatively high number of seedlings overall since 1999 (down only 6%). In all years, the lowest density of seedlings has consistently been found within Control plots.

FIGURE 8. FLOWERING LILY ABUNDANCE BY VEGETATION REMOVAL TREATMENT
24 VEGETATION PLOTS, CCMWA, 1998-2002



In contrast, the percentage of seedlings still present at July census is consistently lower in Short-Fence plots than in Tall-fence plots, and is comparable to the seasonal survival within Control plots (Figure 9B). These results suggest that, ironically, small mammals may actually feed preferentially inside the Short-fence plots. The 18" height of the chicken wire may not be adequate to prevent small mammals from climbing over, and once inside, the enclosure may offer some protection for the animal. Tall-fence plots prevent deer browsing <u>and</u> hoof damage (thus a high percentage of seedlings may escape predation and trampling), although, the total number of seedlings initially was lower, possibly due to the denser vegetation within selected plots.

Since 1999, the number of emerging mature plants has declined significantly within all browsing inhibitor treatments: Tall-Fence down 71%, Control down 66%, and Short-Fence down 30% (Table 4, Figure 9A). In all years, the greatest number of emerged mature plants was also consistently found within Short-Fence plots, and in several years, Short-Fence plots had more than twice the density of the Tall-Fence or Control plots.

Overall, the percentage of mature plants still present at July census has gradually decreased for all treatments since 1999, with the most significant seasonal loss of 42% occurring within Short-fence plots during 2001, the year that exhibited the lowest number of flowering plants (Figures 6 and 9B). Typically, Tall-Fence plots had the greatest percentage of mature plants still present at July census, but in 2002 for the first time, Tall-Fence plots had a greater seasonal loss of mature plants than Control plots.

Since 1999, there has been a decline in the number of flowering lilies in all browsing inhibitor treatments, and generally within each year, there has been no significant difference in the number of flowering lilies between treatments (Table 4). In 2002, Short-Fence plots had the greatest number of flowering plants, but overall, this still indicates a loss of 43% over the past 4 years. Tall-Fence plots, which provide the greatest protection from browsers, have suffered a 77% decline in the number of flowering plants since 1999. These data suggest that factors other than grazing impacts are negatively affecting the flowering population.

Results of Manually Treated Vegetation Plots: In September 2002, vegetation mapping and sampling was conducted for all 30 ft. diameter Vegetation plots in order to compare vegetation patterns in control plots with plots that were manually cleared of woody vegetation (treated) (Attachment 2). Table 5 provides a summary of the changes in species' frequency, cover, and height in treated and all plots since the vegetation removal was conducted in 1998; Appendix D gives species' height and cover for treated and uncleared plots.

FIGURE 9A. WESTERN LILY EMERGENCE BY BROWSING PROTECTION TREATMENT 24 LH PLOTS, CCMWA, 1998-2002

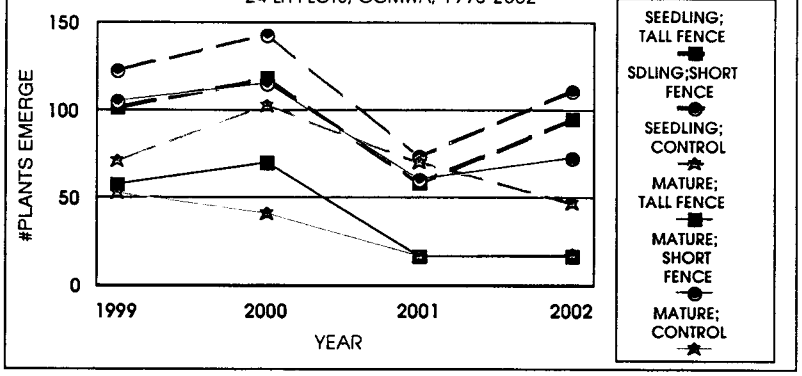
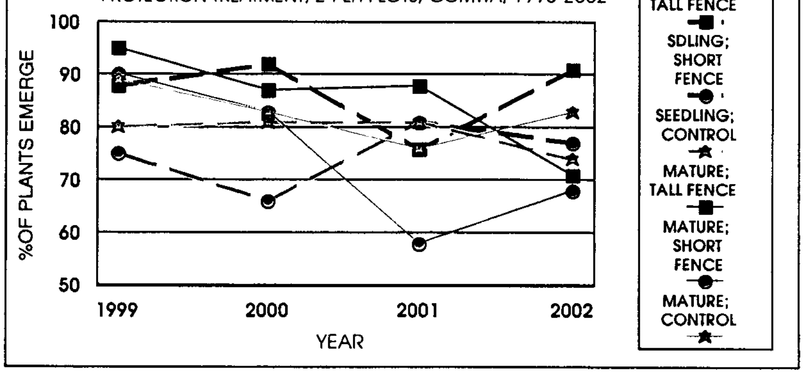


FIGURE 9B. WESTERN LILY PRESENT (%) DURING THE JULY CENSUS BY BROWSING PROTECTION TREATMENT, 24 LH PLOTS, CCMWA, 1998-2002



The most frequent species for all plots remains the same after 5 years (occurring in nearly every plot): *Calamagrostis nutkaensis*, *Ledum glandulosum* (Labrador Tea), *Lysichiton americanum* (skunk cabbage), and *Sanguisorba officinalis* (Table 5). In 2002, the %frequency of many herbaceous species in treated plots is similar to the levels for all plots, although *Potentilla palustris* has had a more noticeable increase in frequency since 1998 than others (from 75% to 92% in 2002). Other herbaceous plants that had a positive response to clearing include *Hypericum formosum*, *Veratrum californicum*, and pteridophytes *Athyrium felix-femina*, *Blechnum spicant*, and *Equisetum* sp. In manually cleared plots, the %frequency of woody shrubs and trees was deliberately reduced, and since 1998, species such as *Rubus spectabilis*, *Rhamnus purshiana*, *Picea sitchensis* have remained low in frequency. Shrubs that were not target species (i.e., *Rhododendron occidentale*) have increased in %frequency in treated plots relative to all plots.

There are few species that exhibit significant cover values in the North and South Marshes (Table 5). For all plots, the following species have remained dominant since 1998: *C. nutkaensis*, *L. glandulosum*, *S. officinalis*, *L. americanum*, and *P. palustris*; however, the native grass, *C. nutkaensis*, has experienced a significant drop since 1999 (58 to 32 %cover). Since removal of woody vegetation, the dominant species within treated plots have remained similar to all plots, but their cover is lower after 5 years. Compared to pre-treatment data from 1999, the manually cleared plots had slight declines in cover for the herbaceous species *C. nutkaensis* (-12%), *S. officinalis* (-4%), *Carex obnupta* (-5%), and *Rubus ursinus* (-5%). Cover of woody vegetation for all plots has generally remained constant since 1998, with the exception of slight decline in *Alnus viridus* (-7%). However, for cleared plots only, %cover of shrubs and trees has continued to gradually decrease since 1998, and still remains lower compared to all plots (i.e., *L. glandulosum*, *A. viridis*, *S. douglasii*,

TABLE 5. SUMMARY STATISTICS FOR ASSOCIATED SPECIES IN 24 VEGETATION PLOTS, CCMWA, OCT 98, JUL 99, AND SEPT 02.

	ALL PLOTS*									MANUAL TREATED PLOTS (TREATED OCT98) *								
	%FRE**			%COV**			HT (in) **			%FRE**			%COV**			HT (in) **		
ASSOCIATED SPECIES	1998	1999	2002	1998	1999	2002	1998	1999	2002	1998	1999	2002	1998	1999	2002	1998	1999	2002
Alnus rubra	17	17	21	2	2	1	199	77	154	25	25	33	1	0	0	185	22	132
Alnus viridis	83	71	88	19	10	12	83	67	73	83	58	92	10	1	4	83	43	59
Angelica genuflexa	92	96	83	5	5	2	57	51	59	92	100	92	2	2	1	52	42	54
Athyrium felix-femina	54	54	67	3	3	2	41	43	40	58	58	75	2	2	1	37	41	38
Blechnum spicant	46	54	58	4	3	3	38	40	38	42	58	67	1	1	1	34	37	36
Calamagrostis nutkaensis	100	100	100	58	58	32	43	44	45	100	100	100	26	26	14	41	42	43
Carex obnupta	88	88	79	21	20	10	45	43	42	83	83	75	10	9	5	43	39	38
Carex spp.	0	0	0	0	0	0				0	0	0	0	0	0			
Cornus sericea	0	0	0	0	0	0				0	0	0	0	0	0			
Deschampsia caespitosa	4	4	0	0	0	0	48	48		0	0	0	0	0	0			
Epipactus gigantea	8	8	4	0	0	0	18	18	12	8	8	0	0	0	0	24	24	
Equisetum spp.	17	21	38	1	1	2	27	31	25	25	33	42	1	1	2	24	30	24
Galium trifidum	0	4	0	0	0	0				0	8	0	0	0	0			
Gaultheria shallon	0	0	0	0	0	0				0	0	0	0	0	0			
Gentiana sceptrum	29	25	25	1	1	1	26	23	27	33	25	25	0	0	0	27	22	24
Holcus lanatus	0	8	0	0	0	0				0	17	0	0	0	0			
Hypericum formosum	17	21	33	0	0	1	21	20	20	8	17	25	0	0	0	24	21	20
Juncus leseurii	25	29	25	2	1	1	50	46	41	17	25	17	1	0	1	48	40	39
Ledum glandulosum	100	100	96	68	64	63	50	42	46	100	100	100	32	28	29	50	34	43
Lonicera involucrata	67	67	67	7	5	4	68	56	55	58	58	58	4	2	2	72	45	48
Lotus formosissimus	0	0	0	0	0	0				0	0	0	0	0	0			
Lysichiton americanum	96	96	100	12	13	12	35	36	35	100	100	100	8	8	7	28	31	30
Maianthemum dilatatum	4	8	0	1	1	0	48	27		0	8	0	0	0	0		6	
Malus fusca	13	8	13	1	1	1	152	87	136	17	8	17	1	0	0	162	42	138
Menyanthes trifoliata	54	58	54	3	5	5	14	14	13	42	50	42	2	3	3	12	12	11
Myrica californica	46	33	46	6	5	5	97	107	105	33	8	25	1	0	0	90	144	92
Oenanthe sarmentosa	0	0	0	0	0	0				0	0	0	0	0	0			
Picea sitchensis	50	25	25	5	2	1	134	165	152	50	0	8	3	0	0	104		48
Rhamnus purshiana	8	8	8	0	0	0	36	36	39	0	0	0	0	0	0			
Potentilla palustris	75	79	88	14	16	14	32	31	30	92	100	92	11	12	9	34	33	31
Pteridium aquilinum	4	4	0	0	0	0				0	0	0	0	0	0			
Rhododendron occidentalis	50	46	42	2	2	1	63	58	56	67	58	58	2	1	1	62	53	53
Rubus ursinus	58	58	50	18	14	8	39	35	33	58	58	42	8	4	3	38	30	30
Salix spp.	29	29	29	7	5	7	98	75	93	25	25	25	3	1	2	112	60	80
Sanguisorba officinalis	100	100	100	27	28	21	32	32	34	100	100	100	16	18	12	34	34	34
Rubus spectabilis	8	8	8	0	0	0	54	54	51	0	0	0	0	0	0			
Aster chilensis	42	42	46	1	1	1	38	33	35	42	42	58	1	0	1	41	30	34
Spiraea douglasii	42	42	42	8	7	8	60	50	53	33	33	33	3	2	3	63	39	43
Veratrum californicum	0	21	13	0	1	0				0	42	25	0	1	0			

*All plots (N=24) and Treated Plots (N=12)

**%FRE = absolute %frequency; %COV = absolute %vertical projection cover;

**HT = average weighted height (contribution to ht calculation proportional to rel. cover within plot)

Salix spp., and *M. californica*). The most distinctive difference in vegetation structure between the cleared and all plots is the significant reduction in *L. glandulosum* and *C. nutkaensis* in cleared plots. These results suggest that manual removal of shrubs and trees reduces the cover of woody vegetation for at least 5 years.

The average height of the dominant herbaceous species has remained generally similar between all plots and cleared plots. In 2002, the mean height of most trees and shrubs was still below 1998 levels, but many species are quickly approaching pre-treatment heights (especially *L. glandulosum*, *M. californica*, *L. involucrata*, *Salix* ssp., and *R. occidentale*). Although still below pre-treatment mean heights, *A. rubra* and *Malus fusca* have made tremendous growth in only 4 years (110" and 96" respectively).

In 1999, there was a significant increase in the number of flowering plants in both cleared and uncleared plots, corresponding to the peak flowering year (Figure 8). Since then, both the cleared and uncleared plots have exhibited a significant percent decrease in the total number of lily plants (Table 4). Overall since 1999, seedlings and flowering plants have had a smaller percent decline within the cleared treatment (for seedlings: -6% cleared vs. -30% uncleared; for flowering plants: -48% cleared vs. –54% uncleared), while mature plants have done better in uncleared plots (-40% uncleared and –56% cleared) (Table 4, Figure 8). Paired t-tests indicate that 2001 was a poor year for the lily, with both 2000 and 1999 having a significantly higher numbers of seedlings, mature plants, and flowering plants (Table 4). After 5 years these results show no significant benefit for the lily from clearing, although the long-term benefits of clearing are without question

Photomonitoring: In 2002, annual photomonitoring was conducted for the 24 Vegetation plots at CCMWA. For each plot, a photo was taken towards the plot center (towards the interior of the marsh), from 15 ft. outside the plot boundary. The photomonitoring provides a visual record of the quantitative data recorded. The slides are included as Attachment 3.

5.0 COMPARISONS BETWEEN TBER AND CCMWA

5.1 Plant Development

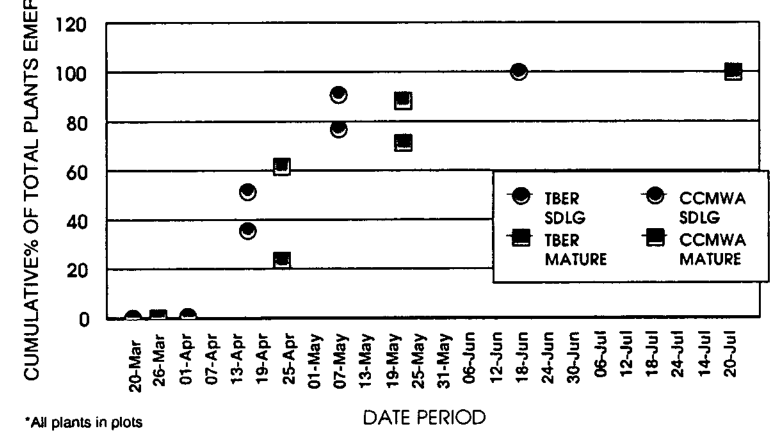
The mean height for mature, ungrazed plants in both the North and South Marshes at CCMWA (18" and 19" respectively) remains consistent with the previous 3 years, however, this average is nearly half that of the original, baseline data (33" and 35" in 1998; Table 4). Flowering and lily abundance also has declined significantly throughout the marsh, although selective browsing by deer does not appear to be a factor. Changes in hydrology (e.g., water table depth) may be a contributing factor, but our data do not indicate it has changed.

At TBER, the mean height of mature, ungrazed plants has dramatically decreased since 1998 from 21" to 11". This apparent decrease is likely an artifact caused by the greater intensity of deer browsing that has occurred at TBER in the past couple years, rather than by environmental change that imparts physiological changes. The deer preferentially browse on the taller, more readily seen lilies. In doing so, they leave behind proportionately more of the smaller, shorter, immature lilies. Thus, this data reflects the demographics of the population in that a large proportion of mature plants are juvenile, multi-leaved individuals that are not yet reproductive. There is no indication that the total population at TBER has declined as dramatically as the population at CCMWA.

5.2 Emergence of Plants

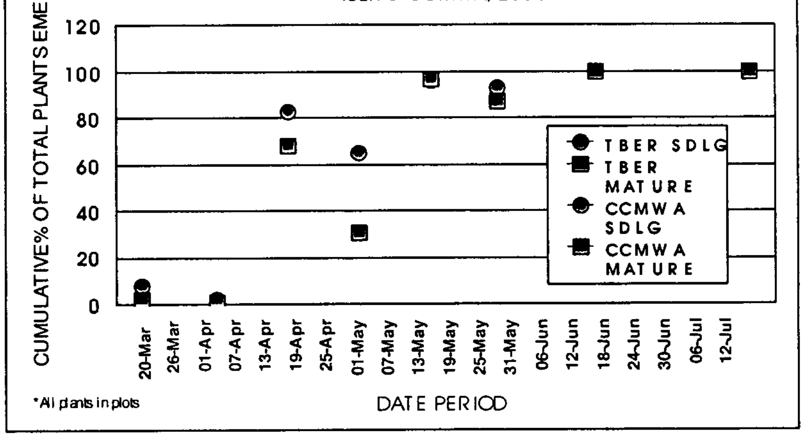
Cumulative emergence over the course of the season was plotted for seedlings and mature plants over the past four years for each site (Figures 10A-10D). The emergence curves were interpolated to determine the data at the point where 80% of the plants have emerged. In general, the 80% emergence point for seedlings at TBER occurs during mid to late April, while the 80% emergence point for seedlings at CCMWA is delayed anywhere from 2-4 weeks later, usually in early to mid May. In 2002, the peak of seedling emergence at TBER did not occur until mid May, while peak emergence at CCMWA was delayed until early June.

FIGURE 10A. EMERGENCE OF WESTERN LILY IN LIFE HISTORY PLOTS TBER & CCMWA, 1999



The 80% emergence point for mature plants at TBER occurs consistently during late April to early May. At CCMWA, the peak for emergence of mature plants has occurred between mid May and early June. In the 4 years of monitoring at TBER and CCMWA, the 80% emergence point of mature plants at CCMWA occurred anywhere from 2-5 weeks after TBER, the largest lag occurring in 2002. The delay in emergence at CCMWA for both seedlings and mature plants is expected given the high water table and the somewhat lower soil temperatures there (described below).

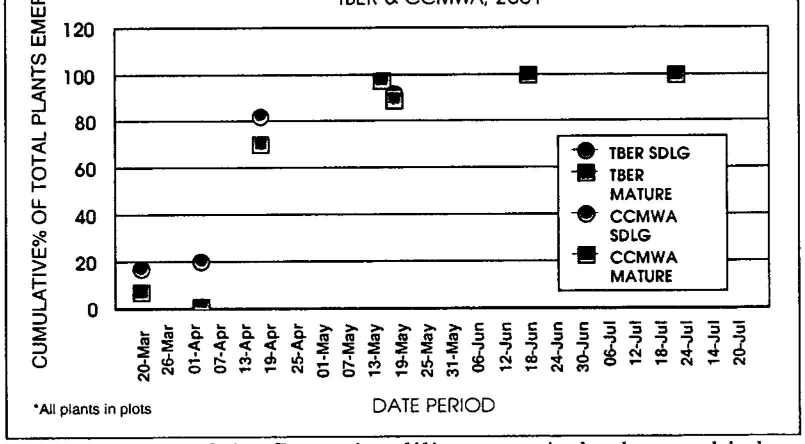
FIGURE 10B. EMERGENCE OF WESTERN LILY IN LIFE HISTORY PLOTS TBER & CCMWA, 2000



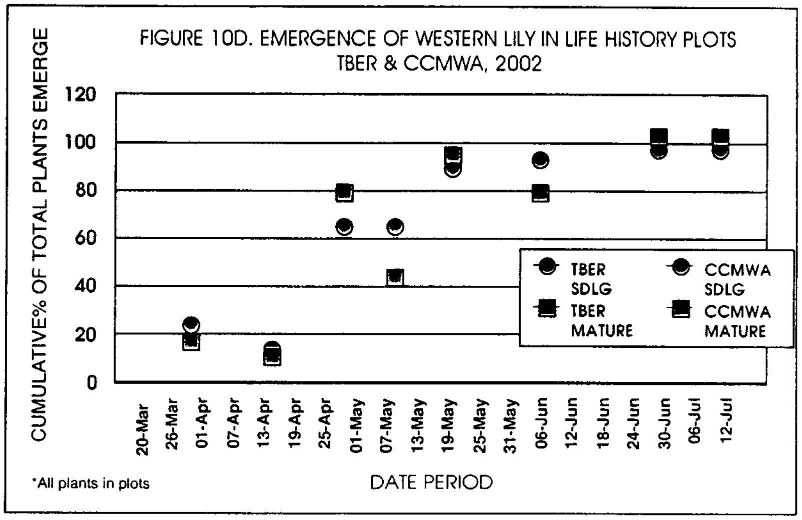
5.3 Reproductive Phenology

The flowering period at CCMWA, along with many of the populations in Oregon, has traditionally been thought to reach peak flower approximately one month later than the Table Bluff populations. Our data support these observations, as the population at TBER reaches peak flower generally 2-3 weeks earlier than the CCMWA population (Imper and Sawyer, 2002). Based on the annual census conducted at TBER in 2001 and 2002, by late June approximately two-thirds of the flowering lilies were in bud, one-third were in flower, and a small number were developing fruits (Table 2A, Figure 11). In most years at CCMWA, approximately two-thirds to one-half of the flowering plants are in bud at the time of census during mid July, and in all years, there has been no apparent difference in phenology between the North and South Marshes (Table 4, Figure 11). In 2001, the blooming period at CCMWA was

FIGURE 10C. EMERGENCE OF WESTERN LILY IN LIFE HISTORY PLOTS TBER & CCMWA, 2001

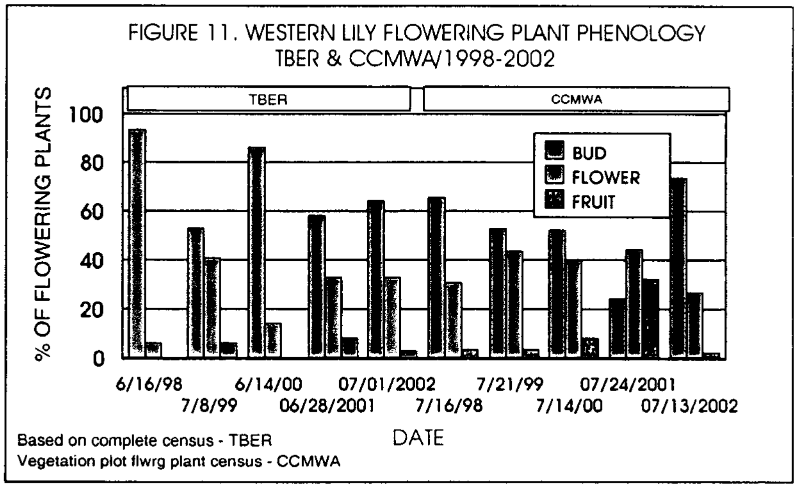


advanced by several weeks, so that by mid July, over half the flowering plants were already in flower, and approximately one-third were in fruit.



5.4 Soil Temperature

In order to better characterize soil temperature variation throughout the year, correlate soil temperatures with plant phenology, and compare temperatures between TBER and CCMWA, Onset temperature dataloggers were buried at two locations at both sites. At TBER, data was recorded at two-hour intervals at a depth of approximately 5-6 inches beneath the soil surface in both the *Coastal prairie* (NW corner of LH plot #17) and *Spruce forest* (NE corner of LH plot #13) (Map 1). At CCMWA, Onset temperature dataloggers were installed at 5-6 inches below the soil surface in the North Marsh (LH plot #2), and in the South Marsh (LH plot #17) (Maps 3 and 4). Mean monthly temperatures for each site from April 2001 until October 2002, including mean maximums and minimums, are summarized in Appendix C and shown in Figures 12A-12C.



In general, the mean temperature is greater at TBER than at CCMWA at any time of year, averaging up to 4 degrees higher from February to April. The mean maximum is also greater at TBER with nearly a 6° F difference during February to April, which also corresponds in time with the greatest difference in maximum temperature between *Coastal prairie* and *Spruce forest* at TBER (Figure 12C). Overall, the *Coastal prairie* has a higher mean temperature (by 1° F) than the adjacent *Spruce forest* for most of the year (February to November), and although cooler on average, the *Spruce forest* is always warmer than either of the North or South Marsh sites at CCMWA. At CCMWA, there is no significant difference in average temperatures between the North and South Marshes. The coolest period at TBER occurs during January and February, but still, the mean temperatures do not drop below that of CCMWA. The mean minimum temperature at TBER averaged up to 4.6° F higher than CCMWA during February, 2002.

Monitoring results for TBER over the past 15 years, (Imper and Sawyer, 2001b) have shown a strong relationship between air temperature recorded at Eureka and floral development, and have indicated a delay in flowering of approximately 4 days per degree (F) cooler air temperature. Assuming air temperatures are correlated with soil temperatures (but undoubtedly dampened to a degree), the differences in soil temperatures observed between TBER and CCMWA suggest flowering would be delayed two weeks or more at CCMWA compared to TBER, in good accordance with the phenological data described above. Both emergence and reproductive phenology is undoubtedly linked to soil temperature, though that data has not yet been analyzed.

FIGURE 12A. AVERAGE MONTHLY SOIL TEMPERATURE (F)
5-6 INCHES BELOW SURFACE; TBER & CCMWA

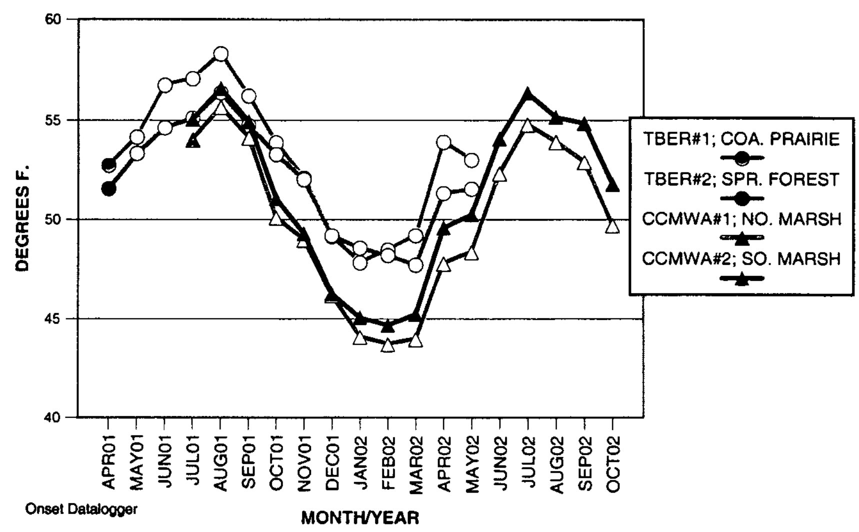


FIGURE 12B. MINIMUM MONTHLY SOIL TEMPERATURE (F)
5-6 INCHES BELOW SURFACE; TBER & CCMWA

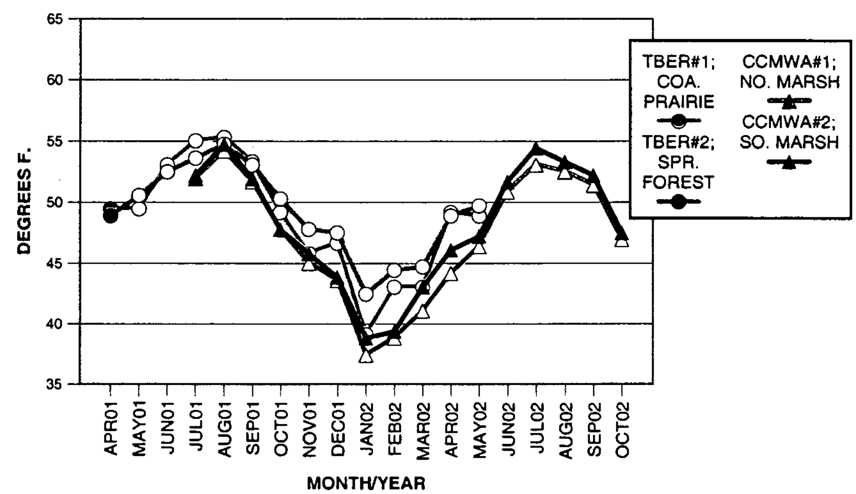
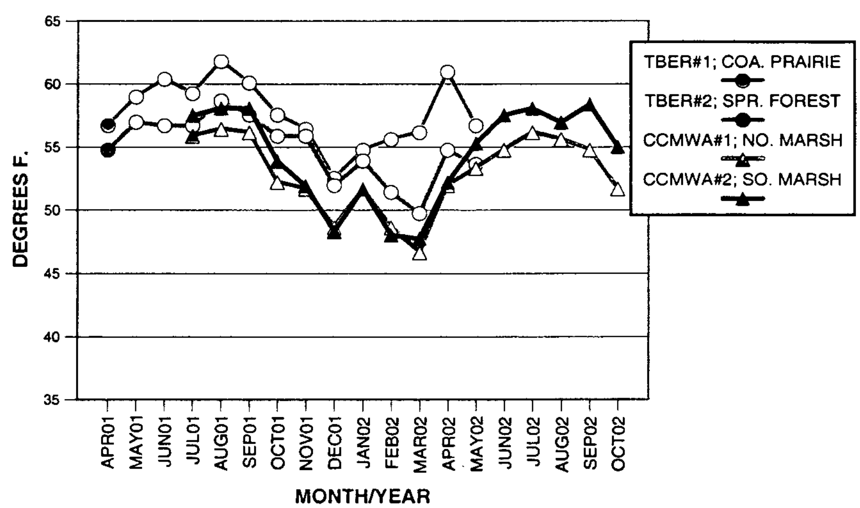


FIGURE 12C. MAXIMUM MONTHLY SOIL TEMPERATURE (F)
5-6 INCHES BELOW SURFACE; TBER & CCMWA



5.5 Browsing

The impact of natural browsing (i.e., loss of plants prior to the final census date) in the LH plots was significantly greater at TBER than at CCMWA in 2001 and 2002 due to the large population of deer that resides on Table Bluff. At TBER during 2002, deer browsing accounted for a loss of approximately 75% of the flowering plants by the time of the annual census (early July), and up to a 40% browse rate for mature plants within LH plots (Table 2A). Seedling browsing by small mammals (rodents) also appears significant at TBER, in conjunction with desiccation, as a principal cause for seedling mortality.

Overall, there has been little evidence of decline in flowering plants at CCMWA as a result of deer browsing. There is some indication of rodent or slug browsing in a small percentage of plants, which generally occurs in the Short-Fence or Control plots rather than in the Tall-Fence plots.

6.0 SUMMARY

The primary goals of this study have been to examine the life history of western lily in two large, disjunct populations occurring in very different habitat types, to evaluate the effectiveness of fencing and chemical control in reducing predation by both deer and small mammals (primarily rodents), and to assess the impacts of habitat change resulting from both manual thinnings and different grazing regimes. After 5 years, the data reveals important trends in the populations, including changes in population size and degree of predation, and provides guidelines towards enhancing management of western lily and its habitat. The interpretation of our results have been complicated by the increase in deer browsing at TBER, and the overall decline in population size at CCMWA that appears unrelated to predation, disease, changes in vegetation structure, or obvious microenvironmental factors. In addition, because western lily is a long-lived, bulbous perennial, the fate of a single individual due to direct or indirect impacts from change in habitat, predation levels, or controlled grazing, may not be quantifiable or noticeable in the population for some time given our level of examination in this study. Based on these considerations, continued annual monitoring of both populations is warranted, and a detailed examination of the life history of a single individual may be necessary in order to evaluate long-term impacts of continual high-intensity browsing on plant reproduction and longevity.

The population at TBER has exhibited a dramatic decline in the number of flowering plants and the seasonal survival rate of seedlings and mature plants (Table 2A), as well as, a corresponding increase in the proportion of flowering plants grazed, contributing to a decline in overall reproduction. These trends reflect the increase in deer density and browsing, however, historical fluctuations in deer populations have likely been experienced by western lily before, and at this point, it is too early to determine with certainty whether this level of natural browsing will be detrimental to the population in the long-term.

The results from the Browsing Inhibitor treatments at TBER indicate that for seedlings, the greatest overall increase since 1999 has occurred within Tall-Fence plots where deer are excluded (Table 2A). Control and Chemical plots exhibited a much lower percent increase in number of seedlings, while Short-Fence plots had a percent increase similar to Tall-Fence plots. Thus, Fence treatments were beneficial by nearly doubling the percent increase in number of seedlings.

Between 1999 and 2001, the seasonal survival of mature plants (% of plants still present at census) was similar between all Browsing Inhibitor treatments (>90%; Table 2A). In 2002, there was a significant decline in the seasonal survival rate for mature plants in all treatments, but the greatest proportion of mature plants still present at census was found within Tall-Fence plots. Although this result was expected, the data indicates that Tall-Fence plots since 1999 have had only a 1% overall