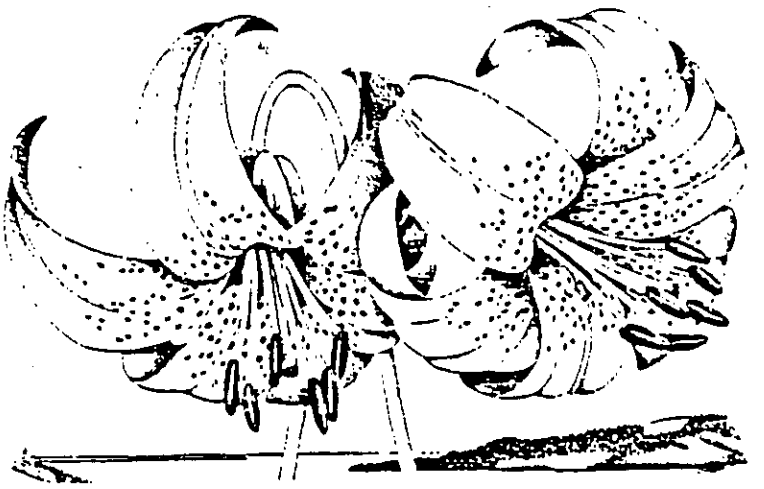

TABLE BLUFF ECOLOGICAL RESERVE

CALIFORNIA DEPARTMENT OF FISH AND GAME
HUMBOLDT COUNTY, CALIFORNIA

MANAGEMENT PLAN

Prepared under
Interagency Agreement C-1582.2
California State University/
California Department of Fish and Game

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(REVISED OCTOBER 1988)

ABSTRACT

The Table Bluff Ecological Reserve includes approximately 140 acres on the northwestern tip of Table Bluff, a heavily dissected coastal plateau located in Humboldt County, California. About 94 acres are grassland, and the remainder mostly spruce forest. The majority of the Reserve has supported agriculture for more than a century. Approximately 30 acres of spruce forest and grassland remain relatively undisturbed by human influence, and a portion of this contains the largest of four populations of the endangered western lily (*Lilium occidentale*) known in California. Approximately 38 acres have been recently fenced to exclude cattle grazing, and will be managed specifically to maintain and enhance the western lily population.

The physical setting and biological resources of the Reserve are described in detail in Section #1. The Reserve overlooks the southern half of Humboldt Bay, at 30 to 170' in elevation. Parent material consists of softly consolidated sediments of the Hookton Formation. Soils include the fine textured Rohnerville and Hookton series, and range from quite shallow on the steeper, more eroded hillsides, to relatively deep on the flat grassland. The spruce forest and western lily are predominantly associated with the imperfectly drained, shallower Hookton soils in the northern half of the Reserve. Seven vegetation types were identified on the Reserve, including the *Tall fescue* and *Sweet vernal-grasslands*, the *Spruce/maianthemum* and *Spruce/swordfern* forests, the *Spruce/salmonberry woodland*, and the *Willow scrub*. A small amount of freshwater marsh occurs at the southern tip of the Reserve. The Reserve supports a diverse flora and fauna, with 139 plant, 23 mammal, 17 reptile and amphibian, and 95 bird species observed or presumed present. Overall, the flora is heavily influenced by introduced taxa, these primarily associated with the grassland and adjacent forest. Wildlife species were primarily observed associated with the spruce forest. The majority of bird species nest on the Reserve, with a Great Blue Heron and Great Egret rookery supporting 15-20 pairs combined this year. Gray Fox, Coyote, and Black-tailed Deer were among the many mammals observed.

The population of western lily included an estimated 920 individuals in 1987, with the large majority as seedlings. Forty-nine plants were known to have produced buds or flowers, of which 17 retained intact fruits in August. The lilies are limited to about three acres, most of it dense, immature spruce forest. The Reserve appears to offer abundant potential western lily habitat, and provides an exceptional opportunity to expand the resident population of western lily.

Section #2 describes the western lily in detail, including its taxonomy, morphology, distribution, general life history and ecology, habitat characteristics, and the relationship between the California and Oregon populations. The major threats and past management of the lily are reviewed, and speculation is given of overall genetic diversity and viability. Based on this information and a detailed description of the distribution and demographics of the population at the Reserve, Species Management and Enhancement Goals are described. These goals include: restoration and maintenance of lily habitat; protection; close communication with persons and organizations having knowledge of the lily and its requirements; expansion of the population on the Reserve; establishment of new populations around Humboldt Bay; and various means to ensure the future viability of the species as a whole.

The opportunities and constraints relating to the biological, cultural, and jurisdictional setting of the Reserve are described in Section #3. The important biological opportunities include maintenance or enhancement of the western lily population, the Heron rookery, and the spruce forest in general. The overall wildlife and aesthetic values, and vegetation diversity on the Reserve can be improved through appropriate management of the dominant grassland. This section also describes objectives for management of the Reserve which will achieve the Management Goals defined for the western lily, and exploit some of the other opportunities available. Four levels of western lily management are defined, including No Action, Maintenance, Enhancement and Optimization. Overall, little further assessment needs to be done to effectively maintain the population. However, immediate thinning of the young spruce stand and continued exclusion of cattle appear necessary to maintain the existing lily population. If thinning is delayed until Winter 1989, limbing of the spruce should be conducted immediately, as a temporary means to prevent decline of the population. The Reserve and the lily population will require minimal but routine monitoring. Formal closure of the fenced exclosure is recommended, at least until the population has been expanded.

In Section #4, the various Reserve objectives are incorporated into a formal operations and maintenance plan. Staffing and financial commitment appear relatively low, with at least some of the responsibilities occasionally shared by volunteers. A five-year schedule of operations and maintenance is proposed.

Recommendations for activities that will achieve the Enhancement Goals defined for the western lily, or that will enable more effective management of the Reserve are included in Section #5. Some of the activities recommended include: research on the genetic viability of the western lily, and on the suitability of seasonal grazing and fire for maintenance of lily habitat; management of the *Tall fescue grassland* to recreate, if possible, the original coastal prairie; and various projects for recovering the western lily in general.

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* The authors wish to thank Andrea Pickart for the cover illustration.

1: INVENTORY AND DESCRIPTION

INTRODUCTION

This section describes the physical characteristics, biological resources, and cultural and historical setting associated with the Table Bluff Ecological Reserve, and provides the basis for development of management objectives and guidelines in succeeding sections.

The Reserve includes about 140 acres, which is the northeastern portion of 933 acres acquired in the "Ocean Ranch acquisition" by the California Department of Fish and Game in 1986, specifically for the purpose of wetland maintenance and habitat protection. The Reserve will be managed to benefit the western lily (*Lilium occidentale*), listed as "endangered" by the state of California. The remainder of the acquisition was added to the Eel River Wildlife Area, and will be managed for coastal wetlands.

The western lily was once relatively common around Humboldt Bay, but now occurs at only four known sites in California, all on Table Bluff. The Reserve contains the largest population and most coterminus lily habitat of the four sites in California, and therefore offers a unique and exceptional opportunity to manage specifically for the western lily.

The first step in successful management of the lily is identification and mitigation of factors threatening or restricting the resident population. This step was begun in June, 1987, with construction of a cattle exclosure around 38 acres in the northeastern corner of the Reserve and encompassing the entire lily population. Monitoring, habitat manipulation and controlled experimentation can now begin to provide information on how best to maintain and enhance western lily populations.

PHYSICAL AND HISTORICAL SETTING

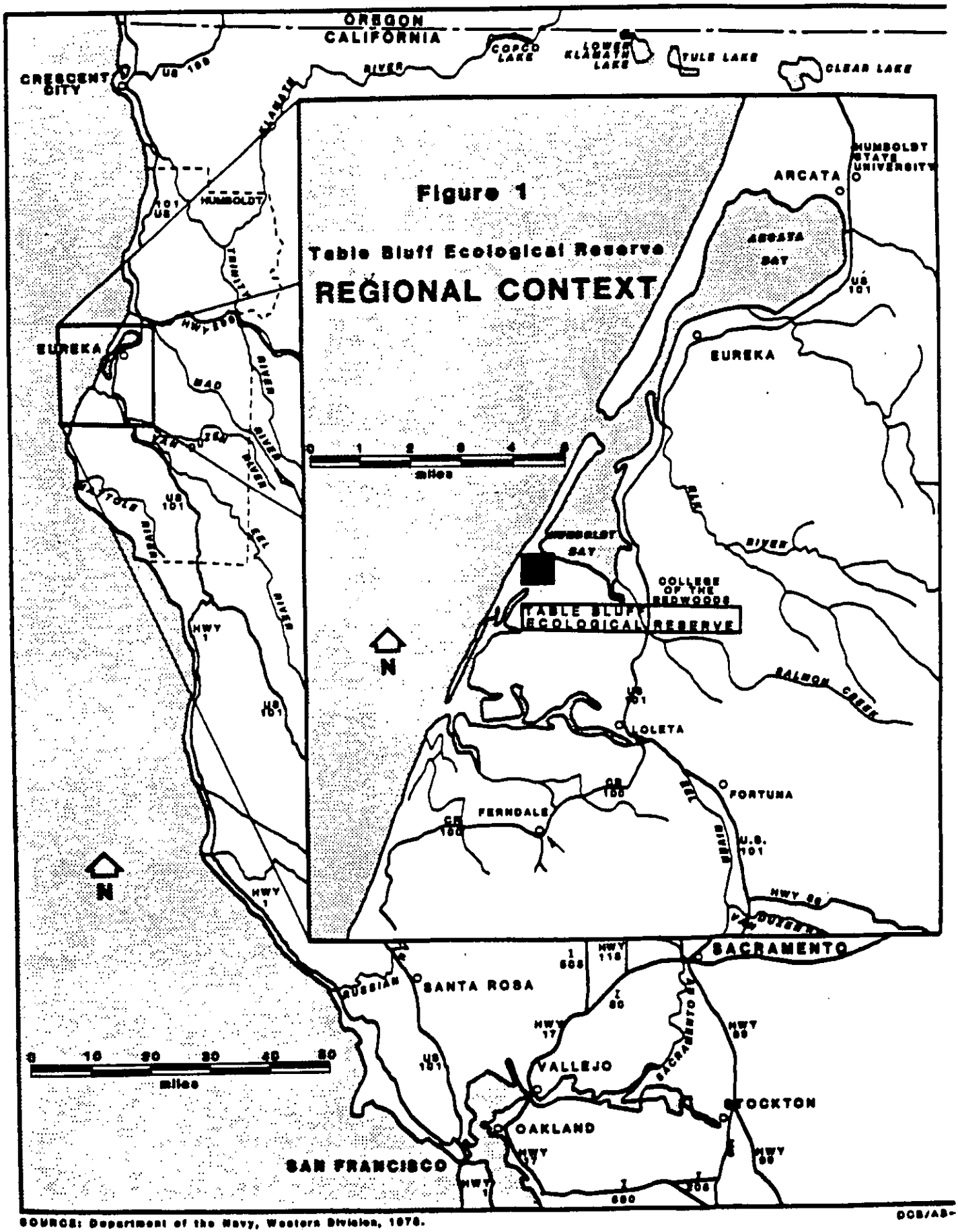
Regional context

The Table Bluff Ecological Reserve lies on Table Bluff, 280 miles north of San Francisco, at the southern end of Humboldt Bay, Humboldt County, California (Figure 1). The Reserve is located four miles west of US Highway 101, and is bordered on the south and west by Table Bluff Road, on the north by Humboldt Bay, and on the east by private land. The surrounding setting is rural, with the nearest major population center, Eureka (population 42,000+), about eight miles to the northeast. The small community of Loleta, lies about three miles to the southeast.

Current and historical land use

Historical ownership. Dr. Jonathan Clark was the first owner of the property, dating back to the middle 1800's. Ownership remained in his family until 1919, when William S. Clark sold it to Harry W. Jackson, H. L. Ricks and Nis Petersen. In 1940, Mansel P. Griffiths bought the Jackson and Petersen half-interest in the property. The other half remained in the Ricks and Murphy family until 1986, when the entire parcel was purchased by the State of California.

Historical land use--Table Bluff environs. Much information on general land use in the Loleta area is provided by Parry's M.S. Thesis, "A History of Loleta" (1963). Table Bluff has been under agricultural use since first settled in the middle 1800's. Early settlers grew subsistence crops such as carrots, turnips and potatoes in the wetter ravines. By the turn of the



SOURCE: Department of the Navy, Western Division, 1978.

DCB/AB-

century, most of the land that was usable for farming was under cultivation, although some areas were more difficult to begin to farm due to existing stands of spruce. In the late 1800's, dairying became the main agricultural pursuit. Hay, turnips and other forms of cattle feed were grown in the wetter ravines, while cattle grazed the drier slopes. Sheep, which had also grazed the slopes, became less important overtime. Continuous and intensive grazing has caused severe soil erosion in some areas of the Bluff (Parry 1963).

Current land use--Table Bluff environs. Today, most of the surrounding land is in Humboldt County, state, or federal ownership. The grazingland to the east, and a small parcel on the western boundary are privately owned.

The Humboldt Bay National Wildlife Refuge lies to the north, including salt marsh at the base of the bluff. According to Eric Nelson, U.S. Fish and Wildlife Service in Arcata, the Service is currently modifying dikes within the refuge to achieve better tidal circulation and restore the marsh. The area behind the dikes is closed to people, and in the future, hunters will be allowed access to the area only by way of the dikes. They have no plans for hiking trails in the area.

The Table Bluff County Park borders the Reserve to the west and northwest. The original portion of the Park was acquired in 1936. An additional 13 acres, mostly on the South Spit, were acquired in 1976. Vehicle traffic and recreational use associated with the County Park on the spit is relatively heavy during the summer, and may increase, since the area is especially scenic and no use fees are collected. The County also owns the Lighthouse Park to the west of the Reserve, that includes a small area surrounding the site of the old Table Bluff lighthouse. Built in 1892, the lighthouse was decommissioned in 1972, and moved to Woodley Island on Humboldt Bay in 1982. The park is relatively unknown, and currently receives few visitors.

The Lighthouse Ranch, a Christian religious commune, occupies a small parcel to the west of the Reserve.

The remainder of the adjacent property to the west, and the property to the south is part of the Eel River Wildlife Area, administered by State Department of Fish and Game. According to Gary Monroe of DF&G, plans for the area include restoration of wetlands, and maintenance of the existing saltmarsh. A levee and tidegates will be restored to allow greater control over fresh and saltwater distribution. The primary goal for the area is maintenance of high species diversity. No on-site personnel are planned at this time.

Historical land use--Table Bluff Ecological Reserve. Since it was first settled, the majority of the Reserve land appears to have been used for farming or grazing. A photo taken sometime during the 1900's (Steenfott photo #C61, Humboldt County Library) shows some kind of crop, perhaps a legume, planted in the center of the west grassland. The earliest aerial photograph of the area (1939) suggests the area was plowed to a boundary closely coinciding with the existing spruce forest, and intensively managed for farm crops. Aerial photos from 1939 to 1958 show what appears to be an irrigation feederline running north-south on the western portion of the Reserve, connected to a windmill powered water source. The well was a three-foot diameter well casing near the scrub patch in the northwest corner of the Reserve (Figure 2). The well was recently filled in. The remains of the windmill are nearby. Judging by aerial photos, the windmill appears to have stood until after 1948.

A homestead (Figure 2) was established west of the spruce-lined ravine before or soon after the turn of the century. Eucalyptus and Monterey

cypress trees around the old house, probably planted as a windbreak, date to the 1900's. Monterey pine was planted near the old barn at the southwestern boundary. An ornamental rose on the roadside face of the old barn is a popular visual and photographic attraction for passersby.

The Russ family leased the Reserve property between 1961-1986 and grazed cattle year-round. Some hay cutting occurred until about 10 years ago. Under the terms of sale for the Ocean Ranch acquisition, the sellers retained grazing rights for a period of five years. The Department of Fish and Game administers the lease, which expires in 1991. After that date, under Title 14, DF&G regulations, management activities must be consistent with the maintenance or enhancement of the western lily population. According to Gary Monroe, secondary priority will be given to development of riparian vegetation in one or more of the ravines on the Reserve, and maintenance of the spruce forest for its wildlife value. The Reserve land was leased to the Bishop - Garrison Oil Company between 1960-1970, and to Standard Oil of California between 1970-1973, for gas and oil exploration. Exploration activities consisted of drilling seismic holes, which were filled and capped. Little evidence remains of the exploration activities except, perhaps, some graded and leveled areas in the southeastern portion.

Physical environment

Topography. Table Bluff is a heavily dissected plateau extending about four miles northwesterly of the southern tip of Humboldt Bay. Elevation ranges from sea level to approximately 400'.

The Reserve ranges from 30' elevation at its southernmost tip to 170' at the northern boundary (Figure 3). Elevation drops rapidly north of the Reserve, down to the bay flat. The northern portion of the Reserve is relatively flat, with slopes ranging up to 3%. Relief is greater over the southern portion, with slopes reaching more than 15% in the open fields. Three large ravines extend about two thirds the length of the Reserve north from the southern boundary. Sideslopes to these ravines are often steep, with the westernmost ravine having slopes over 100%. The ravines are normally dry for most of their length.

Elevation varies less than 30' within the fenced lily protection area. Relatively low, moist areas are scattered within the spruce stand in this area.

Geology. All of Table Bluff, and much of the region around the lower Eel River and Humboldt Bay as far north as Big Lagoon is part of the Hookton Formation, an uplifted, folded and dissected terrace originating in the middle Pleistocene (Mclaughlin and Harradine 1965, Division of Mines and Geology 1962). Rock composition ranges from softly consolidated to slightly indurated mudstones, siltstones, shales, sandstones and conglomerates. Sedimentary layers are strongly stratified, and together represent several thousand feet of deposition around the perimeter of Humboldt Bay. Bedrock is exposed on the Reserve at an old excavated roadbed near the center, and south of the large spruce stand.

Soils. The soils on the Reserve were most recently mapped as representing the fine-textured Rohnerville and Hookton series (McLaughlin and Harradine 1965; Figure 4).

The Rohnerville series (Humic, Normudult, fine silty, mixed, isomesic) generally includes the area west of the spruce-lined ravine that more or less divides the Reserve into eastern and western halves. It is also mapped to include the young spruce stand where the western lily occurs. Typical Rohnerville soils are deep, with an A horizon ranging from 18-36" thick.

Figure 2

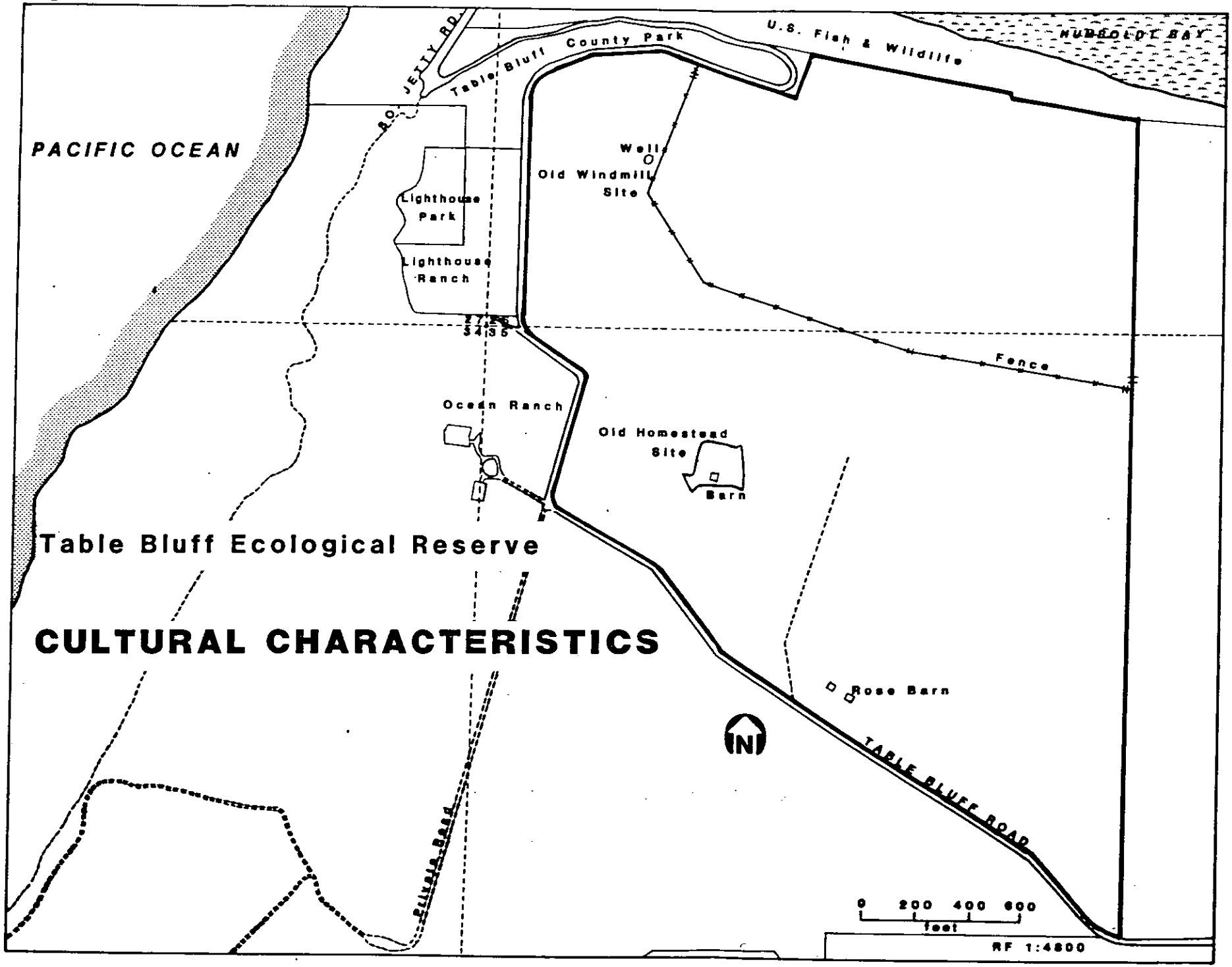

PACIFIC OCEAN
JETTY RD.
Table Bluff County Park
U.S. Fish & Wildlife
HUMBOLDT BAY
Well
Old Windmill Site
Lighthouse Park
Lighthouse Ranch
Fence
Ocean Ranch
Old Homestead Site
Barn
Table Bluff Ecological Reserve
CULTURAL CHARACTERISTICS
Rose Barn
TABLE BLUFF ROAD
0 200 400 600
feet
RF 1:4800

Figure 3

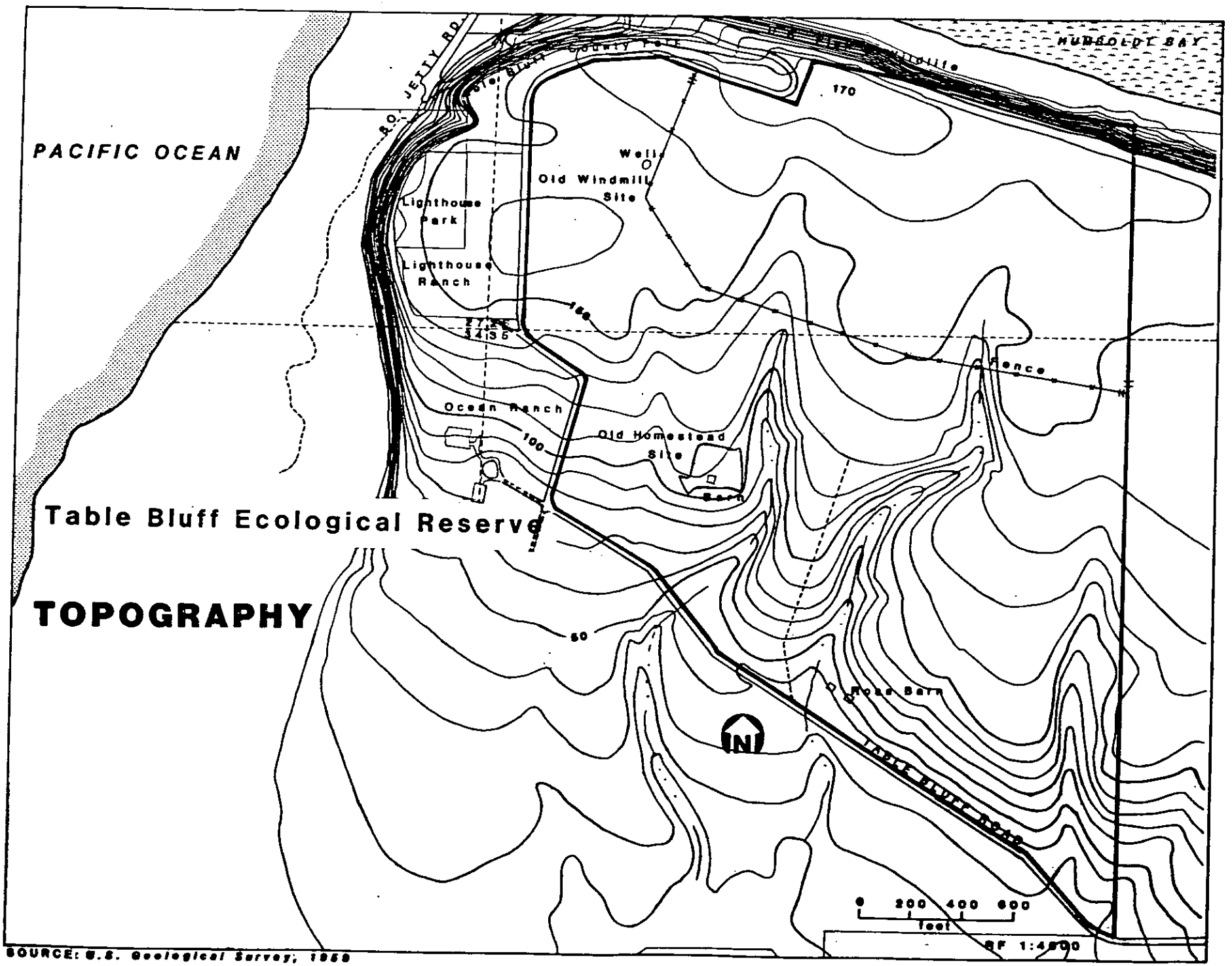
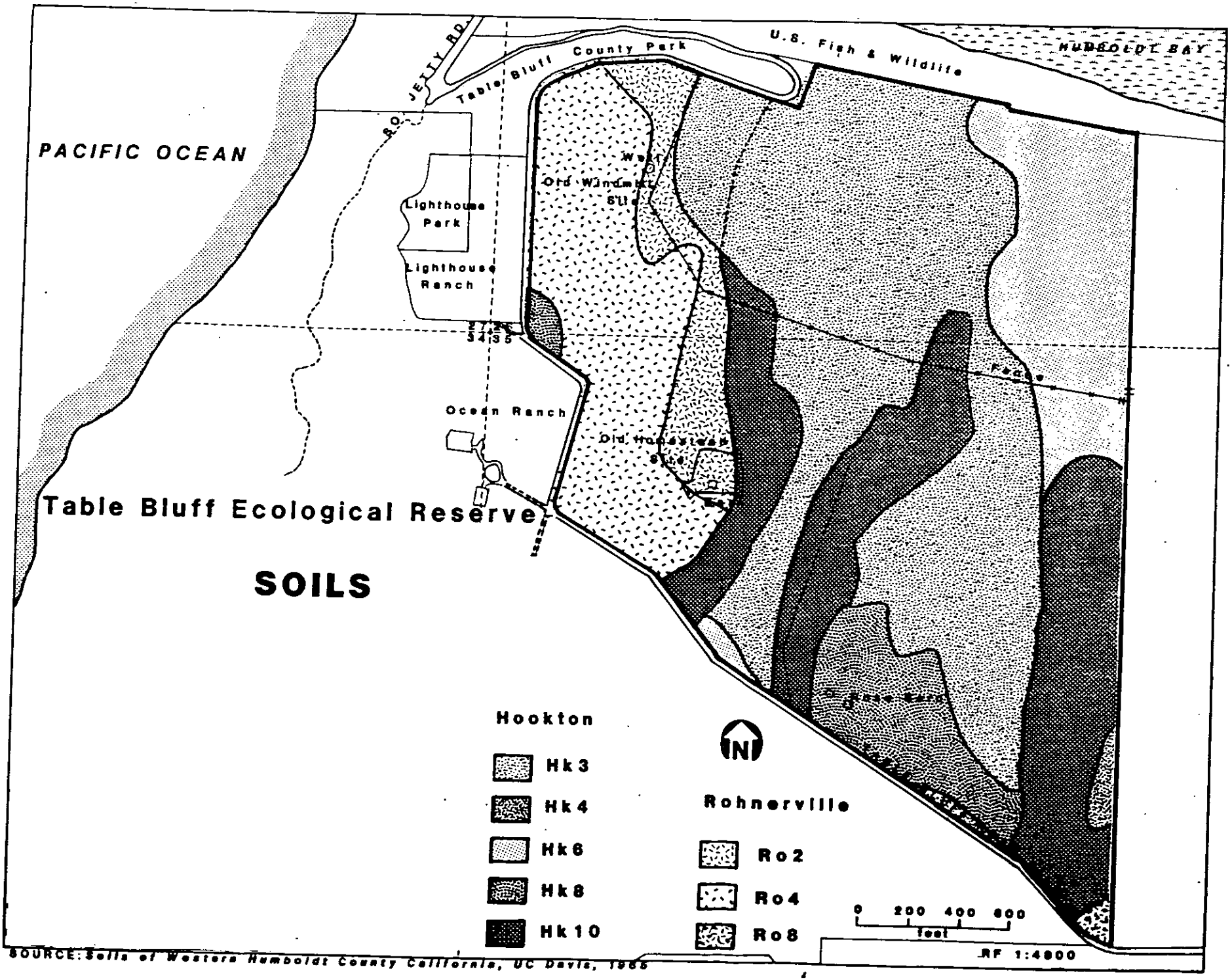


Table Bluff Ecological Reserve

TOPOGRAPHY

Figure 4


PACIFIC OCEAN
JETTY RD.
Table Bluff County Park
U.S. Fish & Wildlife
HUMBOLDT BAY
Lighthouse Park
Lighthouse Ranch
Ocean Ranch
Table Bluff Ecological Reserve
SOILS
Hookton
Hk3
Hk4
Hk6
Hk8
Hk10
Rohnerville
Ro2
Ro4
Ro8
N
0 200 400 800
feet
RF 1:4800
SOURCE: Soils of Western Humboldt County California, UC Davis, 1965

Three phases were mapped, the most common being the Rohnerville loam, 3-8% slope (Ro4), that occurs over most of the gently sloping, western portion of the Reserve. Rohnerville silty clay loam, 0-3% slope (Ro2), occurs in the vicinity of the western lily population, and a small area is mapped as eroded Rohnerville silty clay loam, 3-8% slope (Ro8), at the very southeastern corner of the Reserve.

The Hookton series (Entic Haplumbrept, fine silty, mixed, nonacid, isomesic) is mapped over the remainder of the Reserve. These soils are normally shallower than Rohnerville soils. The solum (A + B horizons) ranges from 18-36" thick. Though normally well drained, they can be poorly drained when overlying a clayey substratum. Four phases are well represented on the Reserve, the most common being the imperfectly drained, silty clay loams (Hk3 and Hk6), that differ primarily in degree of slope (0-3% and 3-8% respectively). These soils are wet for long periods of time, and occur generally in the northeastern quarter of the Reserve, including most of the main stand of spruce. The other common phases of Hookton present (Hk8 and Hk10) occur on the steeper slopes in the southeastern portion of the Reserve. The Hookton 10 phase, found in the ravines, has been associated with significant soil erosion due to past agricultural practices. A small amount of Hookton silty clay loam, 3-8% slope (Hk4) is mapped on the eastern boundary.

Field checks on soils throughout the lily protection area verified the presence of Hookton soils. Only rarely was the depth to a clayey C horizon greater than 24", and soils ranged from moist to wet at this depth in June. However, the Hookton series extends farther west than mapped previously in the Soils Survey (dashed line, Figure 4), at least to include all of the young spruce stand, and the adjacent grassland for approximately 1-200'. The depth of the A horizon is always less than 14" in the young spruce stand, but reaches 30-36" or more in some places out in the grassland. The soils outside the fence exclosure were not field checked.

BIOLOGICAL RESOURCES

Vegetation

Overview. Six major vegetation types are recognized on the Reserve (Table 1; Figure 5). The types are easily distinguished by differences in species composition and structure, and in most cases, appear correlated to differences in soil moisture. The immature spruce stand (Figure 5) is included with the *Spruce/maianthemum forest*. An additional type, the ephemeral freshwater marsh, is of minor extent and was only informally sampled.

Names for the major vegetation types are based on dominant species and overall physiognomy, and include two grasslands, one scrub, two forests and one woodland.

Vegetation types

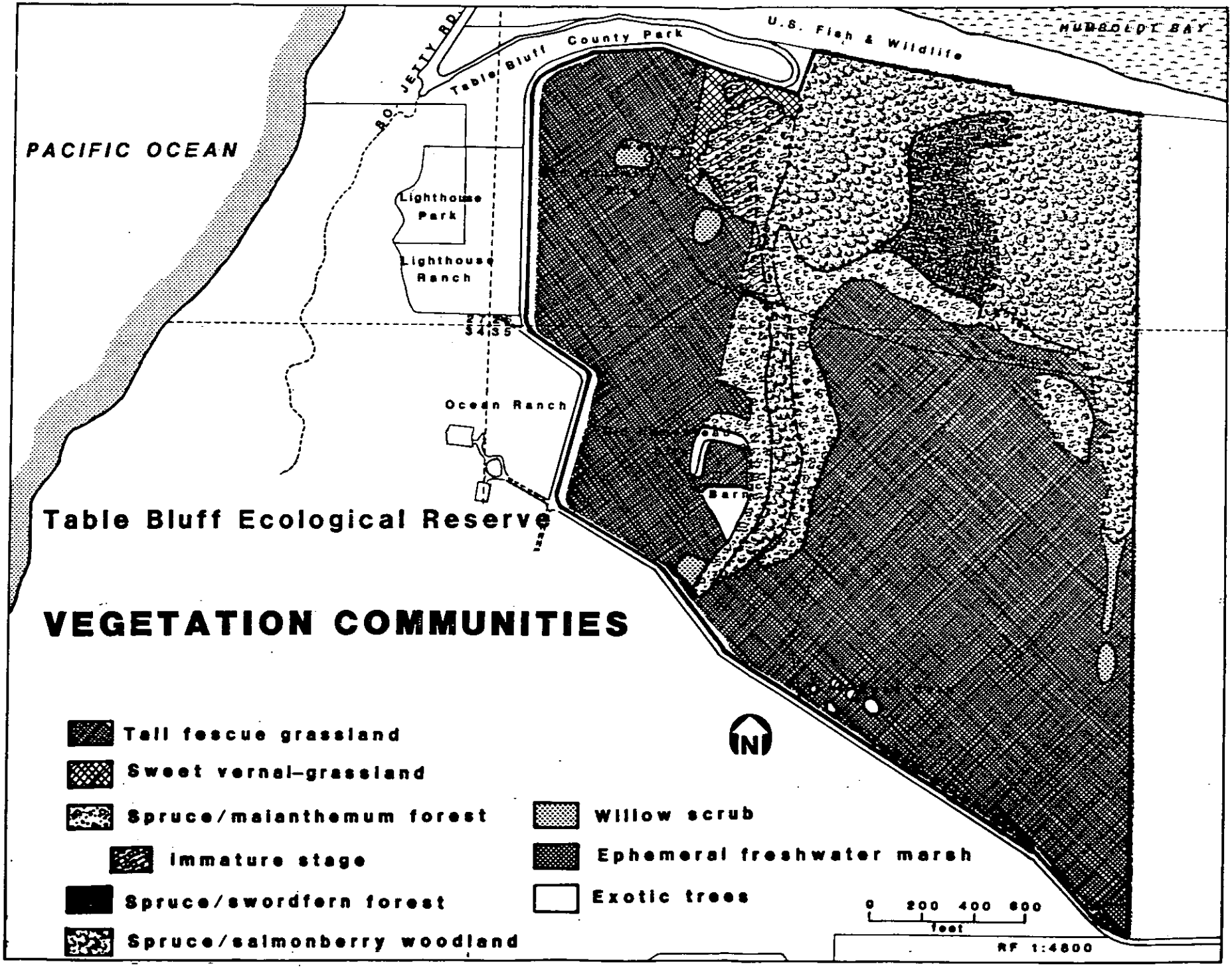
Tall fescue grassland. The *Tall fescue grassland* is the most common type on the Reserve, covering about 95 acres. It appears to have been grazed or cropped continually for more than a century. As a result, it exhibited the highest proportion of introduced species (81%) of the types sampled on the Reserve (Table 1). This grassland is characterized by high cover of a few perennial grasses, including tall fescue (*Festuca arundinacea*), sweet vernal grass (*Anthoxanthum odoratum*), perennial rye (*Lolium perenne*), and velvet grass (*Holcus lanatus*).

Table 1. Summary table for the major vegetation types, Table Bluff Ecological Reserve.

SPECIES	VEGETATION TYPE															
	Tall fescue grassland		Sweet vernal-grassland		Spruce/ maianthemum forest		Spruce/ swordfern forest		Spruce/ salmonberry woodland		Willow scrub	
	Cov[1]	Con[2]	Cov	Con	Cov	Con	Cov	Con	Cov	Con	Cov	Con
Medicago lupulina	5	52										
Cerastium viscosum	t[3]	8										
Lotus corniculatus	1	12										
Festuca myuros	2	24										
Juncus patens	t	4	t	4								
Achillea millefolium	1	8	7	96							1	100
Bromus mollis	6	28	t	5								
Geranium dissectum	1	12	t	12								
Linum perenne	3	64	1	32								
Festuca arundinacea	24	84	t	8								
Aster chilensis	1	20	2	32							t	20
Vicia angustifolia	1	12	1	24								
Rumex acetosella	2	44	3	80								
Potentilla edegei	4	36			t	5					2	100
Trifolium repens	8	96	1	60	t	5						
Bellis perennis	t	8	t	4	1	5						
Trifolium wormskioldii	1	28	1	48	1	15						
Chrysanthemum leucanthemum	t	8	t	8	t	5			t	20		
Hypochoeris radicata	11	88	6	52	7	55			t	20	2	100
Plantago lanceolata	12	96	6	92	3	35	1	75			1	100
Carex obnupta	t	4	1	8	3	30	t	25			4	100
Lolium perenne	17	64	8	80	11	65	t	25	t	20		
Rubus vitifolius	1	12	7	76	4	25	2	100	2	100	33	100
Poa trivialis	8	84	1	40	4	20	2	75	4	60		
Anthoxanthum odoratum	20	88	35	100	6	50	t	50	1	40		
Holcus lanatus	24	88	27	100	10	75	1	75	2	80		
Agrostis alba			11	52								
Gaultheria shallon			t	4	t	5					2	60
Agoseris grandiflora			t	16	t	10						
Corylus cornuta			2	20								
Fragaria californica			2	48								
Rosa nutkana			t	16							9	80
Prunella vulgaris			t	28								
Lotus formosissimus			2	52								
Stachys rigida			t	5							1	80
Iris douglasiana			13	84	7	25					2	60
Calamagrostis nutkaensis			1	8	1	5					2	60
Sanicula crassicaulis					t	5						
Brassica nigra					1	5						
Ranunculus repens					t	5						
Baccharis pilularis			1	4					1	20	3	60
Oenanthe sarmentosa			1	24			t	25	1	60	1	60
Maianthemum dilitatum			3	48	33	100	1	25	2	60	2	80
Cirsium vulgare			t	8	t	5	t	25	1	60	2	100
Rubus parviflorus			1	24			t	25	t	20	4	60
Pteridium aquilinum			9	60					1	40	t	20
Solidago spathulata			t	28			t	25	1	60		
Rubus spectabilis					1	20	2	100	54	100	15	100
Picea sitchensis					80	100	85	100	25	100	1	80
Polystichum munitum					3	15	65	100	6	100	4	100
Lonicera involucrata					t	15	1	75	2	80	21	100
Disporum smithii					1	5	t	50	t	40		
Galium triflorum					1	10	1	100	5	100		
Sambucus racemosa					t	5	29	100	22	100	1	20
Stachys chamissonis							1	75	3	60		
Myrica californica							2	50	23	80	2	20
Juncus effusus							t	25	1	60	4	100
Athyrium felix-femina							5	100	4	100		
Erechtites prenanthoides							1	25	3	80	1	60
Carex leptopoda							25	100	3	80		
Trisetum cernuum							1	100	2	80		
Heracleum lanatum							t	25	1	40		
Montia sibirica							t	50	t	20		
Stellaria media							t	25	t	20		
Rhamnus purshiana							t	25			2	40
Veronica americana							t	25				
Vaccinium ovatum							t	25				
Alopecurus pallescens									t	20		
Salix hookeriana									5	60	46	100
Marah oreganus									4	60	t	20
Rumex crispus									t	20	1	80
Urtica holosericea									t	20		
Malus fusca											4	80
Spiraea douglasii											7	80
Rubus procerus											2	40
Arctium minus											t	20

[1] Cov = average % cover (see Appendix A: Methodology for calculation procedure).
[2] Con = % constancy, or the # plots occurrence divided by the total # plots sampled.
[3] t = <0.5% cover.

Figure 5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Lighthouse Ranch
Ocean Ranch
Barn
Table Bluff Ecological Reserve
VEGETATION COMMUNITIES
Tall fescue grassland
Sweet vernal-grassland
Spruce/maianthemum forest
immature stage
Spruce/swordfern forest
Spruce/salmonberry woodland
Willow scrub
Ephemeral freshwater marsh
Exotic trees
N
0 200 400 600
feet
RF 1:4800

Soils are highly variable, and include both the Hookton and Rohnerville series. The average depth of solum based on five samples taken east of the immature spruce stand was 25" (range 22-30"), but the depth ranges from 36+" in some areas, to less than 6" in the more eroded areas in the southern half.

Sweet vernal-grassland. The *Sweet vernal grassland* is the most restricted type on the Reserve, covering only about two acres entirely within the fence exclosure and west of the immature spruce stand. Like the adjacent *Tall fescue grassland*, this type is characterized by high cover of sweet vernal-grass and velvet grass, but also has relatively high cover of iris (*Iris douglasiana*), blackberry (*Rubus vitifolius*) and false lily-of-the-valley (*Maianthemum dilitatum*). Several other native species only occur here, including grass nut (*Brodiaea laxa*) and sneezeweed (*Helenium bolanderi*). Cover of perennial rye and tall fescue are low, and overall species diversity is high, compared to the *Tall fescue grassland*. The complement of introduced species, though high (49%), is somewhat lower than for the adjacent grassland. This type appears analogous in part, to the *North coastal scrub*, described by Munz (1959).

In contrast to the *Tall fescue grassland*, this type does not appear to have ever been cultivated. The boundary between the two grasslands is easily noticeable on the earliest aerial photos available (1939), and may have been the location of an old fenceline, although no evidence of such remains. In any case, the boundary appears to represent the limit to past plowing.

Soils in this type appeared to be entirely Hookton series. Average depth of solum at six locations (24"; range 22-24") and soil textures were similar to that of the adjacent *Tall fescue grassland*, but soils were noticeably more moist in June and July. Two samples of the A horizon contained about 27% (6/19/87) and 33% (7/9/87) water, when soil from the *Tall fescue grassland* contained 19% and 22%. Perhaps related, sweet vernal grass appeared more robust, and flowered with greater frequency in the *Sweet vernal-grassland*. The difference in moisture may be due to difference in species composition, but is more likely related to loss of soil structure in the *Tall fescue grassland* due to historical plowing and grazing, or to diminished influence of the imperfectly drained Hookton 3 soil, which seems to reach its westerly extent in this vicinity.

The *Sweet vernal-grassland* has been grazed, probably continually, for at least the past 30-40 years. Although grazing has clearly been an important influence on the western lily population, and probably has contributed to the high complement of introduced species, the type has remained surprisingly distinct. Both grasslands contain high grass cover and similar grass species, but the cattle seem to preferentially graze the *Tall fescue grassland*, perhaps because of the higher cover of tall fescue and perennial rye, or to avoid noxious or unpalatable plants such as iris and blackberry. The fact that the *Sweet vernal-grassland* exists today (and the associated western lily), is probably closely linked to the original lack of plowing, and as a result, the maintenance of a forage menu that is less desirable than that of the adjacent *Tall fescue grassland*.

The reedgrass (*Calamagrostis nutkaensis*) occurs frequently in this grassland, and also occurs sporadically in some areas of the *Tall fescue grassland*, where it seems to be a good indicator of imperfectly drained soils. As such, it may also indicate those areas that will rapidly develop into the *Sweet vernal-grassland* after grazing is eliminated. One of these areas lies south of the main spruce stand, in the center of the Reserve, where species such as reedgrass, sedge (*Carex obnupta*), blackberry (*Rubus vitifolius* and *R. macropetalus*), and redtop (*Agrostis alba*) are abundant,

and indicate close affinity to the *Sweet vernal-grassland*. These areas may be important in future expansion of the western lily population.

Spruce/maianthemum forest. The *Spruce/maianthemum forest* is the third most common type on the Reserve (approximately 12 acres), behind the *Tall fescue grassland* and *Spruce/salmonberry woodland*. Dominant species include spruce (*Picea sitchensis*) in the overstory, and a variety of grasses and forbs in a dense ground layer, including perennial rye, velvet grass, maianthemum, and iris. The shrub layer is poorly developed. This type is closely related to the *Sweet vernal-grassland*, differing in its spruce cover, high maianthemum cover, and lower grass cover in general. Like the adjacent grasslands, this type has been heavily influenced by introduced species (48%).

The spruce overstory is relatively even-aged (average 74 years, range 58-80), and appears to have originated after a severe fire swept across Table Bluff sometime in the 1900's (Parry 1963). The average dbh is 22" (range 18-30), and height is 90' (range 80-102). Basal area of spruce averages 310 square feet per acre.

The soils are predominantly Hookton series, and relatively uniform. They appeared similar to those of the *Sweet vernal-grassland*, but tended to be shallower, averaging 21" (range 18-22; n=6), and more moist in July (44% moisture, 7/9/87).

Because of similarities in vegetation and soils, and proximity, the dense young spruce stand (Figure 5) is considered an immature stage of the *Spruce/maianthemum forest*. The characteristics of this stand are important, because it is here that most of the western lily population occurs. The understory is quite dark and largely devoid of plantlife. Old swordfern hummocks in the understory remain from the previous, more open community, and indicate that closure of the canopy was relatively recent. Numerous small openings are characterized by species common in the *Sweet vernal-grassland*, including maianthemum, blackberry, bracken fern(*Pteridium aquilinum*), swordfern, the western lily, and others. Average age of the spruce is 24 years, ranging from 15-35. A few spruce are 40-50 years old. Average diameter is 12" (range 3-32) and height is 63'. Tree height increases going east from the grassland, beginning at about 30' and reaching about 70' at the juncture with the 80-year old spruce stand. Variation in height appears related to exposure to the northwesterly winds and salt spray. Basal area of spruce in the stand averages 200 square feet per acre.

Soils in the young spruce stand are Hookton series, and were the most shallow sampled, averaging 19" deep (range 16-24; n=6). They appeared more moist than even the *Sweet vernal-grassland* soils, with two samples containing about 30% (6/19/87) and one sample 59% moisture (7/9/87). This may be related to the lack of an understory, the affect of fog drip from the spruce canopy, or to differential underground drainage associated with the Hookton soils.

Spruce/swordfern forest. The *Spruce/swordfern forest* is generally restricted to an area in the center of the main spruce stand (about 4 acres), although some *Spruce/maianthemum forest* grades to this type, particularly in the area adjacent to the west ravine. Dominants include spruce, swordfern, and a sedge (*Carex leptopoda*) specific to this type. It differs from the *Spruce/maianthemum forest* in its better developed shrub layer and sparser grass cover. It is similar to the adjacent *Spruce/salmonberry woodland*, but is quite distinct structurally, and occupies relatively higher ground. This type shows the lowest proportion of introduced species (28%) of the major types, probably due to its isolation from the disturbed grasslands, and relatively low grazing pressure.

Like the *Spruce/maianthemum forest*, the overstory is even-aged, (average 75 years; range 67-80), and probably originated after the same fire in the 1900's. However, average height (124'; range 120-135) and diameter (28"; range 15-40) are somewhat greater than for the *Spruce/maianthemum forest*. This may be due to lower stocking, since basal area of spruce is about the same (310 square feet per acre). There is little spruce regeneration.

Soils sampled in this type appeared deeper (two samples with solum about 30" deep) than the adjacent Hookton soils, but were moist, and exhibited the clayey, relatively impermeable C horizon typical of the Hookton 3 soils. Though not measured, soil moisture appeared higher than in the *Spruce/maianthemum forest*, but not as high as in the *Spruce/salmonberry woodland*.

Spruce/salmonberry woodland. The *Spruce/salmonberry woodland* is the second most extensive type on the Reserve, occupying about 23 acres, or most of the main spruce stand in the northeastern corner. It is characterized by a dense, almost impenetrable shrub layer dominated by salmonberry, elderberry (*Sambucus racemosa*), and wax myrtle (*Myrica californica*). The spruce overstory is sporadic and generally sparse, thus the term *woodland*. In the lower, wetter areas the type becomes more characteristically *Willow scrub*, dominated by willow, spiraea (*Spiraea douglasii*), and rush (*Juncus effusus*). In higher areas, elderberry, wax myrtle and salmonberry increase in importance. The contribution by introduced species (31%) is relatively low.

The overstory is uneven-aged, averaging about 90 years, but ranging from 49-140. Because the type occurs generally in the lower, wetter areas, it appears to have escaped the catastrophic disturbance from the 1900's fire experienced by the spruce forest types. There are occasional areas of decomposing downed logs measuring 18-30" dbh. The open nature of the overstory (basal area less than 110 square feet per acre) appears more related to the affect of abundant moisture on increasing competitiveness of the shrub species, than to any thinning produced by past fire. Many of the spruce exhibit an open grown canopy--very full with branching close to the ground. This type includes the largest spruce on the Reserve. The average diameter measured was 44" (range 30-62), and average height was 108'(range 100-120). Growth of spruce is variable, with one 48" at 49 years, and another reaching 31" at 130 years. The largest spruce noted on the Reserve was on the eastern boundary, and measured 62" dbh at about 140 years old.

Soils are variable in this type, but appear to be entirely Hookton series. They generally become more sandy-textured closer to the northern bluff. Average depth is 25" to a clayey, wet C horizon (range 24-30; n=9). Soils were often saturated at less than 15".

Willow scrub. The *Willow scrub* was described based on samples of isolated patches of scrub out in the grassland, which total about an acre. However, there appears little difference between these areas and those within the *Spruce/salmonberry woodland* where spruce essentially drops out. The *Willow scrub* also occurs on the exposed bluff at the northern boundary of the Reserve. It is generally impenetrable, and dominated by willow (*Salix hookeriana*), twinberry, salmonberry, crabapple (*Malus fusca*) and others. The overstory can reach 20' tall or more, with stems generally less than 10" dbh. Cattle largely use this type and the spruce forest for cover during the summer.

Soils appeared characteristic of the Hookton series, even when surrounded by Rohnerville soils in the western portion of the Reserve. Depth of solum averaged 22" (range 22-30; n=4), and generally was dark and moist--significantly wetter than surrounding grassland soils.

Ephemeral freshwater marsh. Since the *Ephemeral freshwater marsh* is restricted to a small area of about 20' by 30' at the southeastern tip of the Reserve, it was not formally sampled. This is the lowest point on the Reserve, receiving runoff from the ravine to the north and adjacent property to the east. The soil is saturated most of the year, but dries to a firm, massive structure intermittently during the summer, depending on the frequency and intensity of irrigation in the fields to the east.

The vegetation includes both species common to moist sites elsewhere on the property, including cinquefoil (*Potentilla egedei*), birdsfoot trefoil (*Lotus formosissimus*), and others, and also species restricted to this site, including water starwort (*Callitriche trochlearis*), bulrush (*Scirpus setaceous*), manna grass (*Glyceria occidentalis*), toad rush (*Juncus bufonius*), and spike-rush (*Heleocheris obtusa*). The contribution that introduced species make is relatively small (about 25%), although the area receives considerable cattle use.

Flora

The total number of plant species observed on the Reserve is 137 (Appendix B). Of these, 40% are introduced, the majority associated with the historically cultivated *Tall fescue grassland*. Three exotic trees, including Monterey pine (*Pinus radiata*), Monterey cypress (*Cupressus macrocarpa*) and blue gum (*Eucalyptus globulus*), were planted near the old homestead, and an old barn near the southwestern border. One ornamental plant, naked ladies (*Amaryllis belladonna*), remains on the site of the old homestead.

Wildlife

The wildlife values of the Reserve are primarily associated with the mature spruce forest and woodland, and the *Willow scrub*. Perhaps the most important is the canopy-nesting Great Blue Heron and Great Egret (Figure 6). An egret and heron rookery is located in the central portion of the main spruce stand, in the open canopy of the *Spruce/salmonberry woodland* (Figure 6). A combined total of 15-20 pair nested this season. The Reserve offers a valuable opportunity to monitor the health and long-term nesting success of the southern Humboldt Bay heron population.

The remainder of the nesting bird species (Appendix C) are also primarily associated with the forested areas, with only four of the 60 nesting species using other habitats. No species listed as rare or endangered nest at the Reserve.

The mammal populations on Table Bluff are typical of the coastal habitats of Humboldt County (Yokum and Dasmann 1965). Summer populations of Black-tailed Deer appear to be small, with no more than two animals seen at one time. Less than six individuals are suspected to use the Reserve in the spring and summer.

No invertebrate species listed as rare or endangered were found on the Reserve.

Western lily population[1]

The total population of western lily on the Reserve in 1987 was estimated at 920 individuals, 27% or 249 of which were mature[2]. The lilies range in size from negligible to 68" tall. Forty-nine plants exhibited buds or flowers on June 9; 17 maintained intact, healthy fruit in August. The number of flowers per individual was normally one, ranging up to four on two plants.

All estimates of population number and individual size are approximate, since cattle grazing was not eliminated from the area until late in June, after the lilies had produced most their annual growth. An estimated 32% of the plants had been crushed, and 25% grazed at the time of initial inventory in June, making their detection in the dense vegetation difficult. At least some additional damage to the lilies occurred between the census time and when the fence was completed. Based on observation and some monitoring data (Imper 1987a), the disturbance by cattle in 1986 and 1987 was worse than the two previous years. The resulting cumulative effects may lead to unusually high mortality, which cannot be anticipated at this time.

Western lily habitat characteristics[1]

Occupied habitat. The distribution of western lily on the Reserve is confined to about 3.25 acres, located at the west edge of the main spruce stand (Figure 6). Greater than 95% of the seedlings occur within the dense, young spruce stand, considered an immature stage of the *Spruce/maianthemum forest*. Mature lilies are about equally distributed between the *Sweet vernal-grassland* at the edge of the young spruce stand, and remnants of this grassland in internal openings within the spruce. However, the largest plants, and the majority of flowering plants occur in the former location, at the edge of the spruce. A few mature plants occur within the 80-year old spruce stand (*Spruce/maianthemum forest*) east of the young spruce, and within patches of *Willow scrub* at the edge of the young spruce stand.

Successional relationships. An early soils inventory of the Eureka area (Watson 1925) describes the original vegetation associated with both the Rohnerville and Hookton soils as open, with dense grasses, ferns and low shrubs, including hazel, ceanothus and wildrose. No mention is made of spruce, except in the wetter, inland valleys. We do not know exactly what the vegetation occupied by the western lily looked like prior to the 1900's, nor how important the Native Americans and fire was in maintaining the vegetation that existed when white man first arrived.

The area now occupied by spruce and the western lily does not appear to have been cultivated. We can speculate that this was related to the distribution of imperfectly drained soils that seems to follow the cultivated boundary, apparent to the farmer by the patchy distribution of *Willow scrub* throughout the area. In any case, the Steenfott photo (#C61, Humboldt County Library) indicates there was a significant stand of spruce in the area of the lilies and the main stand of spruce by the 1900's. It also appears to show injured or dead spruce along the edge of the main stand, probably related to the (then) recent fire that swept

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[1] A more detailed discussion of the demographics and distribution of the population is included in Section #2.

[2] For the purpose of discussion, western lily individuals less than six inches tall are referred to as seedlings; those greater than this as mature.

through the area (Parry 1963). Much of the spruce stand remained intact, explaining the sharp demarcation in age between the *Spruce/maianthemum and Spruce/swordfern forests*, and the unburned or lightly burned *Spruce/salmonberry woodland*, that is the wettest spruce type on the Reserve. For an unknown reason, however, spruce rapidly invaded the (now) 80-year old spruce sites, but did not in the area of the lilies and young spruce. Perhaps manual control or differential grazing pressure was involved. This undoubtedly is the location where Vollmer (1934) reported "50 western lily in thickets of *Rubus parviflorus, Rubus spectabilus, Gaultheria shallon, Corylus cornuta, Rubus vitifolius, Vaccinium ovatum*, ferns and grasses", and that "the stalk [lily] often goes up through five to seven feet of brush". Some large spruce did remain in the area of the lilies, indicated by the 1939 aerial photo, but by 1948 the area appears largely cleared, with little demarcation between the cultivated field and the area of the lilies. The area remained suitable lily habitat, since in 1955, Vollmer reported 300 individuals in the field near the lighthouse, in the same location cited previously (Vollmer 1955). Based on these early descriptions, it seems likely that the lily has always been associated with vegetation roughly equivalent to the *Sweet vernal-grassland*--albeit with a better developed shrub layer--and perhaps with the *Willow scrub* to some extent.

By 1958, when ownership changed on the parcel, the aerial photo appears to show some kind of ground disturbance in the area of the lilies and the present young spruce stand. Removal of vegetation for fire control, or perhaps associated with oil and gas exploration during this time may have lead to the rapid invasion by spruce, and to the young spruce stand that now threatens a majority of the lily population.

In general, the regeneration of spruce on the Reserve seems to be more cataclysmic, related to disturbance, than an ongoing phenomenon related to successional trends. Spruce invasion into the grassland appears to have subsided; the youngest tree noted was 15 years old. However, elimination of grazing within the exclosure undoubtedly will have significant affects on the character and dynamics of the vegetation, particularly the *Sweet vernal-grassland*. This type will likely develop more of a shrub layer, with native grasses like reedgrass (*Calamagrostis nutkaensis*) becoming more important between shrub patches.

Historical influences. The primary factors that have influenced the western lily habitat we see today on the Reserve are cattle grazing, lily bulb collecting, ground disturbance and exotic species invasion. Fire certainly was significant in removing the initial spruce stand, and is thought to be important in maintaining coastal scrub vegetation farther south in California (Barbour and Major 1977), but its importance in maintaining lily habitat on the Reserve is undocumented.

The western lily habitat appears to have been grazed continuously for at least the past 30 years, perhaps back to the original settlement. The negative impact of livestock grazing on the lily population has been cited repeatedly (Ballantyne 1978, Ballantyne and Critchfield 1980, Vollmer 1955, Ness 1985), but little data exist to assess this impact. Without grazing exclusion, and controlled experimentation, an accurate assessment is not possible.

Because of the attractiveness of lilies, and the western lily in particular, bulb collection by ornamentalists is a constant threat. The Reserve population has probably been the hardest hit of any in California because of its accessibility and notoriety (Ballantyne 1980, Vollmer 1934 and 1955). Large fluctuations in population size over the years have been ascribed to bulb collection (Ballantyne 1980). The affect of historical bulb collection on the Reserve population cannot be estimated other than to say it has been

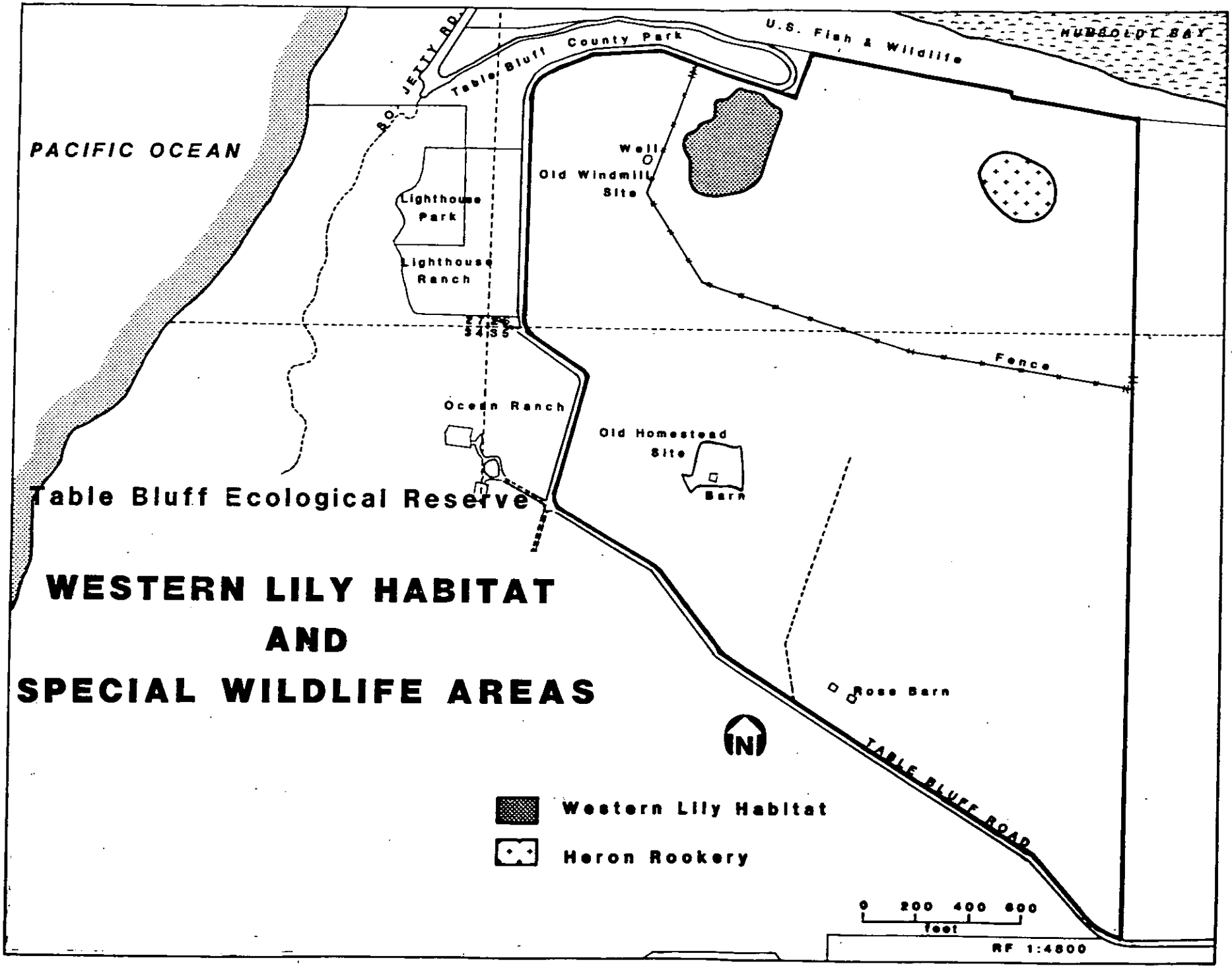
negative.

Ground disturbance, either from fire, human activities, or overgrazing has been a factor influencing the lily habitat. Fortunately, the most significant ground disturbance on the Reserve, the original cultivation and continued cropping of land, left intact at least part of the original western lily habitat. The disturbance that stimulated the wave of spruce regeneration and lead to the existing young spruce stand has negatively impacted a majority of the lily habitat on the Reserve.

Cattle have long been present, but cannot be assessed as to their impact on soil compaction and direct crushing of bulbs, particularly during the wet season. A feature common to all known western lily sites is the absence of historical plowing. The most important aspect of plowing may be its affect on increasing soil compaction, which can be a result of cattle grazing.

Exotic species make up a large portion of the flora on the Reserve (40% overall), and are an important component of the current western lily habitat, constituting 49% of the *Sweet vernal-grassland*, and 48% of the *Spruce/maianthemum forest* composition. This can be attributed to a long grazing history, and the close proximity to the *Tall fescue grassland*. The western lily appears to compete successfully under these conditions.

Figure 6


PACIFIC OCEAN
JETTY RD.
Table Bluff County Park
U.S. Fish & Wildlife
HUMBOLDT BAY
Well
Old Windmill Site
Lighthouse Park
Lighthouse Ranch
Fence
Ocean Ranch
Old Homestead Site
Barn
Table Bluff Ecological Reserve
WESTERN LILY HABITAT
AND
SPECIAL WILDLIFE AREAS
Rose Barn
N
TABLE BLUFF ROAD
Western Lily Habitat
Heron Rookery
0 200 400 800
Feet
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2: WESTERN LILY MANAGEMENT GOALS

INTRODUCTION

Because the western lily is extremely attractive, and important to the horticultural trade, much has been written about it since its original description in 1897. Most of the accounts occur in journals published by the Royal Horticultural Society and the North American Lily Society. These papers include discussions on its relationship to other California lilies, habitat requirements and conditions suitable for propagation, and other characteristics of its ecology or distribution. Not all of these accounts are accurate, and often are based on a single or few observations in the field or garden. However, in sum they are useful and provide a valuable record of the historical lily habitat on Table Bluff and in southern Oregon.

This section summarizes what we know about the species; its background, habitat relationships and major threats, current interest and management, and a detailed description of the population at the Reserve. This information is used to define Species Management Goals, and determine the direction that management should take at the Reserve.

BACKGROUND

Taxonomy

The taxonomic nomenclature for the western lily, beginning at the family level, is:

Family:	Liliaceae
Subfamily:	Lilioideae
Genus:	*Lilium*
Subgenus:	Martagon
Species:	*L. occidentale* Purdy

Lilioideae includes four local genera, *Lilium*, *Calochortus*, *Erythronium*, and *Fritillaria*. *Lilium* is primarily distinguished by presence of scaly bulbs, leafy stems, similar perianth segments, and versatile anthers.

Lilium includes about 80 species distributed throughout the temperate regions of the world, and is normally divided into four subgenera on the basis of form and stance of the flowers, ranging from trumpet or bowl to turkscap in shape, and reflexed or pendulous to upright in stance (Woodcock and Stearn 1950). Martagon is characterized by pendulous flowers with strongly recurved perianth segments, and includes most of our North American species.

Lilium occidentale (from *occidens*, "the quarter of the setting sun") was described by Carl Purdy (Purdy 1897), based on plants or plants grown from bulbs collected on Table Bluff (Ballantyne and Critchfield 1978). The species has been linked taxonomically by various authors to other wet-ground species, including *L. vollmeri*, *L. pardilinum*, and *L. maritimum*, on the basis of similarities in morphology and habitat (Feldmaier 1970, Purdy 1937, Vollmer 1939).

Unfortunately, considerable confusion exists in identification of the various northern California turkscap lilies, including the western lily. Some plants often mistaken for western lily are actually *L. pitkinense*, *L. maritimum*, *L. vollmeri*, or *L. wigginsii*. This is partly due to the extreme variability in some vegetative and floral characteristics within *Lilium*. Characteristics of the bulb are often used to classify *Lilium*, but are now

thought to be relatively inconsistent (Ballantyne 1980, Imper 1987a). Eastwood (1948) published a key to the turkscap lilies of northwestern California which avoided the use of bulb characteristics. Instead, she used the close clustering of stamens around the stigma to distinguish western lily from others. This character remains as one of the most useful and consistent characters to distinguish western lily.

The relationship between the California and southern Oregon populations has been controversial almost since the species was described. This is examined in detail in a later section. Recent attempts to find more decisive characteristics to distinguish the California and Oregon populations, and the western lily from other *Lilium* in general, have used morphometric analysis, electrophoresis, chromatography, and electron micrography (Ballantyne 1983, Skinner 1987a, Schultz 1987b). Most of this research is not yet completed.

Morphology

Bulb. All *Lilium* have perennial bulbs. The bulb is essentially an underground stem comprised of a basal plate, a compressed stem, and overlapping scales (modified leaves), from which the above ground stem and roots grow. Munz (1959) describes the bulb of western lily as "rhizomatous, 4-5 cm long, scales simple or jointed, 12-18 mm long". However, some characteristics of the bulb appear to vary with age and environment. Bulbscales of plants growing in very wet sites (e.g., some of the Oregon sites) tend to be more stubby and jointed, typical of some wet-site species. Bulbscales of plants at the relatively dry Barry site on Table Bluff tend to be thin and broad, more like some dry-ground species (Ballantyne 1980). In some species, "daughter bulbs" arise in the axils of the bulb scales and above ground leaves; in the western lily, bulbs either arise directly from seed or from detached bulb scales.

Stem. Munz describes the erect stems as slender, normally 6-18 dm, and occasionally up to 25 dm high. Height of the lily appears to be a complex function of environment and age. Flowering plants growing in the grassland at the Reserve are normally only 2-3 feet tall, not quite or barely topping surrounding vegetation. Plants completely surrounded by dense vegetation generally do not flower until they reach the surrounding vegetation height, as much as 8 feet. However, the relationship of flowering height to surrounding vegetation appears less direct at the Christensen site. The lack of disturbance at this site has allowed development of what appear to be very old plants, many of which overtop the surrounding vegetation by several feet. Numerous authors refer to plants reaching 8-9 feet (Vollmer 1934, Wallace 1934 1938). Until 1985, two individuals at the Christensen site exceeded 8 feet. Average heights for plants sampled at all of the known sites, in 1987, ranged from 22 to 60 inches (Schultz 1987b).

Leaves. The leaves in *Lilium* are parallel-veined, linear to lanceolate in shape, alternate or whorled, and generally absent from the lower portion of the stem. Munz describes the leaves as "narrowly oblanceolate, 6-15 cm long, 5-25 mm wide, usually only the central whorled". Again leaf characteristics are influenced by age, and vary considerably within and among sites. Leaf measurements taken at the Brookings, Rainbow Rock, and Harris Park wet-sites in southern Oregon averaged between 18-22 cm in length, and 13-15 mm in width (Schultz 1987b); these averages were the longest, and among the narrowest measured of all the known sites. The averages for the four Table Bluff sites were between 12 and 14 cm in length, and 14-20 mm in width, comparable to many sites in Oregon. The incidence of leaf whorls varies considerably within western lily, and appears strongly correlated with stem height. Within the California sites, the tall plants at the

Christensen site have the most whorls. Historically, populations in California were described as exhibiting considerable more whorling than those in Oregon. Many of the conclusions about the Oregon plants appear based on only the Brookings sites, or wet-sites in general. Some of the drier Oregon sites show considerable whorling, although not to the extent seen at the California sites (Schultz 1987b). Overall, populations may average less than one whorl per plant (e.g., Harris Park site) up to four or more whorls per plant (e.g., Christensen site; Schultz 1987b).

Inflorescence. The western lily produces a terminal flower, or a bracted raceme or panicle. Some large plants produce an umbel. Number of flowers per plant, like incidence of whorling, appears strongly correlated with height and age, and related to habitat. Plants with more than 10 flowers are rare. Until 1985, two plants at the Christensen site produced 25 flowers, and as many as 40 are reported in the literature (Wallace 1934). Currently the most flowers per plant in California is 15 (Christensen site), and in Oregon is 12 (Brookings Marsh). Mean number of flowers per flowering plant at the Reserve this year was 1.5, compared to 6.9 at the Christensen site and 3.1 at Brookings Marsh (Schultz 1987b). Plants growing in the open often have relatively few flowers; this may be more a reflection of young age related to an increased susceptibility to grazing, rather than to habitat.

Flowers. Munz describes the flower as "nodding, green at center, then dark orange and usually dotted maroon, crimson at outside, the segments recurved on outer half, 3.5-5.5 cm long; anthers 5-6 mm long, standing close to the pistil". However, flower color in western lily is variable, ranging from washed out orange to deep maroon on the outer portion of the segments. Kline (1959) suggested that low soil iron or pH may alter blossom color in some *Lilium*. Hybrids of the western lily and *L. colombianum* show more orange than red in the flowers, which may explain some of the variability. However, it is unclear how much of the range in flower color within sites (or among sites for that fact) is due to environment, hybridization, or is inherent variability. The frequency at which flowers contain the green tube and nectaries is also variable (Ballantyne 1980). In general, presence of the green color seems to be relatively constant in both California and Oregon populations. Average length of segments for samples from all populations in 1987 ranged 4.6-6.1 cm, generally longer than Munz' description. Anther measurements are especially sensitive to age of the flower, but the anthers are consistently grouped around the pistil.

Fruits. *Lilium* produces three-chambered capsules, stacked with tiny seeds. Munz describes the fruits as "broadly ellipsoid, 1.5-2.5 cm long; seeds rounded, 6-7 mm wide". The shape of the capsule may vary according to degree of fertilization (Ballantyne 1980). The number of seed per capsule normally exceeds 100, and averaged between 119 and 138 at five Oregon sites (Schultz 1987b).

Roots. Many *Lilium*, including the western lily, produce adventitious contractile roots from the base of the bulb (Stoker 1936). These function to drag the bulb deeper into the soil, as much as one to two inches within a single season. Contractile roots appear to be important in ensuring adequate soil coverage and securing an adequately moist soil environment (Stoker 1936).

Current and historical distribution

The current distribution of western lily extends discontinuously from Table Bluff to Hauser, approximately two miles north of Coos Bay, Oregon (Figure 7, Table 2). The Oregon distribution includes nine general sites

scattered over about 120 miles, never more than two to three miles from the ocean. Based on records from the Oregon Rare and Endangered Plant Project, nearly all of the historical collections in Oregon, beginning in 1913, were in the vicinity of current populations. Because of the relative abundance of suitable habitat and difficult access to much of the region, due to dense vegetation and gorse, there appears to be good opportunity for discovery of new sites.

The California distribution includes four sites all within about three miles on Table Bluff. Historical collections and personal accounts indicate that it has always been confined to the immediate vicinity of Humboldt Bay, but ranged from Table Bluff at least as far north as Bayside (Ballantyne 1980, Ballantyne and Critchfield 1978, CNDDB 1987, Ness 1985, Niles 1987). Sites that have apparently been extirpated around the Bay include: near Bayside; the hill above Ryan Slough; Humboldt Hill; Buhne Point; near Henderson Center; near the Eureka Mall; south of Harris Street; College of the Redwoods; and on Table Bluff--upper part of Clough Road, and the route of the old Table Bluff Road just south of Hookton. The many historical collections outside this general area are considered to be misidentified (Ballantyne and Critchfield 1978).

In contrast to the Oregon populations, relatively little opportunity exists for discovery of new populations in California. Most of the grassland, coastal scrub, and freshwater marsh that remains around Humboldt Bay has at one time been cultivated or heavily disturbed. There is a possibility that a few small populations may still be found on Table Bluff, or to the south of the mouth of the Eel River, but it seems unlikely.

Life history and general ecology

The mode of germination in the western lily is referred to as hypogeal, in which the cotyledon remains below ground for the first season after germination while a small bulb is formed (Feldmaier 1970). Evidence from artificial cultivation suggests that the seed must be moist during the few weeks surrounding seed germination and initiation of a small bulb. It may take up to four years in some hypogeal germinators to produce an above-ground shoot. A summary of experience regarding seed viability and methods of propagation for the western lily is included in Appendix D.

Lilium may take several years for the bulb to produce other than a single strap leaf, and longer than this to flower. As the plant grows, food reserves are stored in the bulb scales as starch. Damage to the above-ground shoot can prevent the annual replenishment of bulb reserves, and affect the following year's growth. There are indications that the western lily is a relatively slow grower. Plants were grown from seed under relatively ideal conditions at Humboldt State University; after four years less than 10% of the plants had produced whorled leaves or flowered (Lancaster 1987). In another case, four-year-old plants at the Berry Botanical Garden have yet to flower (Kierstead 1987). Plants will normally produce only one flower for at least the first few years.

The height a plant grows to appears to be a complex function of environment and age. Surrounding shrub height has been directly correlated with height and length of leaves in western lily at Bastendorf Bog (Schultz 1987a). Interestingly, experiments with pruning of the surrounding shrubbery at Bastendorf indicated there is little or no change in height or leaf length for the lily during the year following pruning (Schultz 1987a). It seems that in some cases, response by the lily to environmental change may be delayed for at least one year. Data for individual plants at the Reserve and the Johnson site indicate that once a plant reaches some stable height, usually just exceeding the surrounding vegetation, its height as

Figure 7

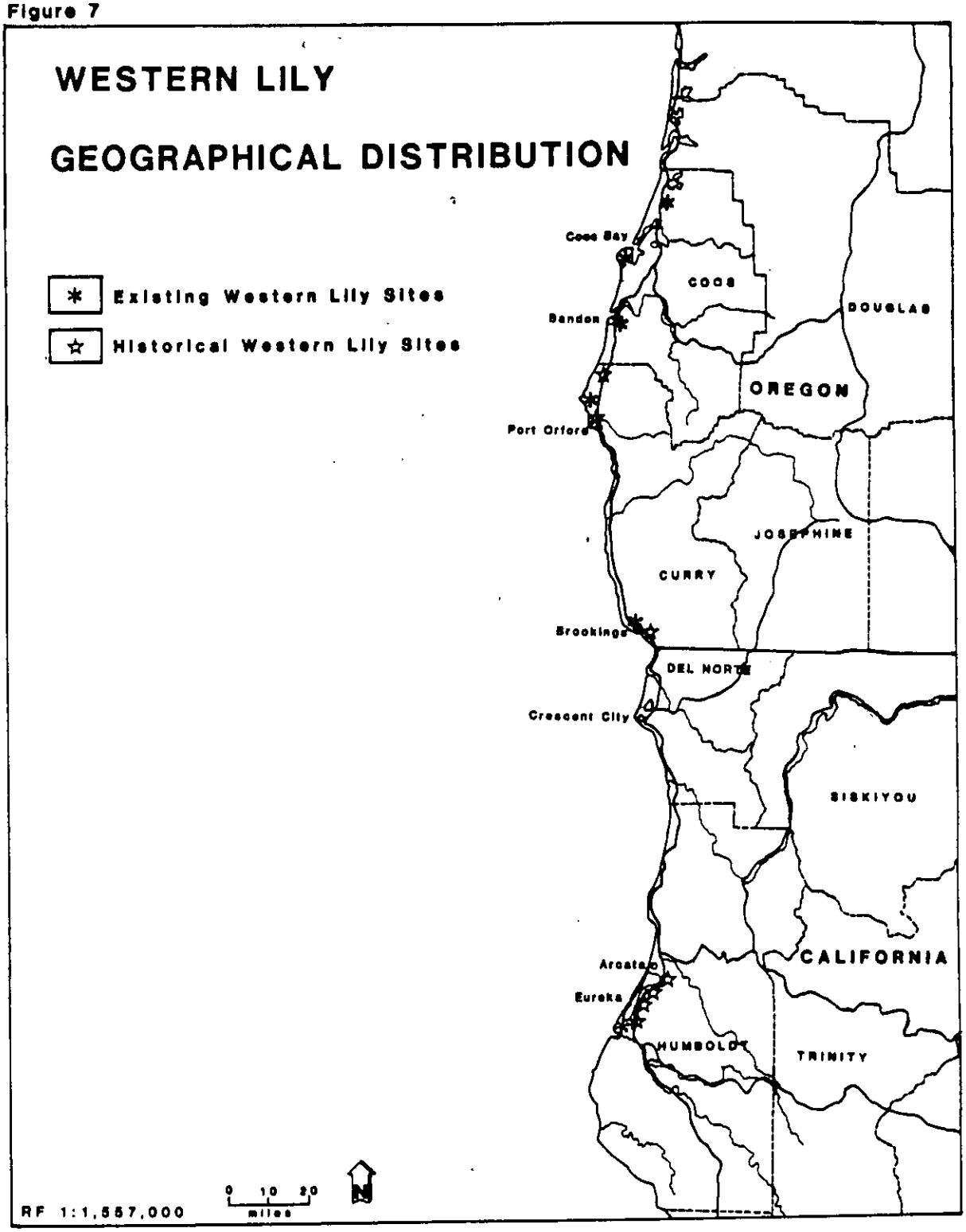

WESTERN LILY
GEOGRAPHICAL DISTRIBUTION
Existing Western Lily Sites
Historical Western Lily Sites
Coos Bay
Bandon
Port Orford
Brookings
Crescent City
Arcata
Eureka
COOS
DOUGLAS
OREGON
JOSEPHINE
CURRY
DEL NORTE
SISKIYOU
CALIFORNIA
HUMBOLDT
TRINITY
0 10 20
miles
N
RF 1:1,557,000

Table 2. Summary of western lily populations in California and Oregon.

Population name/ property owner*	State	CNDDB code[1]	Population size[2]	Threat category[3]	Owner-ship[4]
Table Bluff Reserve	CA	EO9	925 (49)	S	G
Christensen*	CA	EO24	>130 (>100)	S	P
Barry*	CA	EO10	>100 (~8)	E	P
Johnson*	CA	EO21	237 (48)	S	P
Hauser	OR		? (37)	T	P
Bastendorf Bog	OR		>470 (65)[5]	S	TNC
Sewage treatment	OR		? (~10)	T	G
Shore Acres	OR				
trail north			? (~10)	T	G
main bluff			? (~100)	T	G
trail south			? (~10)	T	G
Bowman* (Bandon)	OR		? (>70)	S/T	P
Blacklock Point	OR		? (~30)[6]	T	G
Rainbow Rock	OR		? (25)	T	P
Harris State Park	OR		? (~40)	T	G
Brookings marsh	OR		? (~50)	T	P

[1] California Natural Diversity Database, Dept. of Fish and Game.
[2] 1987 estimates by David Imper (California) and Stewart Schultz (Oregon); Number in parentheses is estimate of plants flowering.
[3] S = safe; E = endangered; T = threatened.
[4] G = governmental; P = private; TNC = The Nature Conservancy.
[5] Does not include ~20 plants thought to be hybrids with *Lilium columbianum*.
[6] Includes plants along Airport Road.

well as flower number in succeeding years generally fluctuates around a mean (Imper 1987a). The lily appears to continue yearly increase in height to a point, but at a slow rate. This tendency suggests that very tall plants that exceed the surrounding vegetation, are uncommonly old plants. The long-protected Christensen site is the only one on Table Bluff where this situation is common. Such a growth strategy in which the first priority is to overtop the competition, followed by growth at a more conservative rate as bulb resources permit, makes sense from an energy conservation standpoint; it also would explain the close correlation between lily and competitor height at disturbed sites, and less correlation at older, more protected sites. Stems generally emerge in March or April, depending on the year and population concerned; stems on the Reserve emerged in late March this year. Annual growth is potentially very rapid, since some plants can grow 8 or more feet in 8-10 weeks.

Various characteristics associated with flowering appear related to habitat. Plants growing in open habitat are triggered to flower at a shorter height, and therefore should flower in fewer years than plants growing in dense and tall vegetation. Open-grown plants generally have fewer flowers. Increased height of surrounding vegetation has been associated with later floral anthesis, lower access by pollinators, and lower seed set by the lily (Schultz 1987a).

There seems to be considerable irregularity, and perhaps periodicity in the appearance of above-ground stems. Monitoring data for Bastendorf Bog suggest that for every four years, the average adult lily will bloom twice, emerge but not bloom once, and remain underground for one year (Schultz

1987a). These results also indicated that adult bulbs can lay dormant for at least two years between production of above ground stems. Monitoring at the Johnson site on Table Bluff showed a large portion of the flowering plants this year did not emerge in 1986 (Imper 1987a), and four years of monitoring at the Reserve suggests considerable irregularity, although cattle grazing at that site has made such conclusions difficult. Undoubtedly the decision to remain dormant is influenced by environment and disturbance, and seems to represent a sophisticated mode of energy conservation or adaptation. It would be interesting to compare bulb dormancy, emergence and flowering rates between the historically disturbed population at the Reserve, and a more protected population such as at the Christensen site.

The western lily has floral morphology generally typical of butterfly-pollinated species, but is almost entirely pollinated by hummingbirds (Skinner 1987a). Because of their small pollen loads, the efficiency of hummingbird pollination in western lily appears quite low; nevertheless, it usually accounts for a significant amount of the seed (Skinner 1987a). Plant that commonly occur in western lily habitat, and that appear important to hummingbirds include *Scrophularia californica*, *Lonicera involucrata*, and species of *Stachys*. *Lilium* generally requires cross-pollination in order to produce seed (MacDaniels 1986), but the western lily appears to be quite self-compatible (Schultz 1987c, Skinner 1987a). However, the degree to which autogamous seed set actually occurs in nature is unclear. Skinner suggests that, more than any other west coast lily, this one reproduces in the absence of cross-pollination (Skinner 1987a). In contrast, field observations at various southern Oregon sites suggested that little if any viable seed is produced from selfing (Schultz 1987c). In this case, the lilies appeared to require nearby plants to produce viable seed.

The start of flowering is variable, beginning anywhere from early June on Table Bluff to mid-July at some sites in southern Oregon. The flowering period generally lasts four to five weeks. Sites having the greatest range in lily habitat, in terms of ground moisture, and having plants with many flowers remain in flower longest. Fruits are generally mature by the end of August, indicated by a reddening of the capsule. The seed being light and broadly winged, is primarily dispersed by wind. The characteristics of plant distribution at most sites indicate that dispersal distance is probably short-range.

The longevity and average population mortality characteristics are not well known. Given the long period apparently necessary to even reach maturity, and the exceptionally large size of some plants, a lifespan of 25 years seems reasonable. Kline (1984) reported the same individuals growing in the wild after 25 years. However, natural mortality appears to be relatively high. Of the total lilies emerging at Bastendorf Bog in 1985, 31% failed to emerge either 1986 or 1987 (Schultz 1987a). Although some plants seem to be able to remain dormant for two years, much longer seems unlikely. Therefore, overall mortality at Bastendorf is something less than 31% annually. Of the individuals flowering in 1985, 16% failed to emerge the following two years, indicating a maximum annual mortality of 16% in the flowering population.

Habitat characteristics

Given the apparent diversity in habitat and broad geographical range shown, it is puzzling that the lily is now and apparently has always been so restricted. Two features stand out to distinguish the immediate area around Humboldt Bay from the surrounding region. The softly consolidated

sediments associated with the Wildcat and Hookton formations are essentially restricted to the vicinity around the Bay, in this portion of the Coast Range. These contrast with the Franciscan hardrock formation, which generally surround the Bay area on all sides (McLaughlin and Harradine 1965). However, soils associated with these formations are highly variable, and it seems unlikely that differences at this level could be responsible for restriction.

The second feature that distinguishes the Humboldt Bay region from surrounding area is its mild winters (Figure 8). Freezing temperatures are relatively rare in this area of the coast compared to farther inland or elsewhere on the coast. Interestingly, this feature is shared by the Oregon distribution of western lily, based on climate data for Brookings, and for other locations farther north on the coast or inland, outside the range of the lily (Table 3). Temperatures at Port Orford, about the center of the distribution in Oregon, average 45 degrees F. in January (Martin and Frenkel 1978). Sensitivity of western lily to freezing temperatures is not well documented, although it has apparently survived relatively cold temperatures (Craig 1936, Secretary 1935). The lily has generally been considered difficult to propagate outside its natural range (MacNeil and MacNeil 1946, Roderick 1984, Slate 1939, Vollmer 1939, Wallace 1938), whereas it has been propagated with little difficulty within its native range (Kline 1984, Lancaster 1987, Woodriff 1987). These observations could be indirect evidence for a climatic limitation, for example freezing temperatures, on distribution of the lily.

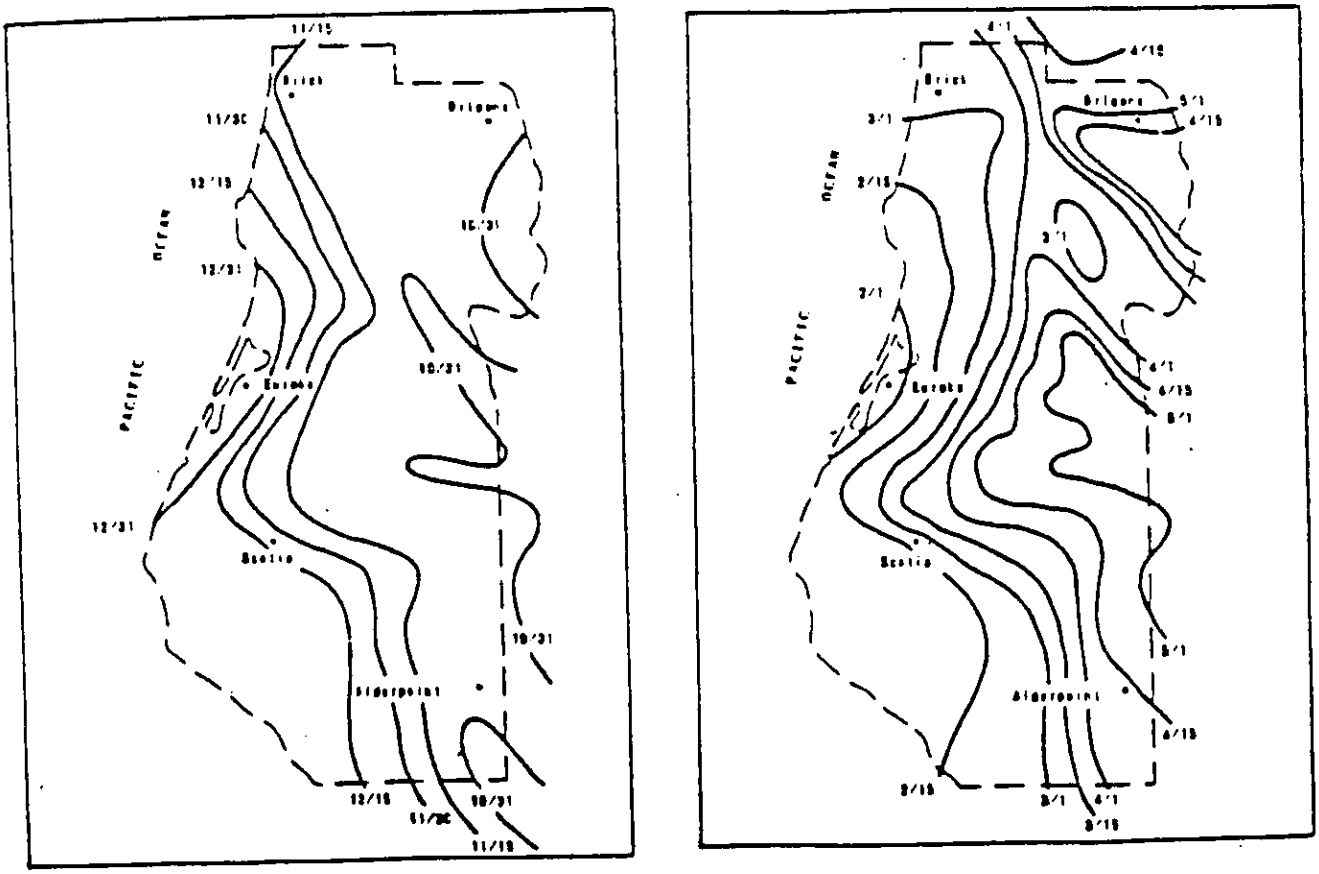


Figure 8. Average dates of first (left) and last (right) 32 degree freeze in Humboldt County (McLaughlin and Harradine 1965).

Table 3. Annual summary of climatic features for locations in northwestern California and western Oregon.[1]

Location	Years	Temperature mean max	Temperature mean min	Mean # days <32 degrees	Mean precip.
Scotia, CA	51-74	61.9	45.5	13	51.0
Eureka, CA	41-70	57.5	46.8	5	39.8
Brookings, OR	51-73	60.9	45.4	7	79.4
Elkton, OR	41-70	65.6	42.6	36	55.4
Cloverdale, OR	51-73	60.2	43.0	30	86.0
Astoria, OR	41-70	58.0	43.0	38	66.3

[1] From National Oceanic and Atmosphereic Administration (1980).

In terms of soils and soil moisture relationships, there are several features common to most western lily sites in both California and Oregon. The soils at all the sites on Table Bluff range from loam to clayloam in texture, and lie on top of a clayey C horizon that appears to cause a perched water table. The Christensen and Johnson sites are similar in that lily habitat occurs at the base of old slope failures, where water surfaces from an exposed stratum. A clayey C horizon occurs at the Johnson site within 18", and between 18 and 30" at the Christensen site. Soil moisture content at the surface ranged from 23-54%, and 16-55% (6/19/87) where the lilies grow at the Johnson and Christensen sites, respectively. In both cases, the lilies do not grow in areas where the moisture content much exceeded this amount, or where water was standing. Lily habitat at the Reserve and at the Barry site differ from these sites in being located on stable terrace formations, but are similar in having a clayey C horizon within 17-20" of the surface. The Barry site appears drier in general, but had 17% soil moisture at the surface, and 25% moisture just above the dense C horizon (6/19/87). Soils in the historically cultivated and heavily grazed area around the Barry site population were too compacted to insert a soil sampling tube at that time. At the same time, soil moisture at the Reserve ranged from 21-35% where the lily grows, compared to 17-20% adjacent to the lily habitat in the *Tall fescue grassland* (Table 4).

Some of the Oregon sites contain areas of standing water. These are generally in the southern portion of the distribution (Brookings Marsh, Rainbow Rock, Harris Park). However, many northern sites exhibit soil moisture regimes similar to those on Table Bluff, and all of the Oregon sites show evidence of imperfect drainage or a seasonal perched water table (Imper 1987a). In the case of Blacklock Point and Bastendorf Bog, the perched water is due to an iron pan at 7-28" in depth, which is characteristic of Blacklock soils (Martin and Frenkel 1978). Many of the other sites show tendency toward development of a pan, but not sufficiently to be classified as Blacklock Series. There are some sites however, such as near the bluffs at Shore Acres, where the iron pan is replaced by a clayey horizon within 18" of the surface, similar to the California sites. In general, the varied hydrological situations surrounding the Oregon sites determine whether the site is marshy or merely wet at some time of the year. Overall, the evidence suggests that the western lily has a critical seasonal soil moisture requirement, which largely determines the soil characteristics of its habitat.

The characteristics of western lily habitat reported in the literature are often contradictory, and depend entirely on the specific sites an author visited. Even Purdy, who described the species, contradicted him-

Table 4. Species cover % and soil characteristics across western lily habitat, Table Bluff Ecological Reserve.

SPECIES	TRANSECT DISTANCE (feet)[1] 0	20	40	60	80	100	120	140	160	180	200	220	300
Western lily habitat[2]					|**********	**********	**********	**********	**********	**********	**********	**********	**********
Tall fescue grassland	|**********	**********	**********	**********	**********								
Sweet vernal-grassland					|**********	**********	**********	**********	**********				
% soil water (0-10")	20		17		21		29		35		29		30
Depth of solum (inches)	22		26		24		24		24		20		18
Festuca arundinacea	7[3]	7					1						
Lolium perenne	37	26	37	62	15	26	9	1			1		
Anthoxanthum odoratum	37	62	26	37	26	26	26	26	9		2		
Holcus lanatus	26	9	9	15	15	37	37	50	26	20	50		
Plantago lanceolata	15	15	15	15	2	9	2	15	9	1	2		
Hypocheris radicata	2	15	26	15	2	2	2		1		1		
Trifolium repens	2	9	9	9	1	2	1						
Rubus vitifolius	15	7	9		2	1	15	9	15	9			
Medicago lupulina		2	2	2	1			1			1		
Lotus corniculatus		2	2		9	2	1						
Rumex acetosella	2		1		1	2	2	2					
Poa trivialis		1	2			1	1						
Achillea millefolium			2		15	7	15	15					
Pteridium aquilinum					26	26	9	15	15	15	1		
Iris douglasiana					26	15	15	37	73	37	9		
Maianthemum dilitatum						9	1	1	15	1			
Calamagrostis nutkaensis							1	20	7				
Carex obnupta						1				7	2		
Agrostis alba					1				1	9	7		
Rubus parviflorus								1	7	18			
Lilium occidentale							1	1					
Salix hookeriana									73				
Picea sitchensis										61	73	97	100
% bare ground										7	15	100	100

[1] Transect begins x/y coordinates 525/00 (sample grid); runs 90 degrees to the 00 baseline

[2] Lilies growing within the spruce beyond distance = 200' are generally <6" tall.

[3] Values are the average for two 1 yd² quadrats placed adjacent to the transect, at the distance indicated; vegetation and soils were sampled 6/19/87.

self; he originally described it as growing in "boggy places in barrens and woods about Humboldt Bay to above Arcata" (Purdy 1897), but later described it as "growing among brake ferns, not at all boggy" (Purdy 1935). Various accounts of historical habitat on Table Bluff include: shrub/grassland mixtures of bracken fern, salmonberry, salal, hazelnut, evergreen huckleberry, and blackberry often 5-7' high (Vollmer 1934); sedge swamp, wet azalea patch, and ferns or natural prairie grounds (CNDDB 1987). The former distribution of western lily around Humboldt Bay may have included very wet sites, suggested by the collection from a sedge swamp, and in a report by Lee Harris, who undoubtedly was familiar with the lily around the Bay (Harris 1949). The association of the lily with wet conditions, whether or not the soils had standing water, is often mentioned in the literature; e.g., Vollmer (1939) states "It does not grow in wet situations, but receives abundant moisture....In addition, summer fogs condensing on the surrounding vegetation keep the ground moist". Fog drip seems to be a significant source of moisture, and may be an important factor in the dense reproduction under spruce at the Reserve.

While historical accounts of western lily habitat in Oregon include some descriptions of very wet conditions, many describe habitat similar or identical to that in California. Some of these include: well-drained marsh with azalea and salal (Ford 1959); scattered nearly dry sphagnum bogs near the coast (Woodcock and Stearn 1950); dry bog with bracken, rhododendron, salal,and huckleberry (Kline 1959); low shrubs with ferns (Field 1955); and pasture with shrubs including azalea, salmonberry, salal, blackberry, evergreen huckleberry and others (Vollmer 1939). The latter description is nearly identical to Vollmer's (1934) for habitat on the Reserve, with the exception of azalea. The historical western lily site near Bayside included azalea.

A survey of existing known lily sites in both states yielded many common associates (Imper 1987a). All sites include *Gaultheria shallon*, and all but Hauser include *Calamagrostis nutkaensis*, often as a dominant. Many or most sites include *Picea sitchensis*, *Spiraea douglasii; Juncus*, *Gentiana sceptrum*, *Lonicera involucrata; Ledum glandulosum*, *Pteridium aquilinum*, *Carex obnupta*, *Maianthemum dilitatum*, *Rubus vitifolius*, *R. spectabilus*, and others. Coastal bluff sites in both California and Oregon include *Potentilla egedei*, *Helenium bolanderi*, and others. Six sites in Oregon, including Hauser, the sewer treatment plant, Bastendorf Bog, Rainbow Rock, Harris Park, and Brooking Marsh are distinctive in containing *Darlingtonia californica*, *Sphagnum*, and other species typical of *L. vollmeri* habitat, farther inland. There appears to be no reason why these species could not grow at the wetter of the Table Bluff sites, if their distributional ranges overlapped.

When compared to the historical descriptions, and to other current lily habitat, the vegetation associated with western lily at the Reserve appears typical (Table 4). Of the four sites on Table Bluff, the Barry site is most different. Most noticeable is the presence of *Ceonothus thyrsiflorus*, absent at all of the other sites. The Barry site is similar to lily habitat on the Reserve in many respects, and could represent what the Tall fescue grassland, in the drier portions of the Reserve, looked like before it was originally cleared.

Relationship between California and Oregon populations

Speculation on the relationship between the Oregon and California populations of western lily dates almost to its original description. Purdy's type description (1897) described its distribution as extending from Table Bluff to above Arcata. He later cited "a lily possibly refer-

rable to this [western lily] along the coast for 150 miles north of Humboldt bay, but with lighter flowers and jointed scales" (Purdy 1935). Based on perceived differences in habitat and morphology, Ballantyne (1980) suggested the Oregon form may be an entirely different entity. Mark Skinner is reviewing the California *Lilium* for the new Jepson Manual, and tentatively plans to publish taxonomic recognition of two subspecies within western lily (Skinner 1987b).

Western lily habitat in Oregon has been characterized as quite different from that in California, primarily with respect to degree of wetness and associated vegetation (Ballantyne 1980). These conclusions appear to be based on the wettest of the Oregon sites. The similarities in habitat between the Oregon and California distributions, both historically and currently, were described at length in the previous section. Overall, there seems to be no consistent distinction, except to say that the Oregon distribution now includes some sites that are wetter than sites around Humboldt Bay.

Morphological differences are often cited as distinguishing the Oregon and California populations. Ballantyne (1980, 1983) cites differences in morphology of the bulb, stem, flower and flower color, anther orientation, pedicel length, leaf morphology, and other features. These comparisons were based on samples from only the Barry site on Table Bluff, and only the Brookings Marsh and Harris Park sites in Oregon, which represent the extremes in habitat, based on associated vegetation and hydrology. Skinner (1987a) found statistically significant differences in leaf morphology and 10 different floral traits, including among others: petal length, width and angle; and tube length and diameter. Again, these comparisons appear based entirely on the Brookings and Rainbow Rock populations in Oregon, and do not include the Christensen site on Table Bluff, one of the wettest sites and therefore most similar in terms of habitat to the Brookings site.

Schultz (1987b) used cluster analysis to identify relationships, based on morphological traits, among all but two of the western lily populations, as well as populations of *L. vollmeri* and *L. columbianum*. The study had some limitations, in that the Johnson and Barry sites on Table Bluff were not included, and sampling of the Table Bluff sites was after the peak of flowering. In summary, the western lily fell into four morphological groups: (1) the Reserve population was grouped with all but four of the Oregon populations; (2) a group containing the three wet sites at the south end of the Oregon distribution; (3) the Hauser site; and (4) the Christensen site on Table Bluff. Interestingly, the Brookings group also included the four populations of *L. vollmeri* sampled. The two *L. columbianum* populations sampled were grouped alone. The isolation of the Christensen population in the analysis might be expected, given its status as the oldest population with the tallest individuals, and greatest number of flowers per plant. Overall, the analytical results were in agreement with intuitive impressions held by both Schultz and Imper, after inspection of all of the existing sites in 1987.

Date of flowering is another characteristic that varies considerably across its range. The sites on Table Bluff are relatively synchronized with respect to when flowering begins and peaks. Flowering usually begins in the first or second week of June, and is nearly completed by the last week of June or first week in July (Imper 1987a). This is comparable to the earliest flowering sites at the north end of the distribution in Oregon. Sites at Bandon and Blacklock Point are somewhat later, peaking in early July. Sites at the south end in Oregon are the latest, peaking in mid to late July (Schultz 1987b, Skinner 1987a). Thus there is no consistent difference in flowering phenology between lily populations in the two states. In general, variation in time of flowering within western lily

seems to be synchronized with the respective *Lilium* that they are sympatric to on a regional basis, and most similar to morphologically; i.e., *L. vollmeri* and *L. columbianum*.

An investigation of chromosome characteristics found differences in the frequency with which accessory chromosomes and secondary constrictions on the second metacentric chromosome occurred between plants from Table Bluff, and from the Brookings and Harris Park populations (Skinner 1987a). It is not clear which population(s) was sampled on Table Bluff. In general, the Table Bluff samples showed some similarity in chromosome characteristics to *L. columbianum* from Patrick's Point.

In summary, western lily exhibits considerable variability in morphology and phenology, and some variability in habitat and chromosome characteristics across its range. Some of these characteristics may vary consistently across the lines of its northern and southern regions of distribution. However, at present the variation seems more local rather than regionally oriented, and is to some extent correlated with different levels of genetic influence by *L. columbianum* and *L. vollmeri*. Separation of the two forms at the subspecific level, if initiated, will probably not follow state boundaries, but will reflect site-specific differences in morphology or habitat, and apparent relationships to other *Lilium*.

OTHER MANAGEMENT FACTORS

Genetic diversity

Since no detailed study of genetic diversity within the western lily has been conducted, all conclusions here are necessarily based on speculation and the available evidence.

In general, morphometric analysis by Skinner (1987a), Schultz (1987b), and Ballantyne (1980) all indicate that there is wide variation in vegetative and floral characteristics among the various populations, both within and between California and Oregon sites. Analysis of pollen grain exine patterns (Ballantyne 1980) found considerable difference among the Harris Park, Brookings Marsh and Rainbow Rock populations, which are the most similar in terms of habitat of the Oregon sites. Chromatography of floral pigments showed difference between the two samples from the Barry site on Table Bluff, and minor differences among the southern Oregon populations sampled (Ballantyne 1980). However, it is not clear how much of this variability is genetically-based.

Much of the variability in western lily could be the result of genetic isolation of the populations, allowing inbreeding, genetic drift, and other genetic processes that could cause divergence of populations. However, it appears that genetic influence by other *Lilium* species is a significant factor.

Hybridization among *Lilium* species in general, and between western lily and other species is well documented (Brown 1984, Stryker 1951). Hybridization of the western lily with *L. columbianum* often results in plants with more orange flowers, stamens that flare more from the stigma, broader leaves, more whorling, and earlier flowering, and plants that occupy drier habitat (Elmsweller 1950a, Kline 1959, Mayell 1960, Schultz 1987a, Stryker 1951, Vollmer 1955). Most reports of natural hybridization with *L. columbianum* refer to the northern part of the Oregon distribution, although some plants at the Barry site on Table Bluff frequently exhibit some of these characteristics.

To some extent, the morphological variation appears related to different levels of genetic relationship to *L. columbianum* and *L. vollmeri*.

Chromosome analysis by Skinner (1987a) found two characteristics that varied considerably among the Table Bluff, Brookings Marsh and Rainbow Rock populations. Presence of secondary constrictions on the second metacentric chromosome, and absence of accessory chromosomes in samples of western lily from Table Bluff, in contrast to Rainbow Rock and Brookings Marsh plants, indicated genetic influence by *L. columbianum* not seen in the Oregon samples (Skinner 1987a). The Brookings area is probably the closest range contact between western lily and *L. vollmeri*; this and similarity of western lily at the Brookings sites to *L. vollmeri* in terms of morphology, some floral pigments and pollen grain exine patterns (Schultz 1987b, Skinner 1987a, Ballantyne 1980) suggest that some genetic overlap.

In summary, based on the minimal evidence available, western lily habitat, floral and vegetative morphology, and phenology appears to vary concurrently with level of genetic relationship with *L. columbianum and L. vollmeri*. We can therefore assume that much of the variability seen in those characteristics is genetically-based, suggesting that western lily has a relatively broad genetic base across its range. However, given the apparent low frequency of outcrossing in western lily, a more critical concern may be the genetic variability within populations. Broad genetic diversity at the species level as a result of many divergent populations, is of limited value to ensuring future adaptation and survival of the species if there is no genetic exchange among populations. A factor which may have further narrowed genetic diversity of individual populations is that some populations appear to have passed through genetic bottlenecks, e.g., the Reserve population was thought to be extirpated in the 1970's. As a result, genetic diversity at the Reserve and other sites with a similar past may be very low.

Major threats

The major threats to the western lily are of two categories, human and non-human related. Both threats have severely impacted the western lily for at least the past 80 years. Almost since first described, the western lily has been considered one of the rarest of all California *Lilium* (Ford 1955 1968, Purdy 1937, Vollmer 1934, Wallace 1938). We do not know if the rarity of western lily early on was due to human impacts in the latter part of the 1800's, or if the species was rare from the beginning civilization of the area. In the latter case, the species could be recently derived or young in an evolutionary sense, or very old and in a state of decline.

Human threats. *Lilium* in general is attractive, with showy flowers, and is relatively easily propagated and hybridized. As a result, a large horticultural trade has developed specifically related to this genus. Add to this the prevalent infatuation with rare species, and it is no wonder the western lily has been a prime target for bulb collectors over the years. Ballantyne (1980) lists bulb collection as one of the principal causes for periodic decline in the Reserve population over the years, primarily related to historical publication of the location in lily journals. The Brookings area was also publicized periodically (e.g., Elmsweller 1950a 1952), and probably shared the same fate. Bulb collecting continues to be a threat, with at least 8 plants taken this year in Oregon (Schultz 1987c).

Unwitting depredation by the public probably is not a significant factor, given the relative isolation of most populations from the beaten path. Many of the roadside plants near Charleston, Oregon, a popular tourist area, are picked each year, probably for their pretty flowers (Schultz 1987a). Nearly the entire flowering population at the Barry site was maliciously pulled up in 1980 (Ballantyne 1983). The population made a

rapid recovery within a few years, until the onset of severe cattle grazing about 1985 (Imper 1987a, Skinner 1985). Although plants appear to easily survive loss of an inflorescence, the impacts of repeated damage to the above-ground plant on the strength of the bulb, and the repeated loss of reproduction on the population in general, are more serious though difficult to quantify.

Undoubtedly the most important human impact on the lily has been the conversion of habitat to buildings or agricultural practices. All of the existing lily sites share a common feature--none have been historically cultivated, or had severe alteration of the native soils. This applies even to the site in the backyard of a residence in Bandon, Oregon. The specific area where the lilies grow has been altered by surrounding drainage, and periodically mowed over the years, but apparently was never filled or plowed (Imper 1987a). We can speculate that this is important in terms of its affect on soil compaction, which can change soil water holding capacity, or perhaps the ability of the contractile roots on the lily to function. In any case, cultural practices on Table Bluff and around the Bay have impacted a significant amount of suitable habitat over the last 140 years.

Non-human threats. Non-human threats include those related to physical environmental factors, competition with other plants, and damage or mortality caused by animals, fungi and virus.

There are no reports of chemical toxicity for western lily. However, plants appearing to show symptoms of chloride (saltspray) toxicity were noted at the Reserve, the Barry site, and on an ocean bluff near Charleston, Oregon (Imper 1987a). In each case, the plants were the most exposed to the northwesterly winds within the population, and exhibited symptoms including: later or aborted flowering; distortions in the inflorescence; limp and discolored or burned tips of leaves. Salt toxicity may be beneficial in terms of limiting surrounding shrub growth, but appeared detrimental to the lilies.

Without a doubt, the major non-human threat to the western lily is the loss of habitat due to encroachment, generally by spruce or shrubs. This is cited in the literature repeatedly (Ballantyne 1980 1983; Ness 1985), and along with building and agricultural practices, best explains the extirpation of all of the historical sites around Humboldt Bay. Specific examples are the historical sites above Ryan Slough, and above the old town of Hookton adjacent to the abandoned road across Table Bluff, as identified by Doris Niles, long-time Table Bluff resident. These sites are now completely dominated by spruce, with a dense shrub understory (Imper 1987a). The major current threat to many populations in Oregon, particularly at Bastendorf Bog, is competition by salal (Schultz 1987c).

Impacts by cattle are the most significant, and the best documented of the animal-related threats. Grazing impacts can be described as severe, when the population is restricted primarily to individuals that escape through isolation, and chronic, when the population is consistently repressed and prevented from exploiting otherwise suitable nearby habitat. The Barry site currently suffers from severe grazing; nearly all lilies occur in dense, tall islands of shrubs, where they are shielded from cattle. Any plants that appear in the more open areas do not last more than a few years.

The chronic effects of cattle grazing are presently seen at the Reserve and Johnson site populations. Monitoring data taken at the Reserve over the last four years illustrates the a typical chronic affect of cattle grazing (Figure 9). In 1983, the size-class distribution (roughly equivalent to age-class distribution) for the plot is somewhat backward J-shaped. Based on data for the Johnson site, this appears typical of moderately

grazed lily habitat, and suggests the high reproductive potential of the lily. Relatively little cattle activity occurred in the vicinity of the study plot in 1984 and 1985, which allowed the sample population to develop a more level size-class distribution, as well as increase overall. In 1986, severe cattle grazing and traffic related to research occurred in the area, resulting in a population crash. In 1987, moderately high cattle use of the area still restricted the overall population, but enabled growth in some plants equal to two years previous. Little progress toward leveling of the size-class distribution occurred this year.

The effect of withdrawing cattle grazing is also shown by monitoring data from the Johnson site exclosure for the past two years (Figure 10). Although the overall population increased, the size-class distribution levels off considerably in the second year. The frequency distribution of flower number per flowering plant is also an indicator of relative age of the population. Both the Johnson and the Reserve populations are heavily weighted in the single flower category (Figure 11). Due to the past consistent grazing, this is probably as far as the Reserve population has ever progressed since 1955, when Vollmer (1955) described the population as having mostly one flower per plant, and one plant having four.

Eventually the repressed populations at the Johnson site and the Reserve should approach the situation seen at the Christensen site, where cattle grazing has been excluded for many years. Informal monitoring at this site indicates the population is composed primarily of tall, old individuals; young lilies constitute a relatively minor portion of the population, but presumably are sufficient to maintain the population. The average number of flowers per flowering plant at this site in 1987 was 6.9 (Schultz 1987b).

The impacts of cattle on the western lily through direct damage to the bulb, and indirectly through compaction of the soil can only be speculated, but could be significant.

Evidence indicates that natural grazing, primarily by deer, can be a major threat to reproduction of the lily. Grazing mostly by deer, caused at least a 50% loss in fruit production at Bastendorf Bog this year, up from 15% in 1985 (Schultz 1987a). The Christensen and Johnson sites have experienced less than 5% loss to deer in the past two years, but these estimates may be low since they were made in July (Imper 1987a). As in the case of cattle grazing, the plants that reproduce successfully are often those that are protected by dense shrubbery. Experience at Bastendorf Bog indicates that grazing is lighter on non-flowering plants, even if they are exposed.

Discussion of the remainder of the animal and viral threats is primarily based on Feldmaier (1970) and Genders (1973). The other potential mammalian threats include voles, mice, brush rabbits and gophers. There is no evidence to indicate the extent of their impacts.

Slugs and snails cause some loss of foliage at the Reserve, and can attack young shoots and bulbs, but should not normally be a significant problem. Millipedes cause some damage by eating bulb scales, but again this does not seem to be a significant threat.

Nematodes are generally confined to commercial lilies, where they cause considerable damage and expense locally. Leaf and flower nematodes require damp weather, and enter the leaves. They leave the leaves and flowers discolored, lifeless and malformed. Root nematodes enter the bulbs and cause yellowing of the leaves and root decay. Both are difficult to control.

Insects appear to be the most significant animal threat after cattle and deer. An unidentified moth larvae has been observed feeding on developing flower buds, flowers and fruits, causing some loss of seed

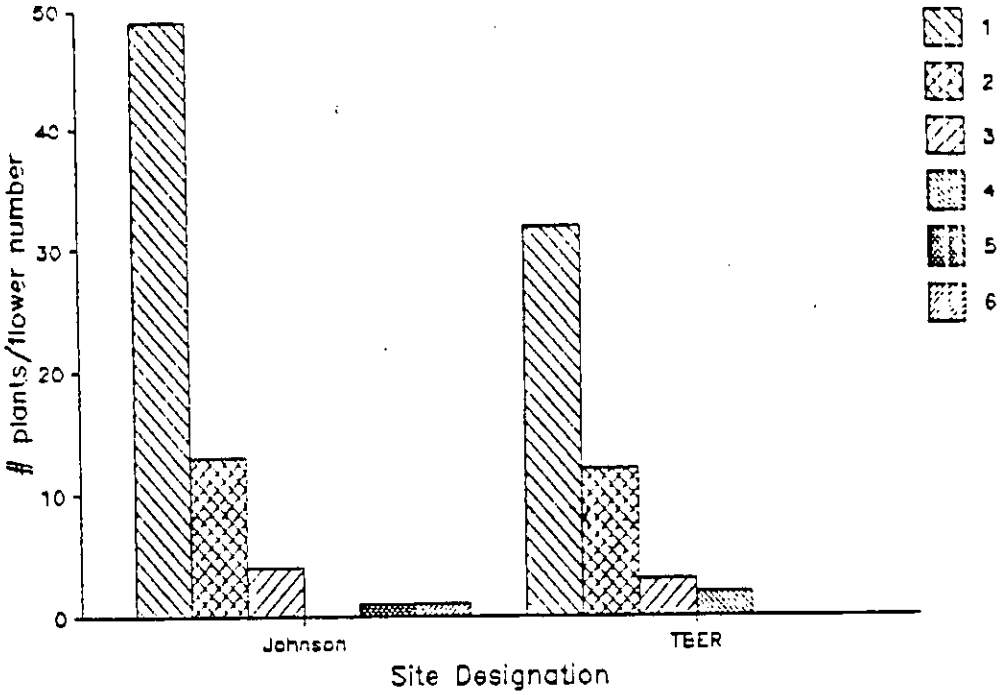


Figure 11. Frequency distribution of number of flowers per plant for western lily at the Table Bluff Ecological Reserve and the Johnson sites, 1987.

production at the Reserve. The attack was worst in 1984, when an estimated 30-40% of the fruit crop was affected (Imper 1987a). Damage often amounted to eating of the stamens or stigma, in some cases causing total loss of reproduction. The larvae was tentatively identified at that time as an army cutworm by the County Extension Office. Perhaps attributable to that same species, larvae caused damage this year to 10-20% of the fruit crop at the Reserve. In this case, no larvae could be found, but the damage to the fruits was identified as similar to that caused by orange tortrix moth larvae (Woodriff 1987). The damage this year was often confined to borings into the fruit, and partial consumption of the seed, suggesting the possibility that two separate pests are involved. Fungal infection of the damaged capsules was observed, and may constitute more of an impact than the larvae itself. Other reported threats to the western lily specifically include a lily cane borer, that causes damage to a small number of the larger lilies by eating the pith and pupating in the stem, and an unidentified insect that stings the developing bud, causing it to abort (Ballantyne 1984).

Some other general insect pests are not currently documented in native lilies but are a potential threat. Lily thrips can live between the bulbscales, causing the flower to be malformed, or increased susceptibility of the bulb to fungal infection. Another pest is the "lily beetle", a small red beetle that lays eggs on the underside of leaves between May and June. The larvae feeds on the leaves and flowers, leaving a characteristic series of semi-circular notches along the leaf margins. While this pest is not reported in our native lilies, symptoms similar to these were noted at the Reserve this year, from an unknown cause.

It is unlikely that fungal diseases will be a significant threat to the Reserve population. There are two potential threats; *Botrytus* and *Fusarium* are the most prevalent fungal diseases of lilies in general. *Botrytus* blight or 'leafspot' appears able to infect any lily, native or not, and is most common in the summer during periods of fluctuating warm, wet and dry conditions. It is usually first noticed on the leaves as small brown areas

(*Botrytus elliptica*). As it advances, a second infection of *Botrytus cinerea* attacks the entire above ground plant, and covers it with a grayish mold. It indirectly retards the bulb,and can affect seed viability. *Fusarium* fungus is found in most soils and attacks the bulbs, causing root dieback and ultimate death. *Lilium pardilinum* has been shown to be slightly susceptible (Woodcock and Stearn 1950).

No incidence of virus-related disease in native California Lilium has been found (Ballantyne *et al.* 1979), although it is common in commercial lilies grown in this area, and the potential for infection of natives is everpresent. Feldmaier (1970) lists two viruses that could have disease potential, symptomless and mosaic virus. Plants infected with symptomless virus only show affects after secondary viral infection. It is primarily transmitted by aphids, and possibly thrips. Mosaic virus is common in many commercial varieties, and is recognized by a mosaic pattern of light green spotting and streaking of the leaves, and stunting of the stem. It includes many forms with slightly different symptoms. *Lilium pardilinum* and its allies appear to be immune to this virus (Woodcock and Stearn 1950). Western lily seedlings and other west coast native lilies were grown alongside infected *L. regale* without infection (Green and Tincker 1940).

Threat of extinction

Assessment of threat of extinction for the western lily in the wild should recognize several factors: (1) likelihood that a single threat capable of causing 100% mortality in a population can reach a sufficient number of populations so as to threaten species viability, (2) likelihood that natural fluctuations in populations will synchronize at a low point and threaten species viability, (3) the genetic viability of the species, or the ability of the plant to cope with future change that is not under human control, and (4) likelihood that suitable habitat will continue to be available, and that some protection against severe grazing is afforded.

The possibility that some factor, e.g., disease or severe fire, could threaten all populations throughout the range simultaneously is low. Considering that one population may represent a considerable fraction of the species genetic base, loss of even a few populations simultaneously may drastically reduce the total species genetic variability. Since it appears that little or no genetic exchange goes on among most of the sites, this may not appear to be a critical consideration. However, future research may indicate that manipulated crossing among populations is necessary to maintain viability, substituting for what once may have been a system of interbreeding colonies. The simultaneous loss of the California populations is a distinct possibility. The obvious remedy is to reintroduce or introduce new populations to suitable habitat around Humboldt Bay.

The occurrence and magnitude of natural fluctuations in western lily populations are not known. The extent to which this threatens the species will depend on future monitoring and the level that we can mitigate the factors responsible.

The genetic variability of the species overall may be relatively high; however this may be of little consequence if individual populations are not viable in the long term, and no genetic exchange occurs among populations. This area should be assessed soon, so that informed decisions can be made on the need for cross-introduction of populations.

The likelihood that suitable lily habitat will continue to be available seems moderately good at this time. Eight of the 15 sites listed in Table 2 are in governmental or The Nature Conservancy (TNC) ownership. Only two, Bastendorf Bog and the Reserve, are currently under management that pre-

cludes activities detrimental to the lily. As recently as 1984, the Oregon State Department of Parks allowed a road to be bulldozed through the Harris Park site, potentially endangering the population. This example illustrates the vulnerability of populations even within government ownership. This year at Shore Acres, also under State Park ownership, at least five western lilies were removed by normal trail maintenance (Schultz 1987c). While the potential exists for public agency protection of over half the existing populations, it is clear that all government agencies involved must adopt a management policy specifically pertaining to the western lily, and train their personnel on its recognition.

Two of the privately owned sites on Table Bluff are currently protected, and monitored in conjunction with the TNC Landowner Contact Program. The agreements with these owners are not legally binding, and the owner has the discretion at any time to terminate protection.

In summary, until more is known about the genetic diversity of western lily, and firm management policy is instigated by the governmental agencies owning a majority of the known populations, the western lily must be considered threatened with extinction.

Previous and current management

Management activities related to the western lily prior to 1983 were restricted to informal attempts to expand populations at various sites. Leota Ness (1985) described how she would spread seed and replant bulbscales at the Reserve site in past years, and Orell Ballantyne (1987) has made similar attempts at the Barry and Christensen sites. Undoubtedly, efforts like these have been repeated in Oregon and California over the years, by people concerned with the declining populations.

In the late 1970's, Orell Ballantyne urged the North American Lily Society to take an active role in preservation of western lily habitat and populations, and specifically urged acquisition of the only known site in California (Barry site), but funds were not available (Ballantyne 1978 1980). An attempt by TNC to purchase the site was unsuccessful due to unwillingness by the owner. Ballantyne informally monitored the Barry site for many years from 1970 on. Many of the Oregon sites have been informally monitored for several years by Veva Stansell, resident of Pistol River, Oregon.

In 1983, TNC purchased approximately 10 acres of western lily habitat at Bastendorf Bog. Initial management activities included only monitoring. In 1985, Stewart Schultz began formal individual plant and vegetation monitoring, as well as small-scale experimentation designed to elicit various habitat relationships such as the extent of animal depredation (Schultz 1986a 1986b 1987a 1987b). This research included construction of exclosures and vegetation manipulation. It is too early to draw conclusions for specific management.

In Fall of 1985, as a result of the TNC Landowner Contact Program, a fence was constructed around the newly discovered Johnson site. This project resulted from a joint cooperative effort involving the owners, TNC, and the California Native Plant Society (CNPS). The Johnson site had been severely impacted by cattle grazing. Formal monitoring of this site began in 1986 (Imper 1987b). Again in Fall 1987, the cooperative effort of the Christensen site owners, TNC, and CNPS resulted in a fence around this site, prior to introduction of cattle into an adjacent field. Formal monitoring will begin at the Christensen site in 1988, and began at the Reserve in 1984 (Imper 1987a).

The Berry Botanical Garden in Portland, Oregon, has initiated a Lily Species Project, in which they are establishing a living collection and

seed bank for all endangered *Lilium*, particularly those endemic to the Pacific Rim (McRae 1979, McRae and McRae 1982). They will also provide a center of reliable information, and act as a clearinghouse for the exchange of information and plant material for all manner of research relating to *Lilium*. They currently have living representatives of western lily from three of the Table Bluff populations (except Christensen) and from various Oregon sites.

DISTRIBUTION AND DEMOGRAPHICS OF WESTERN LILY ON THE RESERVE

The distribution of western lily on the Reserve, according to height class, is shown in Figure 12. The permanent grid established for routine monitoring is indicated for reference. A majority of the population is seedlings (0-6" size class; Figure 13; Appendix E) that occur in the dense, young spruce forest. In general, concentrations of seedlings and repressed adults occur within or around the remnant patches of grassland within the forest. Nearly all of the flowering plants occur at the edge of the forest or in the adjacent grassland.

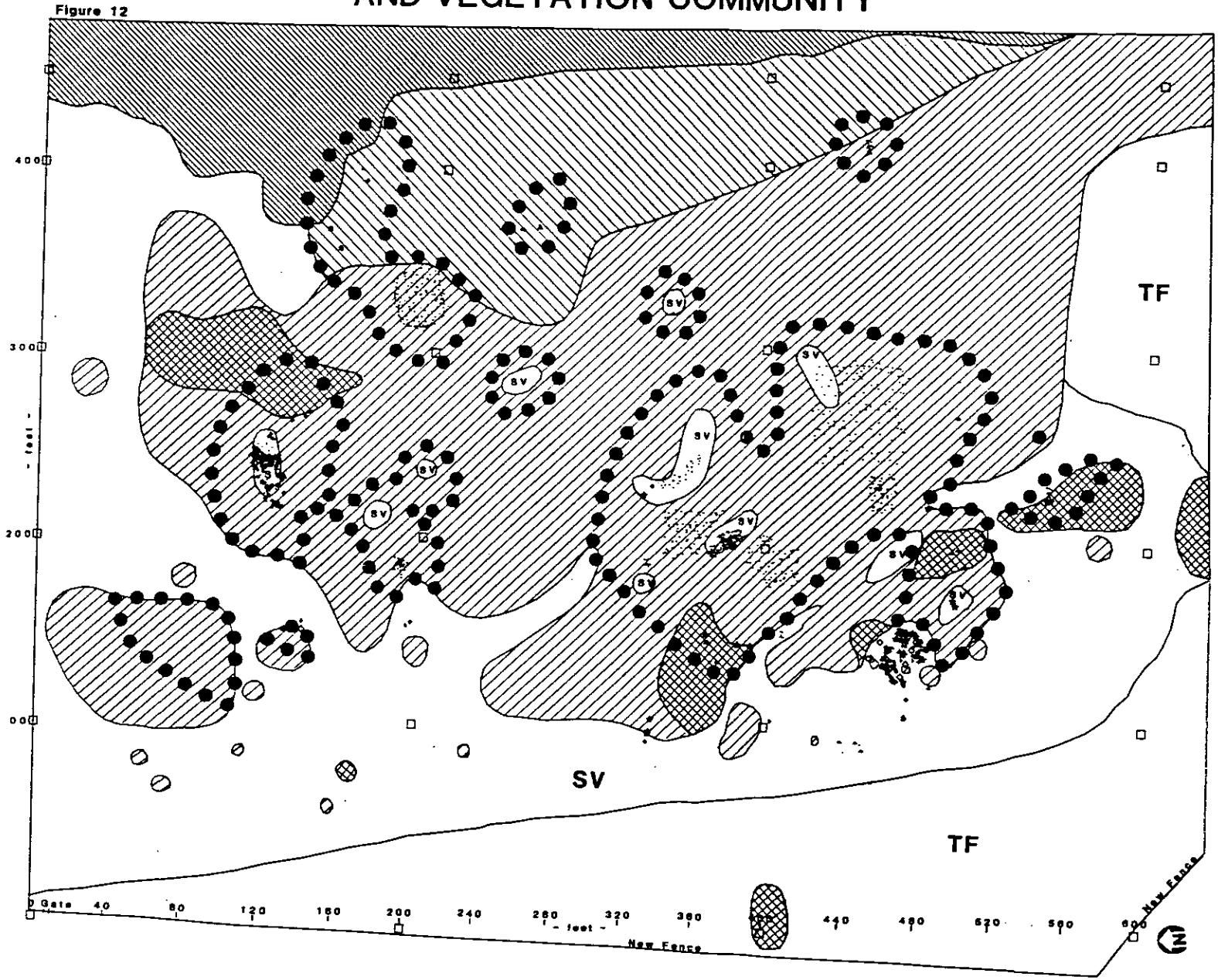
The frequency distributions for both height-class and number of flowers per flowering plant (Figure 11) indicate a relatively young population, weighted in the smaller size and single-flower categories. These distributions are in part due to the large amount of (apparent) reproduction underneath the spruce, and due to a large portion of the population being in a repressed condition as a result of continuous cattle grazing and heavy shading. The bulbs of these plants are weak, and though perhaps relatively old, incapable of producing larger stems or many flowers. In this sense, the effects of shading and grazing probably confound the normal progression of aging, and make it difficult to know what is a young plant as opposed to a repressed plant.

Most of the concentrations of seedlings in the spruce forest were located downwind (southeast) of some mature plants that (presumably) have set fruit recently. The high concentrations of seedlings, and their systematic location suggest that these are seedlings and not adults in a state of decline. Informal reconnaissance of the spruce stand in past years, usually in June, failed to detect more than 10 seedlings in any one year (Imper 1987a). The seedlings could have been missed since many tend to die back earlier than mature lilies; however, a significant number remained visible this year after the end of June.

WESTERN LILY--TABLE BLUFF ECOLOGICAL RESERVE

MAP OF DISTRIBUTION BY HEIGHT CLASS AND VEGETATION COMMUNITY

Figure 12



Vegetation Communities

- TF — Tall fescue grassland
- SV — Sweet vernal grassland
- Spruce/malanthemum forest
- Spruce/malanthemum forest immature stage
- Spruce/salmonberry woodland
- Willow scrub

Height Classes (in inches)

- 0 - 6
- 7 - 12
- 13 - 18
- 19 - 24
- 25 - 30
- 31 and taller

Management Information

- Permanent Grid Points
- Area Enclosed By This Symbol Represents Phase 1 Management Spruce & Willow Scrub Thinning

Figure 13. Frequency distribution of height-class for western lily at the Table Bluff Ecological Reserve in 1987.

WESTERN LILY MANAGEMENT AND ENHANCEMENT GOALS

The goals for management or enhancement of the western lily are based on critical aspects of its life history, general ecological and habitat relationships, genetic diversity, and threats. As a matter of priority, they are divided into Management Goals, those that must be fulfilled in order to maintain the existing population, and Enhancement Goals, those that will serve to enhance the population and the overall viability of the species.

Western Lily Management Goals

(1) Restore and maintain western lily habitat on the Reserve to a condition suitable for growth and reproduction of existing plants.

Methods for achievement
- Vegetation manipulation
- Vegetation monitoring

(2) Prevent natural or unnatural impacts which threaten the viability of the population.

Methods for achievement
- Monitor population on routine basis
- Control disease and animal depradation as necessary
- Maintain protective facilities (signing, fencing)
- Control cattle and public access as necessary

(3) Ensure proper and sufficient management through utilization of local interest and knowledge concerning the lily and the Reserve.

Methods for achievement

Maintain communication with local organizations and knowledgable individuals

Western Lily Enhancement Goals

(1) Increase the Reserve population and distribution.

Methods for achievement

Identify unoccupied suitable habitat and establish colonies

Maximize suitable habitat through selective removal of spruce along stand boundaries; establish colonies

(2) Reduce the current uncontrolled human impacts in western lily habitat on the Reserve over and above Maintenance objectives.

Methods for achievement

Develop a nature trail; establish and maintain lilies to meet the needs of the public

(3) Increase the number of populations and distribution around Humboldt Bay.

Methods for achievement

Encourage and engage in the reintroduction or introduction of western lily to suitable and protected habitat

(4) Help to ensure the future viability of the species.

Methods for achievement

Sponsor research on the genetic diversity of the species, and need for cross-introduction of populations

Acquire currently occupied, or unoccupied suitable habitat around the Bay; work with The Nature Conservancy or other organizations to ensure future protection of existing populations

Establish populations that are removed from the existing populations, both on the Reserve and off-site.

3: RESERVE MANAGEMENT OBJECTIVES

INTRODUCTION

This section summarizes the various opportunities and constraints for the Reserve, from which are developed management objectives. These objectives are designed to achieve the western lily Management or Enhancement Goals described in the previous section, and maintain or enhance other significant values on the Reserve, including the spruce forest, Heron rookery, and general wildlife diversity.

OPPORTUNITIES AND CONSTRAINTS

Resource-related

The Reserve provides opportunities to maintain or enhance the western lily population and two featured habitats (western lily; coastal spruce forest), and perhaps recreate coastal prairie. Opportunities are also available to enhance the wildlife values in general, and maintain the existing Heron/Egret rookery. Range utilization may be considered an opportunity, if it can be shown compatible with the other primary values of the Reserve.

Western lily. Several facts or assumptions are pertinent to developing management objectives:

(1) The Reserve includes the largest population, and the most occupied habitat for the lily known in California. This habitat is typical, or is potentially typical of historical lily habitat around Humboldt Bay.

(2) A majority of the Reserve population is in a small size class, and apparently capable of future reproduction if habitat manipulation is conducted without delay.

(3) Seed viability for the species appears to be high.

(4) Cattle grazing has been excluded from all of the currently occupied lily habitat, and some potential habitat.

(5) The Reserve deer population appears small at this time, and probably does not pose an immediate threat to the lily population.

(6) The Reserve includes a large amount of potential western lily habitat, based on its vegetation, soils, and soil moisture relationships. This habitat includes all of the area occupied by the *Sweet vernal-grassland*, portions of the spruce forest, and much of the boundary between the grassland, spruce forest and *Willow scrub*. We estimate that at least 3-5 acres, in addition to the 2-3 acres currently occupied, could grow western lily without significant impact on the older spruce stand or its associated wildlife. Additional lily habitat may become apparent inside the exclosure, and outside if grazing pressure is reduced, allowing natural vegetation patterns to develop.

The primary external constraints for management of western lily on the Reserve are its susceptibility to vandalism, bulb or plant collection, and general overuse by lily enthusiasts or recreationalists. The following factors should be recognized in development of the area objectives and protective measures:

(1) Hookton Road, which bounds the Reserve on three sides, receives considerable recreational traffic during the summer. Many of these vehicles stop at the overlook on the north side of the Reserve. The overlook is also used by model airplane enthusiasts, some of which use the field in

the northwest portion of the Reserve for a landing area.

(2) The Reserve population has more publicity than any other specific site in California or Oregon, due to publications by Vollmer (1934, 1955) and others. Because of this, the site is probably the most vulnerable to bulb collection.

(3) Both the Reserve and the Barry site populations are well known by local lily enthusiasts. Annual visitation is unknown, but may be relatively high.

(4) The Lighthouse Ranch and a Native American rancheria are located nearby. Both of these normally provide residence for many people. The Reserve provides a nearby natural and peaceful setting, and may be subject to recreational use from these sources.

(5) With respect to enhancement of the western lily population, maintenance of the Heron rookery and the main spruce stand intact can be conceived as a constraint. However, considerable enhancement of the population can be achieved without impacting these areas or the wildlife values of the Reserve in general. It may not be desirable to maximize western lily occupancy of the Reserve, since susceptibility to disease outbreak could increase with density of the population.

Western lily habitat. Western lily habitat on the Reserve includes several vegetation types, including the *Sweet vernal-grassland*, *Spruce/maianthemum forest*, and minor amounts of *Willow scrub*. Successful management of the western lily will involve management of these habitat types.

Coastal spruce forest. The general habitat described as coastal spruce forest on the Reserve includes three plant communities; *Spruce/maianthemum* and *Spruce/swordfern forests* and the *Spruce/salmonberry woodland*.

Due to the rarity of substantial, mature forest stands on Table Bluff, and the proximity of the Reserve to the ocean and Eel River delta, the Reserve provides elements of structural and species diversity that are unique in the immediate region. These are important factors in wildlife abundance and diversity. As such, the main spruce stand assumes greater importance than if it occurred in a more forested area. Management activities should recognize the importance of this resource.

Coastal prairie (potential). The majority of the Reserve (over 90 acres) is the disturbed *Tall fescue grassland*. This area provides a unique opportunity to manage specifically for upland wildlife species, and perhaps recreate vegetation similar to the coastal prairie that probably occurred in the drier areas of Table Bluff prior to the 1850's. However, it is likely that the impact of over a century of cattle grazing and intermittent cultivation have changed the soils such that a return to more natural vegetation, if left to natural invasion, would be exceptionally slow or impossible. Nevertheless, it is a significant potential opportunity that is worth pursuing.

Whether or not the natural prairie community is restored, any relief from grazing pressure should improve the structural diversity over a majority of the Reserve, as shrubs and occasional spruce become established; this will contribute significantly to wildlife values, and improve the natural appearance of the grassland. At the same time, monitoring will be necessary to ensure that structural enhancement does not stimulate an increase in the deer population, and consequent threat to the western lily.

Wildlife. An important consideration in all future management is maintenance of the Heron/Egret rookery, which is relatively rare in the region. The Reserve also contains a freshwater source, relatively uncommon in the area, and probably related to the shallow Hookton soils. Establishment of riparian vegetation in some of the ravines, if feasible, is an opportunity to significantly increase wildlife habitat availability.

Range utilization. Under the Interim O&M Plan for the Reserve, a maximum 552 AUMs (animal unit months) of cattle grazing are allowed on the Reserve. While grazing has undoubtedly impacted the lily population in the past, seasonal and controlled grazing may be shown to be an effective tool for lily habitat maintenance or exotic species control on the Reserve. Related research is recommended in Section #5.

Cultural

Perhaps one of the most significant cultural opportunities, as well as management tools available to the Reserve is the creation of a technical and public relations advisory group. The group could be called the Table Bluff Contact Group, and be composed of members of local and interested conservation organizations, DF&G personnel, and a specialist in western lily ecology and management. Such a committee would have many advantages.

Involvement of conservation organizations, such as the Audubon Society and the California Native Plant Society, with an obvious interest in the management of the Reserve, will help in the areas of professional guidance and general protection against vandalism and abuse. Group fieldtrips to the area, which will mostly involve these groups, could be controlled more effectively. The involvement of an expert in lily ecology will provide the specific familiarity with the western lily that would generally not be available from DF&G personnel. This benefit may be especially important in situations where an immediate response is needed to counter some threat, such as an outbreak of disease.

The role of the Committee would be advisory and public relations. The committee would relieve some of the responsibilities of management from DF&G, and in many cases could help provide volunteer labor for projects.

Other cultural opportunities provided by the Reserve are generally in the area of natural interpretation and public education. The attractiveness of both the western lily and the general area of the Reserve are highly conducive to generating increased awareness and concern for conserving our diminishing natural resources. If carefully developed, the long term benefits to natural resource conservation arising from this Reserve can extend far beyond its boundaries.

A small-scale nature trail and interpretive brochure might be used to increase awareness of the western lily and the Reserve management objectives, and also accomodate the needs of the Wildlife Conservation Pass Program. Ideally the trail would funnel some of the presently uncontrolled use of the area into one area. Within this area, mitigative measures could be used to ensure that the impact of public use on the western lily population and the Reserve in general are kept at an acceptable level.

The cultural constraints on management of the Reserve, i.e., aside from specific jurisdictional requirements, fall into two categories, general opposition to the proposed management activities, and unauthorized entry and abuse of Reserve resources. There may be some people and public officials that will disagree with any shift away from an emphasis on commodity outputs, no matter how well justified. Adjacent residents and landowners may oppose particular management activities. Overall, the kinds of management objectives recommended here will probably not be disagreeable

to most people, if they are informed as to the extent of future manipulation, and the justification for particular management activities.

Permitted public uses of the reserve will include relatively benign activities such as hiking, nature study, birdwatching and photography. The best means to control these uses are maintenance of fencing and signing, public education, and enforcement of closure.

Jurisdictional

The following agencies have jurisdiction over activities proposed on the Reserve: DF&G, Humboldt County, California Coastal Commission, and depending on the method used for spruce removal, the California Department of Forestry (CDF).

Internal DF&G regulations governing the general operation of Ecological Reserves are contained in Title 14 of the California Administrative Code. These regulations authorize livestock grazing, controlled burning, use of chemicals and mechanical treatment to achieve management and enhancement objectives.

Since the Reserve contains a state-listed endangered species, activities on the Reserve that potentially impact this species must comply with the requirements of the California Endangered Species Act of 1984. Some of the pertinent aspects of this legislation include Article 4, concerning the need for jeopardy consultation by DF&G, and Article 3, concerning the "take" of an endangered species for management or other purposes.

With respect to DF&G funding for Reserve operations and maintenance, monies are unpredictable, since several reserves compete for the same available funds. The current funding for maintenance in Region 1 is spread among many operations and projects. Funding for maintenance of the western lily population is available from Unit 778 funds, and for threatened or endangered species work in general from Tax Checkoff funds. In addition, if non-game related funds become available, and a project requires a specific monitoring program, funding can be requested on a two year basis. However, alternate funding sources may need to be explored to initiate some management activities, including WCB, Proposition 19, or EPA monies.

There is also limited DF&G staff to administer the Reserve. At this time, only one person is responsible for the Table Bluff and Lake Earl operations. There is a possibility that a position will be dedicated to the Eel River Management Area (including TBER), but this does not appear likely for at least 2-3 years. On-site staffing for this Reserve is considered unlikely.

The Reserve lies entirely within the Coastal Zone; therefore all management activities are subject to approval under the Coastal Zone Regulations. Since the Humboldt County Coastal Plan was approved by the Coastal Commission, the County is authorized to represent the Commission in issuing Coastal Development Permits (CDP), unless there is an appeal against a proposed activity. Since the Reserve occurs in an Appeal Area of the Coastal Zone, applications must be presented at a public hearing, for which landowners within 300' of the Reserve must be notified. If there is any opposition, the State Coastal Commission makes the final decision.

The majority of the Reserve is zoned as Agricultural Exclusive (AE) under the Coastal Zoning Regulations, with accessory restrictions covering

Coastal Wetlands (R), Flood Hazard (F), and Transitional Agriculture land (T). A small strip in the northeast corner of the Reserve, adjacent to the Humboldt Bay Wildlife Refuge, is zoned as Natural Resources (NR). The principal uses within the AE classification are single family residential, minor utilities, general agriculture and timber production. Fish and wildlife habitat management and resource-related recreation are allowed as conditionally permitted uses. Restrictive regulations that may constrain management activities on the Reserve include section A314-20, regarding major vegetation removal, and if a nature trail is developed, section A314-26 concerning off-street parking. Major vegetation removal is defined to include one or more of the following: removal of one or more trees with circumference equal or greater than 38" (approximately 12" dbh); removal of trees within a total area exceeding 6000 square feet, measured as the area located directly beneath the canopy; and finding by the Planning Director that a significant environmental impact will result. Under these criteria, thinning of spruce in conjunction with phase 1 and 2 of Maintenance level, and thinning associated with Optimization level management for the western lily are subject to County approval.

The only principal use allowed under the NR zoning classification is fish and wildlife habitat management. Conditionally permitted uses include resource-related recreation and wetland management. No foreseeable conflicts or need for permits are related to the proposed management of this portion of the Reserve.

The CDF has jurisdiction over any proposed activity involving the commercial sale of timber. According to Joe Fassler, CDF Forester responsible for the Table Bluff area, a trade agreement in which firewood is provided as payment for services rendered (spruce removal in this case) constitutes a commercial transaction. Under normal circumstances, a Timber Harvest Plan (THP) would be required. However, since firewood is involved, the activity qualifies for exemption from a THP; all that is required is a simple application form and written description of the activity. An alternative approach to spruce removal which would not require a CDF permit, is to make the resulting firewood available to anyone for free. Since this arrangement does not involve commercial transaction, CDF has no jurisdiction.

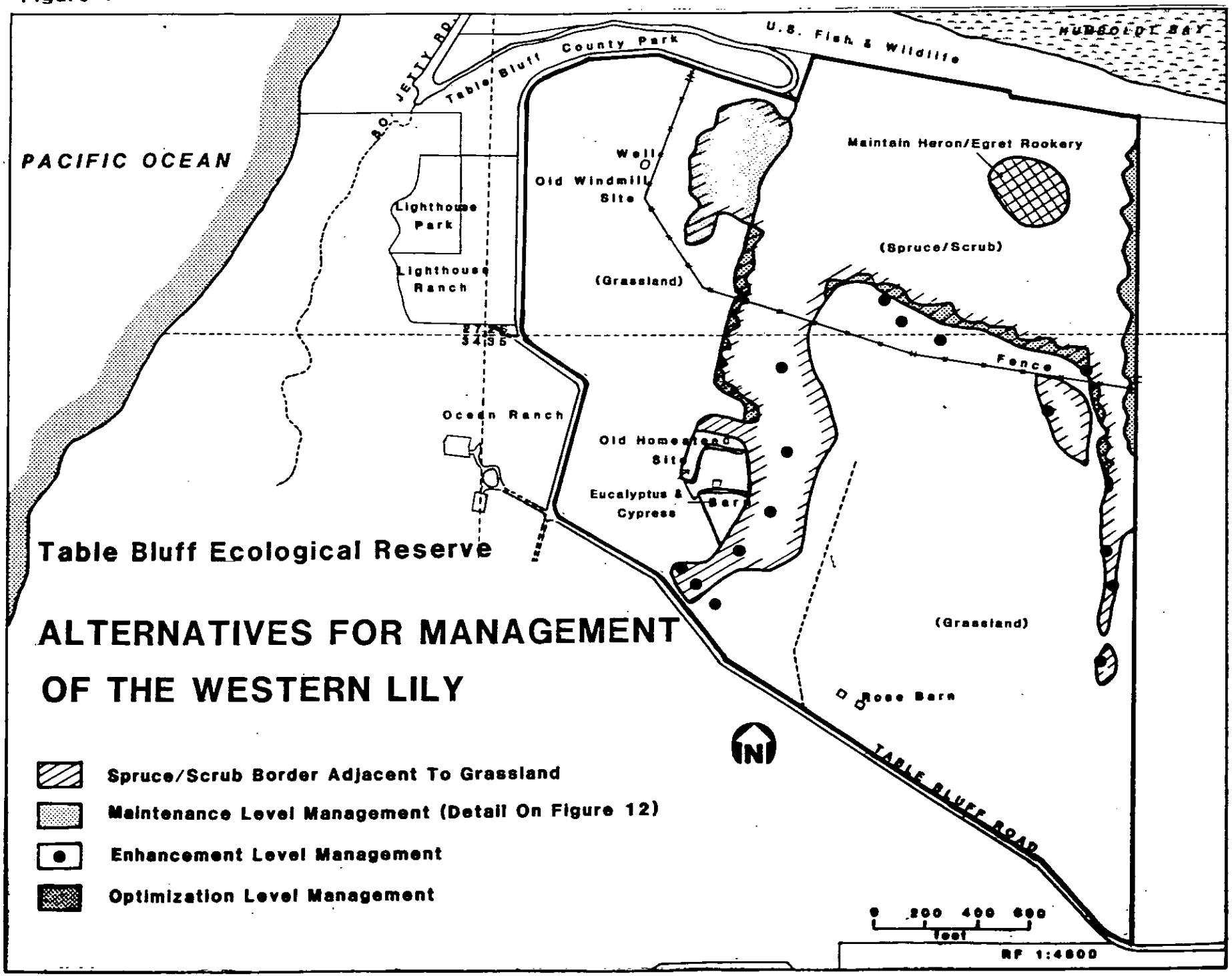
MANAGEMENT OBJECTIVES

In the following discussion of management objectives for the Reserve, the degree to which they attain the Management or Enhancement Goals defined previously for the western lily (pages 41-42) is emphasized. In general, the objectives necessary to attain Enhancement Goals, other than increasing the lily population on the Reserve, are beyond the direct operations of the Reserve and are described in Section #5.

Active management techniques

Western lily. Three levels of management for the western lily are proposed (Figures 12 and 14), differing in the eventual population and amount of lily habitat on the Reserve, degree of impact on the existing spruce forest, and commitment of staff and financial resources. For comparison, a No Action alternative is described. However, Maintenance level management is considered the minimum necessary to maintain the existing western lily population, and meet all of the western lily Management Goals for the Reserve. The Enhancement and Optimization levels are offered in addition to the Maintenance level, each supplementary to the lower level.

Figure 14


PACIFIC OCEAN
JETTY RD.
Table Bluff County Park
U.S. Fish & Wildlife
HUMBOLDT BAY
Lighthouse Park
Lighthouse Ranch
Well
Old Windmill Site
Maintain Heron/Egret Rookery
(Spruce/Scrub)
(Grassland)
Fence
Ocean Ranch
Old Homestead Site
Eucalyptus & Cypress
Barn
Table Bluff Ecological Reserve
ALTERNATIVES FOR MANAGEMENT
OF THE WESTERN LILY
(Grassland)
Rose Barn
TABLE BLUFF ROAD
Spruce/Scrub Border Adjacent To Grassland
Maintenance Level Management (Detail On Figure 12)
Enhancement Level Management
Optimization Level Management
200 400 600
Feet
RF 1:4800

No Action. Under this alternative, no management for western lily would be conducted other than continued exclusion of cattle from the lily population. None of the three Management Goals set for the lily would be met. Since the current trends in spruce encroachment would be allowed to continue, it is apparent that in a short time, perhaps 3-5 years, all remnant openings within the immature spruce stand will close (Figure 12). Without a seed source from nearby openings, lily reproduction under the dense spruce canopy will probably disappear. Spruce will also continue to encroach on much of the *Sweet vernal-grassland* that remains at the west edge of this stand, where relatively young and small trees occur now.

As a result, over the next decade greater that 90% of what appears to be the historical lily habitat on the Reserve, and greater than 90% of the current lily population will probably be eliminated. At the same time, some reproduction may occur along the advancing spruce edge, in the *Sweet vernal-grassland*, and in nearby *Willow scrub*. However, reproduction in the dense grassland appears to be slow, and *Willow scrub* seems to be only marginally suitable habitat. Reproduction will probably offset only a small portion of the ongoing mortality.

For the long term, indications are that spruce will eventually occupy most of the existing *Sweet vernal-grassland* in the vicinity, and therefore most of the lily habitat. Without management intervention, the population of western lily will certainly be restricted, and eventually may be eliminated.

Maintenance level management. Maintenance level management will attain all Management Goals defined for the western lily, i.e., to restore and maintain its habitat, to protect the population from impacts, and to ensure proper management. Restoration and maintenance of habitat will involve manipulation (described below) that will enable the existing level of population to be supported continuously into the future. Protection (described under Protective measures) will be provided through formal closure of the fenced area, routine monitoring of the population and response to threat as necessary, and facility maintenance. Proper and efficient management will be furthered by maintaining communication with local organizations and specialists, and creation of a Contact Group (described below under Public recreation).

If for any reason the initiation of Maintenance level management is delayed, it is imperative that limbing of spruce be conducted without delay in those areas targeted for Phase 1 thinning (Figure 12). This is necessary if the current population is to be maintained. Limbing can only be considered a temporary solution, to be followed by thinning of trees.

Restoration of lily habitat on the Reserve will essentially involve manipulation of the vegetation to its pre-1960 character (Figure 12). This vegetation appears to have been a matrix of *Sweet vernal-grassland* or similar grassland community, interspersed with a patchy shrub layer, and occasional spruce. While this may or may not be a relatively stable community, from a successional standpoint, indications are that the wave of spruce invasion that led to the existing young stand was initiated by disturbance. Therefore, to avoid stimulating renewed spruce invasion, the existing stand should be thinned with as little ground disturbance as possible.

The proposed thinning should also recognize two other factors. The western lily appears susceptible to chloride toxicity, resulting from the combination of salt spray and strong northwesterly winds during the growing season. Symptoms suggestive of toxicity were noted in lilies near the coast in southern Oregon, and in plants most exposed to the coastal winds on the Reserve. In the absence of specific knowledge as to the extent of

salt toxicity in the lily, management activities should recognize this as a potential threat. Thinning of spruce should be done so that a buffer strip is left to the northwest of the existing population and any new colonies.

The second factor to be considered is evidence that the moist, dark conditions underneath the dense immature spruce stand are at least suitable, if not optimal for germination of western lily seed. The large concentrations of seedlings in the stand are often at the edge of openings, and in most cases, downwind from mature plants. While many of these seedlings may actually be very old plants that originated in the previous grassland, their high concentration and systematic location suggests they are recent recruits. If this is true, than the portion of the stand not now occupied by lilies could be utilized as a seedbed. Initial thinning of spruce should be confined to existing concentrations of seedlings and remnant openings; assuming regeneration occurs in the unthinned areas, a second stage of thinning could be done to open those areas later.

As a result, spruce removal is proposed in two, or possibly three phases. The first phase will be a partial thin designed to give immediate relief from shade-induced stress to the plants now surviving under the dense spruce canopy, but maintain a conservative approach to manipulation, and avoid the possibility of negative affects due to lack of acclimation and tolerance to exposure. Partial thinning will also allow the shrub layer to develop without optimizing conditions for spruce regeneration. Phase 1 thinning should be done as soon as possible (but when the plants are dormant), and will involve about one acre of the young spruce stand, and a small portion of the *Spruce/maianthemum forest* to the east of this stand (Figures 12 and 14). The spruce should be thinned to about 50% cover; this will require removal of an estimated 50-100 trees averaging 12" dbh and 30-60' tall in the young spruce stand, and only a few trees, averaging 22" dbh and 90' tall in the older spruce stand to the east (Figure 12). A small amount of *Willow scrub* should be pruned or thinned at the same time.

Timing on the second phase of thinning will depend on the response shown by the lilies now repressed by spruce. There may be a delay period before significant top growth is seen in many of the severely stunted plants. Mature plants now in the remnant openings, and only mildly stressed, should be capable of flowering in one or two years. A positive response should be apparent in most plants within 3-5 years. This period presumably would be sufficient time to have new lily recruitment in the spruce left unthinned. Therefore, Phase 2 thinning should be performed 3-5 years after the initial thin. Most of the remaining spruce in the portion of the young stand thinned initially will be removed, leaving approximately 5% spruce cover overall. Assuming some lily regeneration has occurred in the unthinned spruce, these areas should be opened to about 50% cover at this time, followed by final thinning to 5% cover 3-5 years after the second thinning. In the absence of significant lily regeneration, the entire stand should be reduced to 5% spruce cover 3-5 years from now. Phase 2 thinning will affect approximately two acres overall, and remove 100-150 trees, averaging 12+" dbh and 30-60+' tall.

Vegetation monitoring should be conducted before and after each of the thinnings, and include measurement of habitat characteristics thought to be important to successful growth of the lily. This will enable at least some correlation of response by lilies after thinning with specific changes in habitat.

In summary, the management objectives involved in Maintenance level management are summarized below. Objectives relating to monitoring, protection and public recreation are described in more detail in those sections.

(1) If Phase 1 thinning is not implemented immediately, remove limbs throughout the thinned areas indicated in Figure 12.
(2) Restrict public access to the fenced exclosure.

Phase 1 Thinning

(3) Describe habitat condition (Habitat monitoring-Appendix F).
(4) Mark spruce for removal to achieve 50% cover in areas proposed (Figure 12).
(5) Remove spruce with minimal ground disturbance, on-site slash disposal outside the area of the lilies.
(6) Describe habitat condition immediately after thinning.
(7) Monitor lily population annually (Population monitoring-Appendix F).
(8) Assess timing for Phase II thinning.

Phase 2 Thinning

(9) Describe habitat condition.
(10) Thin previously thinned areas to 5% spruce cover.
(11) If a new cohort of seedlings developed in unthinned spruce, thin remaining spruce to 50% spruce cover (final thin 3-5 years hence); if no new recruitment, thin entire stand to 5% spruce cover.
(12) Describe habitat condition.
(13) Periodically monitor habitat at 3-5 year intervals to assess need for routine vegetation manipulation.

Enhancement level management. The Enhancement level management for western lily involves relatively little commitment of staff or impact on the other resources on the Reserve. By increasing the total population and distribution on the Reserve, this management would attain Enhancement Goal #1 for the lily. Reserve objectives would include exploitation of most of the potential habitat on the Reserve, through periodic planting of seed and seedling stock (Figure 14). This level should be thought of as an ongoing process, the objective being the establishment of stable self-reproducing colonies.

Based on characteristics common to western lily sites elsewhere, criteria that may be used to indicate potential suitable habitat include: 1) presence of relatively uncompacted "native" soils in areas that were not historically cultivated or severely impacted by grazing--these might include much of the boundary to the spruce stands and many of the *Willow scrub* patches, and 2) presence of *Calamagrostis nutkaensis*, iris, or other native plants typical of the *Sweet vernal-grassland*. Colonization of new sites on the Reserve will in the beginning be by trial and error; only after the lily has reproduced unaided can we assume suitability of a new site for long term habitation by the lily.

The new colonies should include at least some locations relatively isolated from the parent population. This isolation is perhaps the most important aspect, since the future survival of the species may depend at some point on the ability of some colonies to escape a single widespread threat, such as disease. While the Reserve does not offer the opportunity for wide geographical separation, isolation can be maximized as much as possible. The best opportunity for isolation at this time is establishment of a colony at the southeast corner of the main spruce stand. If grazing is reduced or eliminated outside of the exclosure, colonization should be attempted in the *Willow scrub* near the southeast corner. Some monitoring will be necessary for the newly established colonies. This could be informal, but at the minimum should include assessment of population size,

disease and herbivory.

In summary, the Reserve objectives involved with Enhancement level management are:

(1) Arrange for volunteers to propagate seedlings from lily seed collected at the Reserve; these may include CNPS volunteers, the Humboldt State University greenhouse, and others.
(2) Plant seed and seedlings in potential habitat as identified (Figure 14) on a routine annual basis.
(3) Identify suitable lily habitat in areas where it is currently obscured by heavy grazing.
(4) Ensure that some colonies are relatively isolated from the main population, for protection.
(5) Instigate monitoring of new colonies.

Optimization level management. The objective of this level of management is to optimize the western lily population on the Reserve without significant negative impacts on the other values. By increasing the total population and distribution on the Reserve, this management would attain Enhancement Goal #1 for western lily. The lily population would not be maximized in terms of the number of individuals, since mass cultivation is neither desirable aesthetically or from the standpoint of long term stability of the population. Rather, the objective is a more natural situation in which suitable habitat and colonies are dispersed in an apparent random fashion over the Reserve, providing some isolation from simultaneous episodes of disease.

Creation of such a "patchy" environment would employ two techniques: selective removal of spruce along portions of the boundaries to the spruce stands, creating an irregular edge effect (Figure 14); and continuous monitoring of the (now) grazed portion of the Reserve for signs of suitable lily habitat. Both steps would be followed by attempts to establish lily colonies. Implicit in the second step is the elimination or seasonal restriction on cattle grazing in the area of each new colony.

Selective removal of spruce, while impacting the spruce forest to a small degree, would serve to increase structural diversity and related wildlife values by maximizing edge. Thinning could be done at a time, and in such a way as to not impact the Heron rookery.

Just as the current lily habitat may require infrequent but routine vegetation manipulation in order to maintain the population, new colonies may require similar maintenance. This will need to be assessed periodically. Annual monitoring of population size, health, and herbivory will be required at all new colonies.

In summary, the Reserve objectives involved in Optimization level management include:

(1) Identify spruce to be removed along stand boundaries, maximizing edge, and creating microsites suitable for lily colonization.
(2) Selectively remove spruce, on-site disposal of slash.
(3) Seed or outplant seedlings to new sites (ongoing process); monitor.
(4) Restrict cattle grazing in new sites.
(5) Conduct ongoing assessment for potential lily habitat.
(6) Monitor new lily sites for management needs and threats.

Public recreation. Development of public recreation on the Reserve in all cases should be secondary to the management goals for the western lily. Recommendations for Reserve objectives are described below. Control of public activities on the Reserve is central to attaining Management Goal #2

for the lily, i.e., preventing impacts on the population. Overall public visibility of the Reserve should be minimized. If the lily population is expanded outside the fence exclosure, formal closure of other areas will need to be assessed. Routine monitoring by wardens, especially during the spring and summer, will be necessary to prevent unauthorized visitation and impacts on the western lily. A short training session should be arranged for the wardens, covering the critical areas and potential impacts on the Reserve. A person from this team will be available to assist.

The formation of a Reserve Contact Group is recommended; to the extent that the Group contributes to proper and efficient management of the Reserve, it should help attain Management Goal #3 for the western lily. As discussed, a contact group will serve as a useful communication and coordination conduit with local groups and individuals. Meetings of the Contact Group should be often enough to maintain interest by members, and provide an opportunity for DF&G to voice requests for advice or assistance in particular projects. Two meetings per year seems reasonable at this time, but this may vary according to DF&G guidelines.

Establishment of a nature trail is an opportunity that could benefit wildlife management and promote concern for rare species in general. To the extent that the trail reduces the uncontrolled public activities in the area of the lilies over and above Management level objectives, it could contribute to attaining Enhancement Goal #2. However, the decision on construction of a trail should be delayed 3-5 years, during which the lily population can be stabilized, the feasibility of establishing lilies in other sites on the Reserve can be demonstrated, and the long term capabilities and direction for lily and wildlife management on the Reserve can be determined.

A potential location for the interpretive trail may be the southwestern portion of the Reserve near the access road to the Eel River Wildlife Area. Some advantages of this location are that parking facilities could be constructed off-site and in conjunction with use of the adjacent wildlife area and the trail would be far removed from the existing lily population. Some disadvantages are the relatively long distance from the trailhead to any (currently) significant wildlife habitat or feature of interest, and the uncertainty of whether lilies can be established successfully in any of the nearby habitat. The most likely prospect for establishment is on the edge of the *Willow scrub* at the base of the westernmost ravine. Regardless of the trail location, seeding and outplanting of lilies will be necessary to enhance the desirability of the trail, and channel some of those seeking to photograph and see the lily away from its natural habitat on the Reserve. At least some lilies should be near enough to the trail to photograph. Passive protection in the form of educational signing and an interpretive brochure will be necessary. New plants may need to be planted periodically to offset loss to public abuse.

In summary, the following management objectives are recommended for the Reserve, regarding public recreation:

(1) Maintain minimal visibility of the Reserve to the general public.
(2) Form a Table Bluff Contact Group, including members of CNPS, Audubon and other organizations interested in TBER; include a specialist in lily ecology and management.
(3) Coordinate meetings of the Contact Group as often as necessary.
(4) Instigate routine monitoring by wardens for unauthorized visitation to the fenced lily area.
(5) Conduct training session for wardens (3-4 hrs) on the critical

elements and potential for impacts on the Reserve.

(6) After 3-5 years assess the need and suitability for a nature trail and related facilities.

Wildlife management. With the exception of potential riparian enhancement projects, the objectives for wildlife management are passive, relating to preservation of the rookery and its habitat, and the coastal spruce forest in general. As such, all other area management activities proposed have and should continue to recognize these constraints.

Monitoring requirements

Monitoring of facilities, and the western lily population and habitat are necessary to attain Management Goals #1 and #2 (i.e., maintain lily habitat and prevent impacts) for the western lily. Management objectives for the Reserve should incorporate the following monitoring:

Facilities. Monthly monitoring and maintenance of fencing and signing is necessary to discourage or prevent unauthorized use of the area, and to control cattle movements, particularly in the vicinity of the lily population. Development of the nature trail will require additional monitoring of the trail condition, trail-related facilities, and need for litter removal.

Western lily--population. Biannual monitoring of the western lily population is necessary to maintain current knowledge of population size, demographics, distribution, reproduction, occurrence of disease, and depredation by herbivores so that informed management decisions can be made. This monitoring is conducted during June, at the peak of the flowering season when the plants are most visible, and in October, after the plants have set fruit.

The proposed methodology for population monitoring and a sample data sheet are included in Appendix F. The sampling format is intended to be simple, relatively quick, and at the same time provide 100% coverage of the population and yield data necessary for accurate assessment. The specific data collected includes locational coordinates for all plants, height and flower number, and occurrence of grazing or disease. If the cause of grazing, or identity of disease is not immediately known to the investigator, a sample of the plant part affected is to be taken and submitted for identification. The data are designed to be entered in a database or spreadsheet program, enabling simple summary statistics, detailed mapping of the population with reference to the vegetation map (Figure 12) and habitat monitoring data, and comparison between years. Number of fruits retained in October, and reasons for non-development of fruit are recorded for all flowering plants at that time.

Initiation of Enhancement or Optimization level management for the western lily will create a need for additional population monitoring. This could be designed on an informal basis, including at the minimum, annual assessment of population size and occurrence of herbivory or disease at each new colony on the Reserve.

Western lily--habitat (specific). Information about the immediate environment of each plant will be taken in conjunction with population monitoring each year. This will enable assessment of the general habitat type, height of nearest plants, and overhead canopy coverage characteristics associated with the location of each plant.

Western lily--habitat (general). However, plant-oriented habitat characteristics provide little information concerning the overall amount of suitable habitat in the area. Additional data designed to assess the overall suitability of the habitat for the western lily will be sampled

along permanent transects encompassing the current lily population. The proposed methodology and a sample data sheet are included in Appendix F. It is important that the lily habitat be described both before and after each of the phases of spruce thinning associated with Maintenance level management of western lily. This will enable correlation of lily response to changes in vegetation structure and exposure as a result of the thinning. After the second stage of thinning, habitat monitoring should only be necessary at 3-5 year intervals in order to assess the need for routine manipulation.

Initiation of the Enhancement and Optimization level management will increase the need for habitat monitoring on the Reserve.

In summary, the following monitoring should be included as objectives for the Reserve:

(1) Facilities; all fencing, signing, and trail-related facilities.
(2) Western lily population; location, size, health.
(3) Western lily habitat; availability, suitability for growth and reproduction.

Further assessment needs

No additional assessment appears necessary to maintain the existing western lily population, except routine monitoring as described in that section. Initiation of Optimization level management will require mapping of suitable habitat outside of the cattle exclosure. Suggestions for more extensive, longer term research projects are included in Section #5.

Protective measures

Protective measures primarily relate to the western lily population, and are necessary to attain Management Goal #2 for the western lily, i.e., prevent impacts on the population. The only other specific resource potentially in need of protection is the rookery. However, its isolation from public activities and active management activities should alleviate the need for active protection measures. Protection of other resources will to some extent be commensurate with the protection aimed at the western lily.

In general, the Reserve facilities should be designed to minimize the potential for human-related threats to the western lily population. Foremost in this respect is formal closure of the lily fenced area to public access without special permit, at least until the population has been stabilized, and enhanced through establishment of colonies elsewhere on the Reserve. This should alleviate most of the current human-related impacts on the existing population. There undoubtedly will be some that ignore the closure signing; formal closure will make it easier for passing wardens, or other concerned individuals to detect unauthorized use.

With respect to the other major categories of threat (disease, depredation, detrimental change in habitat), contingency plans should be in place prior to the advent of a threat. In some cases, such as an outbreak of insect depredation, appropriate response and level of response are best judged on a case basis. Annual monitoring of the lily population, and periodic monitoring of vegetation play key roles in the identification of a threat before it jeopardizes the population as a whole.

In summary, the following Reserve objectives, in the form of appropriate response to threats to the western lily, should be established:

Threat	Reserve objective
Vandalism:	Post Ecological Reserve signing all fencelines. Formally close fenced exclosure, closure signing posted on the internal fence. Maintain minimal publicity about the Reserve and the lily. Post Educational signing along nature trail (if constructed).
General public overuse:	Educate local user groups on formalities. Channel group fieldtrips through DF&G office. Post educational signing along trail, especially areas of young lilies. Route trail past flowering lilies; maintain flowering lilies close enough to photograph.
Disease:	Immediately collect foliar samples; submit to DF&G Specialist or County Extension for identification; corrective action as necessary.
Herbivores:	Cattle grazing: maintain fenceline Other: submit specimens as necessary for identification; corrective action as necessary.
Detrimental change in habitat:	Manipulate habitat as necessary.

In extreme cases where the viability of the lily population is threatened, use of the following animal and disease control measures (in part from Feldmaier 1970 and Genders 1973) may be justified:

Pest	Treatment
Deer, voles, mice rabbits, gophers:	Fence individual plants or areas; control populations.
Slugs, snails:	Metaldehyde.
Millipedes:	Metasystox; Aldrin.
Lily beetle:	Remove by hand; Parathion; Metasystox.
Botrytus:	Captan; Thiram; Bordeaux mixture; Shirlan; monitor weather and fungus, collect seed if threatened by fungal infection.
Fusarium:	Formalin; Vapam; Trapex; Larvacide.
Mosaic or Symptomless virus:	No control known; control aphids; destroy plants; replant with seed.

4: OPERATIONS AND MAINTENANCE PLAN (5-YEAR)

INTRODUCTION

The emphasis of this section is to describe the tasks involved in fulfilling the Reserve management objectives, and translate these into specific DF&G staffing and financial commitments over the next five years. In addition, the specific procedural requirements mandated by those agencies having jurisdiction are described for each management level.

REGULATORY REQUIREMENTS

Regulatory requirements must be anticipated and acted on prior to various stages in the management of the Reserve:

(1) As soon as this plan is approved by DF&G, application should be made for Coastal Development and Conditional Use permits from the Humboldt County Planning Department. The approved plan will substitute as the required environmental document. This application will alleviate the need for multiple applications to County Planning before initiation of each project.

(2) If spruce removal (phase 1 and 2 thinning) is conducted under trade agreement for firewood, DF&G must apply for an exemption from a Timber Harvest Plan, from the California Department of Forestry (CDF), Fortuna. If no commercial transaction is involved, a permit is not required.

(3) The approved management plan must be reviewed by appropriate personnel within DF&G to comply with formal consultation procedures, with respect to potential impacts on the western lily population. A statement certifying compliance should be attached to the front of this plan. Approval at this stage will alleviate the need for consultation at each step in the proposed management.

SUMMARY OF OPERATIONS AND MAINTENANCE REQUIREMENTS

All of the tasks required to fulfill the management objectives proposed for the Reserve, under each of the three levels of western lily management are described below. Each task is assigned a priority level according to the following criteria:

1 = Tasks necessary to prevent extirpation of the western lily population, or to prevent irreversible decline in the population.

2 = Tasks necessary to prevent a significant decline in the size or health of the western lily population, or the extent and quality of its habitat, or some other significant negative impact short of extirpation.

3 = All other tasks necessary to either maintain the western lily population in no less than a minimally viable condition or administer public use.

The staffing and related costs are summarized for all of the maintenance and operations tasks proposed for the Reserve in Table 5. Costs for materials and travel were not included. A five-year schedule of maintenance and operations is proposed in Table 6.

Monitoring. Routine monitoring must be conducted for all site facilities, including fencing, nature trail-related facilities (if applicable)

and signing. Signing includes both general Ecological Reserve signing on the exterior fence and closure signing on the exclosure fence. Maintenance of these facilities is necessary to prevent overall decline in quality of the Reserve for meeting the other area objectives, and to prevent unauthorized entry into the western lily fenced area. Because of the latter, the task overall is given a level 2 priority. Facility monitoring should be conducted on a monthly basis, unless experience shows otherwise. More frequent assessment may be necessary if the nature trail is developed, and receives frequent use. The adequacy of the fenced exclosure should be assessed in the Winter, prior to the emergence of the lilies. The overall function will be performed by DF&G personnel, and generally not require more than eight hours monthly.

Monitoring requirements related to the western lily can be divided into three categories: population monitoring; specific plant habitat; and general overall habitat. Population monitoring will be performed on a biannual basis, and include sampling basic population characteristics in June (Appendix F), and censusing reproductive success after the fruits have matured, in September. At the same time as population monitoring in June, basic habitat characteristics specific to individual lilies will be recorded (Appendix F). These include measurements of surrounding shrub and tree height and canopy cover. Since these data are recorded at the same time as population data, no additional staffing or costs are associated. An estimated four days will be required to complete the population and associated habitat monitoring.

General overall habitat monitoring will utilize permanent transects, and be performed before and after each of the two phases of spruce thinning associated with Maintenance level management of the lily population, and every 3-5 years thereafter (Appendix F). This portion of the monitoring is expected to take three days. Both the population monitoring, and habitat monitoring will include summary reports, and should be performed by a qualified botanist familiar with sampling vegetation and the specific threats to the western lily. These tasks will most likely be contracted out, although a qualified botanist could be made available from DF&G personnel. In the event this monitoring is contracted, contract administration may require up to four hours of staff time for each contract. Because of the potential for significant decline in the lily population or quality of its habitat in the absence of monitoring, all western lily monitoring is level 2 priority.

Western lily management. Tasks associated with management of the western lily can be divided into those related to the formation and coordination of the Contact Group, those specifically related to the three levels of management defined for the western lily, and the potential need for sustained habitat maintenance under all of the management levels.

Department staff will be responsible for the formation of the Contact Group. This will involve verbal or written inquiries, or perhaps slide presentations, to appropriate organizations such as the California Native Plant Society and the Audubon Society, and specific individuals. Minimal effort should be necessary to find persons interested in participating in the management of the Reserve. This task should require no more than eight hours of staff time overall. Depending on the eventual structure of the group, DF&G staff may or may not be responsible for coordinating meeting dates and format. The group might choose to meet at the Reserve twice a year, once early in the field season, and once prior to winter, at which time the need for habitat manipulation can be discussed. Time required from staff would be roughly eight hours coordination, and 16 hours meeting time (2-3 staff attendance), twice annually. It is difficult to assign a

specific priority level to the function of this group, since the value of continuous immediate access to volunteer effort, and professional guidance regarding habitat maintenance and response to an immediate threat to the lily will depend on future circumstances. Since the operation of the group could help prevent a significant decline in the lily population, or quality of its habitat, all tasks associated with the Contact group are assigned level 2 priority.

The Maintenance level management for western lily primarily involves thinning of the young spruce stand and small areas of *Willow scrub* in two stages, and (potentially) subsequent periodic habitat maintenance. The initial thinning should occur between September and February, with the second phase scheduled 3-5 years afterward. Each thinning will require perhaps four days of staff time to mark and coordinate spruce removal in the manner described in Section #3. An additional week may be required to secure a Coastal Permit for phase 1 thinning, if a blanket permit has not already been received. The actual labor required to remove the spruce should be available for little or no compensation, utilizing the Youth Conservation Corps or volunteers, or through a trade agreement for firewood. Phase 1 thinning of spruce is assigned priority level 1, since without prompt thinning, the existing lily population will decline. Given the current situation, this decline could be irreversible. The second phase of thinning is less necessary to maintain the population, and is level 2 priority.

Enhancement level management of the western lily involves seeding and outplanting of seedling stock to currently suitable habitat on the Reserve. All western lily seedlings utilized for enhancement activities should be available for little or no charge, either through volunteer effort or services provided by the Humboldt State University greenhouse. This task can be considered an ongoing process, utilizing seed and seedling stock as they become available each year. Actual transplanting of seedlings should be done between October and February, while the bulbs are dormant. Tasks involved with this level management include collection of seed and coordination of seedling stock, selection of suitable habitat, and planting. Staff time required should be minimal, perhaps 16 hours annually, since in many cases volunteers should be available for many of these tasks.

DF&G staff commitment required to implement the Optimization level of lily management will be divided between habitat manipulation (spruce removal) and planting of seed and seedling stock. Again, volunteer labor or a trade agreement for firewood probably can be utilized. Staff time necessary to mark and coordinate the single thinning of spruce should not exceed four days. An additional two days may be required to coordinate planting of lilies. Because the Enhancement and Optimization level management projects are over and above the basic maintenance of the existing lily population, they are level 3 priority.

The need for future routine maintenance of western lily habitat on the Reserve will be determined on the basis of habitat monitoring. Ideally, only minor manipulation of shrub and spruce height and density will be necessary on an infrequent basis, perhaps greater than three-five year intervals. Since some manipulation may be necessary to prevent a significant decline in the population, this task is level 2 priority.

Public use-related. DF&G staff and contracted personnel commitments will depend on whether an active public interpretation program is initiated. Development of the nature trail and associated facilities, and an interpretive brochure will likely be contracted out. These are one time costs. Staff time required may be 3-4 weeks for general coordination and contract administration, and an additional four weeks to satisfy regulatory

requirements, if a blanket permit has not already been received. Staff commitment to general maintenance of facilities and litter cleanup may increase considerably if the trail is developed.

Basic staff requirements related to public use or abuse, whether or not a trail is developed, include minimal litter removal, and maintenance of the Reserve signing, including general Ecological Reserve signs on the perimeter fence and closure signs on the cattle exclosure. Time required for all of the baseline tasks should not exceed eight hours monthly. If the proposed Non-consumptive Recreation Program is funded by the legislature, additional staff funding will be provided for maintenance tasks. With the exception of maintenance for signing on the fenced exclosure (level 2 priority), these tasks are incidental to maintenance of the lily population, and level 3 priority.

In addition, approximately 32 hours will be required to allow a short training session for all wardens, to be held at the Reserve.

Livestock control. Monitoring will indicate the degree of fence maintenance needed. Staff commitment to this task and liaison with the permittee should be relatively minimal, conducted on an annual basis. In terms of its potential for impact on the existing lily population, fence maintenance is level 2 priority.

Exotic plant and animal control. The requirement for specific pest control measures, such as mechanical removal, use of pesticides, or population control for deer or small mammals, will depend on future circumstances and monitoring results. There is no foreseeable need for any of these measures at this time. However, some form of pest control may be necessary to maintain the viability of the lily population, and maintain quality wildlife habitat or some other resource on the Reserve. While the specific staff commitment to this task cannot be estimated, it is level 2 priority due to its potential importance in maintaining the western lily population.

Riparian enhancement project. Although there are no specific plans for riparian enhancement at this time, some enhancement work will probably be initiated if feasible. In this case, there may be future staff requirements related to fence maintenance or riparian management, but these tasks should be minor. Since implementation is incertain, staff and cost commitment was not projected. Projects in this category should have level 3 priority.

Regulatory requirements. Many of the activities proposed for the Reserve must be approved by various agencies. The application procedures will be minimized if this management plan is submitted for blanket approval to County Planning, and to the appropriate DF&G personnel, with regard to formal consultation requirements. As much as a month of staff time may be required to prepare and coordinate the Coastal Permit application, and as much as two weeks for coordinating the internal DF&G consultation procedures. Fulfilling regulatory requirements for those projects necessary to maintain lily habitat on the Reserve is level 1 priority. Requirements associated with enhancing additional lily habitat or related to other wildlife projects are level 3 priority.

Table 5. Summary of staffing and related costs for the operations and maintenance of the Table Bluff Ecological Reserve (materials and travel not included).

TASK (OBJECTIVE)	GOAL[1]	PRIORITY[2]	FREQUENCY	EST.TIME (hrs) DF&G[3]	EST.TIME (hrs) CONTRACTOR	EST.ANN.COST[4] YEAR 1-5
Western lily management:						
form TBER Contact Grp	M3	2	one time	8		32
coordinate TBER Grp	M3	2	biannual	8		320
attend TBER Grp meeting	M3	2	biannual	16		640
Maintenance mgmt level-						
phase 1 thin	M1	1	one time	72[5]		288
phase 2 thin	M1	2	one time	32[5]		128
Enhancement level[7]	E1	3	annual	16[6]		320
Optimization level[7]-						
spruce removal	E1	3	one time	32		128
seeding/outplanting	E1	3	annual	16[6]		320
routine habitat control[8]	M1	2	3 year?	0-24		0-96
Public recreation:						
construct nature trail/						
parking lot[7]	E2	3	one time	320	?	1280
interpretive brochure[7]	E2	3	one time	4	30	112
signing-Eco Reserve	M2	2	one time	8		32
signing-trail related[7]	E2	3	one time	8		32
litter removal		3	monthly	8		1920
general maintenance[9]						
(trail,fence,sign)	M2	3	monthly	8		1920
training session-wardens	M2	2	one time	32		128
Monitoring:						
facilities (trail, signing,fencing)[9]	M2	2	monthly	8		$1920
western lily-						
population	M2	2	biannual[12]	8	24 + 8[13]	612
habitat[10]	M1	2	annual	0	0	0
habitat[11]	M1	2	4X/5 years	8	24[13]	374
Livestock control:						
fence maintenance	M2	2	annual	8		160
liaison w/permittee	M2	3	annual	16		320
Exotic plant/animal control[14]	M2	2	1X/5 years	0-24		0-96
Regulatory requirements:						
consultation DF&G	M,E	1	one time	80		320
Coastal Permit	M,E	1-3	one time	160		640

[1] The specific western lily Management Goal (M) or Enhancement Goal (E) which this objective helps attain (see pages 41-42).
[2] See preceding text for explanation of priority rating.
[3] Includes contract administration.
[4] Figured at the average hourly rate of $20.00--DF&G personnel (incl. indirect costs) and $16.00--contracted personnel.
[5] DF&G staff requirement based on marking and coordination of spruce removal only; actual removal conducted by Conservation Corps, volunteers or by trade agreement.
[6] Assumes no cost to DF&G for lily planting stock provided by volunteer effort.
[7] Pending DF&G decision to initiate project.
[8] Need based on habitat monitoring; cost and time commitment unknown but may be up to 24 hrs contract labor on 3 year basis; this figure may increase up to 100% if Enhancement and Optimization level management of lily is initiated.
[9] If nature trail is built, estimated staff time and cost may double.
[10] Habitat features sampled in conjunction with population monitoring.
[11] Vegetation transect monitoring of occupied lily habitat.
[12] Population monitoring (June) and census of reproductive success (Sept).
[13] If Enhancement and Optimization level management of lily are initiated these estimates may increase up to 100%.
[14] Need for control unknown; could range up to 24 hrs staff time on 5-year basis.

Table 6. Five-year time schedule for operations and maintenance of the Table Bluff Ecological Reserve upon acceptance and implementation of plan.

TASK	YEAR/MONTH J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D
	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Western lily management:					
form TBER Contact Group	* * * * *				
TBER Contact Group meeting	* * * * *				
Maintenance level-phase 1	* *				
phase 2[4]				* * * *	
Enhancement level[5]	* * * * * * * * * *	* * * * * *	* * * * * *	* * * * * *	* *
Optimization level[5]-					
spruce removal	* * * *				
seeding/outplant	* * * * * *	* * * * * *	* * * * * *	* * * * * *	* *
routine habitat maintenance[6]				* *	
Public recreation:					
construct nature trail/ parking lot[5]				* * * *	
interpretive brochure[5]					
signing-Eco Reserve	* *			* * * *	
signing-trail related[5]				* * * *	
litter removal	* * * * * * * * * * * *	* * * * * * * * * * * *	* * * * * * * * * * * *	* * * * * * * * * * * *	* * * * * * * * * * * *
general maintenance (trail,sign,fence)	* * * * * * * * * * * *	* * * * * * * * * * * *	* * * * * * * * * * * *	* * * * * * * * * * * *	* * * * * * * * * * * *
training session-wardens	* *				
	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D
Monitoring:					
facilities (trail,signing, fencing)	* * * * * * * * * * * *	* * * * * * * * * * * *	* * * * * * * * * * * *	* * * * * * * * * * * *	* * * * * * * * * * * *
western lily population[1]	* *	* *	* *	* *	* *
western lily habitat[2]	* *	*	*	* *	*
western lily habitat[3]	* *			* *	*
Livestock control:					
fence maintenance[7]	*	*	*	*	*
liaison w/permittee	*	*	*	*	*
Exotic plant/animal control[7]	*	*	*	*	*
Regulatory requirements[9]:					
consultation DF&G	*				
Coastal Permit	*				
	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D

[1] Population monitoring (June) and census of reproductive success (Sept).
[2] Habitat features sampled in conjunction with population monitoring.
[3] Vegetation monitoring of lily habitat; Jan/Jun (Y1) = before/after phase 1 thinning; Jan/Jun (Y4) = before/after phase 2 thinning, then every 3 years thereafter.
[4] Initiation of phase 2 will depend on monitoring results of phase 1 manipulation.
[5] Pending DF&G decision to initiate.
[6] Need and frequency of habitat maintenance will depend on monitoring results.
[7] Based on need.
[8] Assuming soils inventory and hydrological analysis indicate feasible.
[9] Assuming County and DF&G approval 5-year management plan prior to implementation; one time permit and consultation procedure; otherwise, consultation and permit required on project basis.

5: ADDITIONAL MANAGEMENT RECOMMENDATIONS

INTRODUCTION

The efficient and successful operation of an Ecological Reserve will always depend on factors beyond the normal operations of the Reserve, and extend outside the Reserve itself. This is most apparent with respect to the long term viability of the western lily, no matter how effective on-site management is on the Reserve. The emphasis of this section is to describe opportunities and considerations largely accessory to the operations of the Reserve, that will contribute to the efficient and successful management of the Reserve, and to the long term viability of the western lily.

RESEARCH

Western lily. There are several opportunities for research which would contribute to the achievement of Enhancement Goal #4 for the western lily, i.e., ensure the future viability of the species. Research should also be initiated as soon as possible to elucidate the most efficient and cost-effective methods by which the western lily and its habitat can be managed on a long term basis. In general, studies which involve potential experimental-induced impacts on the western lily population or its habitat (e.g., assessment of the utility of controlled grazing or fire for lily habitat maintenance) should only be conducted in newly established western lily habitat, and not in the area of the main population. The following projects are recommended:

(1) Perhaps the most critical area of research concerning the western lily involves an assessment of its genetic viability. A similar study is currently underway with regard to Menzie's wallflower throughout its range (Humboldt State University 1987).

(2) A formal assessment is needed of western lily seed viability, in order that future seeding allocations can be matched to the intended density for an area, including future off-site establishment projects. Viability could conceivably differ among the four Table Bluff populations, and should be assessed for each population.

(3) Related to (2), a comparison of seed germination success in the various habitats found on the Reserve (e.g., dense spruce, *Spruce/maianthemum forest*, *Sweet-vernal grassland*, *Willow scrub*) would be especially useful in further defining appropriate lily habitat on the Reserve, and the seeding requirements for particular target densities.

(4) Additional information on the relative impacts of deer, rodents, invertebrates, and virus, and how these impacts fluctuate from year to year is needed in order to make informed decisions on management. General information of this nature will be provided through the annual monitoring program. However, at least for deer and small mammals, more detailed and accurate data on the characteristics of their grazing behavior, and effective alternatives to preventing their impacts short of outright elimination should be developed as soon as possible. This could include the use of exclosures, as is now being done at the Bastendorf Preserve in Oregon (Schultz 1986a, 1986b, 1987a).

(5) A controlled study on the feasibility of using cattle to maintain vegetation in a state suitable for successful growth and reproduction of western lily is needed. This information is not necessary for successful management of the lily, but is desirable from an administrative standpoint to indicate its cost-effectiveness and applicability for vegetation manipu-

lation, as opposed to hand clearing or the use of fire. A location that appears suitable and convenient for this research, after successful establishment of the western lily, lies between the old spruce stand and the south portion of the new fenceline, near the central gate (Figure 12). A paired plot approach should be used, in which seasonal grazing intensity and duration are regulated adjacent to an undisturbed control area. Western lily and vegetation would be monitored over a period of several years.

(6) The same objective and general methodology described in (5) could be applied to assessing the potential for use of fire, if an alternative to hand clearing is desired. The use of fire or controlled grazing may be advantageous for control of exotic species, e.g., himalaya berry, if any species become management problems.

Coastal prairie (potential). If it is determined that all or part of the *Tall fescue grassland* on the Reserve is to be returned to a more natural state, DF&G may wish to sponsor or initiate research on methods to increase its rate of conversion. An area with possible potential involves methods for decreasing soil compaction. Small-scale treatments such as scarification and seeding with natives could be tested prior to application to the Reserve in general.

RESERVE ENHANCEMENT OPPORTUNITIES

Enhancement opportunities relating to the western lily and its habitat are described under the various management scenarios included in the section on management techniques. The opportunity to enhance wildlife values on the Reserve is greatest with respect to the disturbed grassland, that currently provides little wildlife habitat. Another opportunity relates to improvement of aesthetic appeal, or natural appearance of the Reserve.

Although not a featured habitat at this time, the 90+ acres of *Tall fescue grassland* could be restored to a more natural state, perhaps similar to the coastal prairie that probably covered much of the drier upland areas on the Bluff prior to the arrival of white settlers. Restoration would have the obvious benefits of increasing structural and species diversity, contributing to the overall natural appearance, and providing an example of natural coastal prairie, uncommon in this region. Utilizing methods developed in small scale experimental plots, large scale conversion of the grassland could be undertaken. Once established, occasional use of fire may be necessary to maintain the prairie, perhaps re-enacting a historical role played by Native Americans.

The forest boundaries on the Reserve were largely determined by the original settlement and agricultural practices, and to a lesser extent, fire during the 1900's. The opportunity exists to enhance the visual appearance of the Reserve through selective removal of spruce, creating an irregular edge to most of the stands. While natural succession may produce this irregular edge, the rate of change could be slow. In most cases, it appears that spruce regeneration on the Reserve has been episodic, following major disturbance events such as fire or ground disturbance. Natural invasion into the grassland has been slow in the absence of disturbance--the youngest spruce found along the edge was 14 years old. This could be the result of high seedling mortality due to intense cattle grazing, but probably also reflects a hostile environment for seed germination, related to competition in the dense grassland and compacted soils with relatively low available moisture. Most of the spruce on the Reserve

is in areas having greater moisture availability than the disturbed grassland.

In summary, the aesthetic appeal of the Reserve can be enhanced by creation of an irregular boundary to the forest stands. This could be accomplished relatively quickly through selective removal of spruce, or over the long term by encouraging spruce invasion into the adjacent grasslands. The latter method may require management intervention to speed the rate of invasion.

WESTERN LILY RECOVERY PROJECTS

Recovery and maintaining the viability of the western lily are the focus of Enhancement Goals #3 and #4, and were not addressed in the objectives for the Reserve. There are several opportunities which DF&G may pursue to help achieve those goals, i.e., expand the population and distribution of the lily around Humboldt Bay, and help ensure species viability in other ways.

The first priority in the recovery of the California populations of western lily is the removal of threat of extirpation from the four known sites. In this respect, the Barry site is highest priority. Any means available should be employed to secure prompt protection of this site from cattle grazing. These means may include land acquisition, negotiation of a Conservation Easement, or even informal agreement on the part of the owner to allow protective efforts. This site appears to represent somewhat of an extreme population in terms of genetic diversity, compared with the other sites on Table Bluff. As such, its conservation could be important to the future viability of the species. The next priority to ensuring long term protection of the lily should be acquisition or negotiation of a formal protective agreement at the Johnson and Christensen sites.

However, a longlasting recovery of the western lily will require, at a minimum, establishment of colonies representing the range in genetic variability in suitable habitat around Humboldt Bay. Establishment of new colonies that are removed from the immediate influence of factors that could simultaneously threaten the four sites on Table Bluff, such as climatic extreme, fire, or outbreak of disease, is at this point the best way to ensure its long term survival in the wild.

Ideally, many small colonies would be established both on the Bluff and around the Bay. As a start, land currently under governmental ownership around the Bay could be inventoried for suitable habitat. In cases where good quality lily habitat is in private ownership, formal or informal arrangements might be made for establishment and protection of the lily. The Nature Conservancy is especially effective in these regards. Where practical, historical habitat could be returned to a condition suitable for reintroduction of the lily. Potential locations for reintroduction might include the College of the Redwoods campus, the hillside above Ryan Slough, the route of the old Table Bluff cemetery road above Hookton, Humboldt Hill, and others. These areas should be inventoried for specific sites suitable for habitat restoration that are also currently under ownership by city, county or other governmental entities, that potentially could provide formal long term protection.

Western lily seedlings used for off-site establishment should be artificially propagated, and in some cases, include hybrids arising from combinations of the four populations on the Bluff. Establishing hybrids should increase the genetic base of the colonies, and may improve chances for survival in a new location.

AMENDMENT TO DF&G REGULATIONS

The current Title 14 regulations and proposed amendments appear to accomodate all of the activities proposed for the initial five-year period of management. The amendments pending adoption at this time are:

Add to section 630(b):

(38) Table Bluff Ecological Reserve, Humboldt County.

(A) Livestock grazing may be allowed under permit from the department.

(B) The department may carry out management activities for the preservation and expansion of the endangered western lily (*Lilium occidentale*). Authorized management activities may include, but not be limited to, controlled livestock grazing, controlled burning, chemical treatment and mechanical treatment.

(C) No person shall enter the western lily exclosure area, except as provide in section a.10.

LITERATURE CITED

Ballantyne, O. 1980. A Preliminary Study of *Lilium bolanderi, occidentale, vollmeri,* and *wigginsii*. Status report prepared for USDA Forest Service, Eureka, Ca. Unpubl.

Ballantyne, O. 1978. North American lilies: Let's take a closer look. North American Lily Society Yearbook. 1978:10-16.

Ballantyne, O. 1983. Lilies of the Pacific Coast. North American Lily Society Yearbook. 1983:11-26.

Ballantyne, O. 1984. Personal communication, D. Imper.

Ballantyne, O. 1987. Personal communication, D. Imper.

Ballantyne, O and W. B. Critchfield. 1978. Rare Plant Status Report - *Lilium occidentale*. California Native Plant Society, Sacramento.

Ballantyne, O., Allen, T. C. and J. Knoper. 1979. A survey of North American *Lilium* for lily symptomless virus. North American Lily Society Yearbook. 1979:18-20.

Barbour, M. G. and J. Major. 1977. Terrestrial Vegetation of California. John Wiley and Sons, New York.

Brown, D. H. 1984. Western species and their hybrids. J. of Nor. Amer. Lily Soc. 38(3):10-11.

Burt, W. H. and R. P. Grossenheider. 1976. A Field Guide to the Mammals. Houghton Mifflin Co., Boston.

California Natural Diversity Data Base (CNDDB). 1987. Element occurrence records for western lily in California. Sacramento.

Craig, W. N. 1936. North American lilies. Royal Horticultural Society Yearbook. 1936:39-42.

Daubenmire, R. 1968. Plant Communities. Harper and Row, New York.

Division of Mines and Geology, 1962. Geologic Map of California, Redding Sheet.

Eastwood, A. 1948. Studies of Pacific Coast lilies-II. Leafl. of West. Bot. 5(7):120-123.

Elmsweller, S. L. 1950. Exploration for Pacific Coast lilies of the United States. North American Lily Society Yearbook. 1950:7-23.

Elmsweller, S. L. 1950. Suggestions for growing lilies indigenous to the Pacific Coast of the United States. North American Lily Society Yearbook 1950:24-25.

Elmsweller, S. L. 1952. Further exploration for Pacific Coast lilies of the United States. North American Lily Society Yearbook. 1952:7-24.

Elmsweller, S. L. 1986. Propagation of lilies. Royal Horticultural Society Lily Yearbook. 1986:35-40. Feldmaier, C. 1970. Lilies. Arco Pub. Co., New York.

Ford, F. E. 1955. Experience with Pacific Coast lilies. North American Lily Society Yearbook. 1955:69-73.

Ford, F. E. 1959. Pacific Coast lilies in the wild. Royal Horticultural Society Yearbook. 1959:98-102.

Ford, F. E. 1968. Report on the western native lilies. North American Lily Society Yearbook. 1968:7-12.

Genders, R. 1973. Bulbs--A Complete Handbook. Bobbs-Merrill Co., Inc. New York.

Green, D. E. and M. A. Tincker. 1940. Concerning lilies infected with the mosaic virus. Royal Horticultural Society Yearbook. 1940:28-32.

Harris, L. 1949. Native lilies of the Redwood Empire. North American Lily Society Yearbook. 1949:26-27.

Hitchcock, A. S. 1950. Manual of the Grasses of the Western United States. U.S. Govt. Printing Office Misc. Publ. No. 200.

Humboldt State University. 1987. Menzies Wallflower Research Program; J. Sawyer, principal investigator. Submitted to the Environmental Protection Agency, Region IX, San Francisco, Ca.
Imper, D. 1987a. Monitoring data, notes and observations made of western lily in Oregon and California 1981-1987. Eureka, Ca. Unpubl.
Imper, D. 1987b. Annual monitoring report on western lily at the C. Johnson site, Table Bluff. Submitted to the Nature Conservancy, San Francisco, Ca. Unpubl.
Kierstead, J. 1987. Berry Botanical Garden, Portland, Ore.; letter dated 10/1/87 to D. Imper.
Kline, E. L. 1952. Garden culture of our western native lilies. North American Lily Society Yearbook. 1952:29-34.
Kline, E. L. 1959. Some interesting lilies of the Pacific Coast. Royal Horticultural Society Lily Yearbook. 1959:49-52.
Kline, E. L. 1984. Cultivating West coast lilies. Jour. Nor. Amer. Lily Soc. 38(3):11-13.
Lancaster, B. 1987. Informal update on the propagation of western lily at Humboldt State University greenhouse, Arcata, Ca.
Lester, G. 1987. Report on the wildlife species of the Table Bluff Ecological Reserve. McKinleyville, Ca. Unpubl.
MacDaniels, L. H. 1986. The lily plant. Royal Horticultural Society Lily Yearbook. 1986:6-17.
MacNeil, A. and L. MacNeil. 1946. Garden Lilies. Oxford Press, Oxford.
Martin, R. C. and R. E. Frenkel. 1978. Preserve Analysis: Blacklock Point. Report submitted to Oregon Natural Area Preserves Advisory Committee, Salem. Unpubl.
Mayell, E. 1960. Western native hybrid lilies. North American Lily Society Yearbook 1960:36-40.
McLaughlin, J. and F. Harradine. 1965. Soils of Western Humboldt County, California. U. C. Davis in cooperation with Humboldt County.
McRae, J. F. 1979. A lily sanctuary at the Rae Selling Berry Botanical Garden. North American Lily Society Yearbook. 1979:96-100.
McRae, E. and J. McRae. 1982. An update on the Lily Special project at the Berry Botanical Garden. Jour. Nor. Amer. Lily Soc. 36(4):8-9.
Munz, P. A. 1959. A California Flora. U.C. Press, Berkeley, Ca.
National Oceanic and Atmosphereic Administration. 1980. Climates of the States. Gale Research Co., Mich.
Ness, L. M. 1985. Self taught botanist becomes an expert on Humboldt lilies. Humboldt Historian, March-April.
Niles, D. K. 1987. Personal communication, D. Imper.
Ornithologists Union 1983. Checklist of North American Birds, 6th ed.
Parry, M. A. 1963. A History of Loleta. M.Sc. Thesis, Humboldt State College, Arcata, Ca.
Purdy, C. 1897. New west American lilies. Erythea 5:103-105.
Purdy, C. 1935. Western American lilies. Royal Horticultural Society Lily Yearbook. 1935:43-54.
Purdy, C. 1937. Western American lilies. Royal Horticultural Society Lily Yearbook. 1937:20-25.
Redwood Regional Audubon Society. *The Sandpiper: Monthly Newsletter of the Redwood Region Audubon Society. Eureka, Ca. (published monthly).*
Roderick, W. 1984. The lilies of California. Jour. Nor. Amer. Lily Soc. 38(2):34-39.
Schultz, S. 1986a. Management of Lilium occidentale at Bastendorf Bog: Fieldwork. Report submitted to the Nature Conservancy, Portland, Ore. Unpubl.
Schultz, S. 1986b. Census and Ecology of *Lilium occidentale* at Bastendorf Bog: An Initial Synthesis. Report submitted to the Nature Conservancy,

Portland, Ore. Unpubl.
Schultz, S. 1987a. Population status of *Lilium occidentale* at Bastendorf Bog Preserve, Summer 1987. Report submitted to the Nature Conservancy, Portland, Ore. Unpubl.
Schultz, S. 1987b. Preliminary analysis and notes on 1987 field data collect at all western lily sites in California and Oregon; enclosed in letter dated 9/87 to D. Imper.
Schultz, S. 1987c. Personal communication, D. Imper.
Secretary, 1935. Lilies and spring frosts. Royal Horticultural Society Lily Yearbook. 1935:35-36.
Senger, C. M. 1986. Germination in lilies with hypogeal germination. Royal Horticultural Society Lily Yearbook. 1986:45-48.
Skinner, M. W. 1985. *Lilium occidentale* Purdy.--Preliminary Report: Ecology, Population Characteristics, Reserve Potential and Management in California. Submitted to California Dept. Fish and Game, Arcata. Unpubl.
Skinner, M. W. 1987a. Preliminary analysis of field data and draft text pertaining to western lily, in preparation of Ph.D. thesis, Harvard University, Mass.; enclosed in letter dated 8/10/87 to D. Imper.
Skinner, M. W. 1987b. Personal communication, D. Imper.
Skinner, M. W. 1987c. Letter dated 7/1/87 to J. Kierstead, Berry Botanical Garden, Portland, Ore.
Slate, G. L. 1939. Lilies for American Gardens. Charles Scribner and Sons, New York.
Smith, J. P. and J. O. Sawyer, Jr. 1987. A Checklist of the Vascular Plants in Northwestern California. Misc. Publ. No. 2, Humboldt State University Herbarium, Arcata, Ca.
Stebbins, R. C. 1985. A Field Guide to Western Reptiles and Amphibians, 2nd ed. Houghton Mifflin Co., Boston.
Stoker, F. 1936. Contractile roots of lilies. Royal Horticultural Society Lily Yearbook. 1936:92-101.
Stryker, D. W. 1951. Experiments with lilies on the Oregon coast. North American Lily Society Yearbook. 1951:19-22.
Vollmer, A. M. 1934. The California lilies in cultivation. Royal Horticultural Society Lily Yearbook. 1934:5-14.
Vollmer, A. M. 1939. *Lilium pardilinum* and its allies. Royal Horticultural Society Lily Yearbook. 1939:108-119.
Vollmer, A. M. 1955. Hunting lilies in California. Royal Horticultural Society Lily Yearbook. 1955:53-65.
Wallace, R. W. 1934. Lily group discussion. Royal Horticultural Society Lily Yearbook. 1934:75.
Wallace, R. W. 1938. Western American lilies. Royal Horticultural Society Lily Yearbook. 1938:130-133.
Watson, E. B. 1925. Soil Survey of the Eureka Area, California. Govt. Printing Office, Washington D. C.
Woodcock, H. B. and W. T. Stearn. 1950. Lilies of the World. Charles Scribner and Sons, New York.
Woodriff, L. 1987. Personal communication, McKinleyville, Ca.
Woodriff, R, Woodriff L. and W. Woodriff. 1984. Propagation of West Coast lilies. Jour. Nor. Amer. Lily Soc. 38(3):13.
Yokum, C. F. and R. Dasmann. 1965. Pacific Coastal Wildlife Region, revised ed. Naturegraph Publications, Healdsburg, Ca.

APPENDIX A: METHODOLOGY

Cultural and historical research

The history of cultural practices used on the Reserve was investigated in a variety of ways. First, the chain of ownership of the Reserve property was determined from County records. Interviews with previous owners, local residents, and adjacent landowners, and review of written materials and photographs at the Humboldt County and Humboldt State University libraries provided much information, including some first hand historical accounts. Aerial photos dating back to 1939 were reviewed at the Humboldt County Division of Natural Resources. Information on past leases was obtained from official records at the Humboldt County Recorder's office.

The current and past land use of adjacent properties was determined through personal interviews and inspection. Information regarding the Table Bluff County Park and Table Bluff Lighthouse Park was provided by the Humboldt County Department of Public Works.

The following people were interviewed in the course of this research:

Name	Information provided
Charles Gillespie, Table Bluff resident	historical
Gary Monroe, California Dept. of Fish and Game	administrative
Eric Nelson, U.S. Fish and Wildlife Service	administrative
Doris Niles, Table Bluff resident	historical
Joe Russ, Jr., previous lessee	historical
Stanwood Murphy, previous owner	historical
Karen Suiker, Humboldt Co. Dept. Public Works	administrative

Biological inventory

Botanical reconnaissance of the entire Reserve was conducted on several dates between May 1 and August 20, 1987. Plant species not immediately recognized were collected for later determination, using Munz (1959) and Hitchcock (1950). Species nomenclature follows Smith and Sawyer (1987).

Wildlife reconnaissance was conducted on three dates in May and July by Gary Lester, consulting Wildlife Biologist, and included the range of habitats on the Reserve (Lester 1987). Areas of water accumulation and downed woody debris were checked for amphibians and reptiles. Mammals were identified from tracks, scat, visual contact and other sign. Birds were noted by sight, song, and other vocalizations. In addition, other wildlife biologists familiar with the Reserve area, and field observations reported in the *Sandpiper* (Redwood Regional Audubon Society, monthly newsletter) were consulted to indicate species most likely found on the Reserve, but not encountered during the reconnaissance. These include most of the winter resident birds, and a few of the mammals, amphibians and reptiles.

Tentative vegetation types were proposed based on reconnaissance of the entire Reserve. Plots were randomly located within homogeneous examples of the major types found. The average cover and constancy for all species encountered in the sample plots were calculated for each type, and arranged to best show differences among types in the summary table (Table 1). Vegetation type names are based on dominant species and overall physiognomy.

Because of the variability in species composition and structure, different methods were used to sample the different types. The *Tall fescue grassland*, *Sweet vernal-grassland* and *Spruce/maianthemum forest* were sampled using $1yd^2$ quadrats (25, 25, and 20 plots, respectively). Species

cover was estimated using standard Daubenmire (1968) cover classes. The cover values reported in Table 1 are the means of the cover class midpoints for each species. The *Spruce/swordfern forest* and *Spruce/salmonberry woodland* were sampled using 1/10th acre circular plots (4 and 5 plots, respectively), within which actual cover values were recorded. Because of the impenetrability of the *Willow scrub*, five isolated and representative patches were utilized as plots, ranging in size from 10 to 75 yd^2. Actual cover values were estimated.

Tree age, height, and diameter at breast height (dbh at 4.5 feet), were measured for eight dominant trees in each spruce type. Basal area of spruce was measured with a 20-factor prism, at five points randomly located within each of the spruce types and the young spruce stand.

Information on soils in each major vegetation type was collected for comparison to the Soils Survey, and for correlation with the distribution of the types. Representative locations (including most sample plot locations) were sampled with a 36" soil tube. Depth of each soil horizon and an estimate of texture and moisture were recorded. On June 19 and July 9, samples were taken in some locations for gravimetric moisture determination (dried at 105 degrees C). While soil water content is not a direct measure of availability, it does indicate relative availability when compared among soils with similar textures.

Western lily population census

A permanent grid was installed that encompasses the lily population for the purpose of censusing and future monitoring of the lily population, and for use in vegetation manipulation projects. A point of origin was established at the junction of the newly constructed fence and the old fence running E/W at the northern Reserve boundary. Rebar stakes were placed at 100' intervals, ending at 450', in an easterly direction parallel to the old fence, and at 200' intervals, for 600', at 90 degrees from the old fence. Between June 3 and 11, all lilies, boundaries of vegetation types, internal openings in the young spruce stand, and adjacent fencelines were mapped within the area for reference in later stages of the study.

APPENDIX B

PLANT SPECIES ON THE TABLE BLUFF ECOLOGICAL RESERVE[1]

TREES	COMMON NAME	HABITAT[2]
Alnus rubra	red alder	Sp,Sc
Cupressus macrocarpa[3]	Monterey cypress	
*Eucalyptus globulus**	blue gum	
Malus fusca	crab apple	Sp,Sc
Myrica californica	wax myrtle	Sp,Sc
Picea sitchensis	Sitka spruce	Sp,Sc
*Pinus radiata**	Monterey pine	
Rhamnus purshiana	cascara	Sp,Sc
Salix hookeriana	willow	Sp,Sc
Salix sitchensis	willow	Sp,Sc
Umbellularia californica	California bay	Sp,Sc
SHRUBS		
Baccharis pilularis	coyote brush	Sp,Sc,Gr
Ceanothus thyrsiflorus	blueblossum	Sp,Sc
Corylus cornuta	hazelnut	Sp,Sc,Gr
Gaultheria shallon	salal	Sp,Sc,Gr
Holodiscus discolor	oceanspray	Sc
*Ilex opaca**	American holly	Sp
Lonicera involucrata	twinberry	Sp,Sc
Toxicodendron diversilobum	poison oak	Sc
Ribes sanguineum	red flowering currant	Sp,Sc
Rosa nutkana	wild rose	Sp,Sc,Gr
Rubus macropetalus	blackberry	Sc,Gr
Rubus parviflorus	thimbleberry	Sp,Sc,Gr
*Rubus procerus**	Himalaya berry	Sp,Sc,Gr
Rubus spectabilis	salmon berry	Sp,Sc
Rubus vitifolius	California blackberry	Sp,Sc,Gr
Sambucus racemosa	elderberry	Sp,Sc
Spiraea douglasii	spiraea	Sp,Sc
Symphoricarpus albus	snowberry	Sp,Sc
Vaccinium ovatum	evergreen huckleberry	Sp,Sc
FORBS		
*Achillea millefolium**	yarrow	Sp,Sc,Gr
*Agoseris grandiflora**	dandelion	Sp,Gr
Allium unifolium	wild onion	Gr
*Amaryllis belladonna**	naked ladies	Gr
*Anagallis arvensis**	scarlet pimpernel	Sp,Gr
Angelica arguta	Lyall's angelica	Sc
*Arctium minus**	burdock	Sc
Aster chilensis	common aster	Sc,Gr
*Bellis perennis**	English daisy	Sp,Gr
*Brassica nigra**	black mustard	Sp
Brodiaea laxa	grass nut	Gr

[1] Nomenclature follows Smith and Sawyer (1987).

[2] General habitat types: Sp = spruce forest; Sc = scrub; Gr = grassland; Em = ephemeral freshwater marsh.

[3] Introduced species indicated by *.

FORBS (continued)	COMMON NAME	HABITAT
Callitriche trochlearis	water starwort	Em
Camassia quamash	camas	Gr
*Cerastium viscosum**	mouse eared chickweed	Sp,Gr
*Chrysanthemum leucanthemum**	ox-eye daisy	Sp,Gr
*Cirsium vulgare**	bull thistle	Sp,Sc
Claytonia perfoliata	miner's lettuce	Sp
Claytonia sibirica	candyflower	Sp,Sc
Daucus carota	wild carrot	Gr
Disporum smithii	fairy bells	Sp,Sc,Gr
Epilobium angustifolium	fireweed	Sc
*Erechtites prenanthoides**	fireweed	Sp
Fragaria californica	strawberry	Sp
*Galium aparine**	bedstraw	Sp,Gr
*Galium trifidum**	bedstraw	Gr
*Galium triflorum**	bedstraw	Sp
*Geranium dissectum**	cutleaf geranium	Sp,Gr
*Hedera helix**	English ivy	Sp
Helenium bolanderi	sneezeweed	Gr
Heracleum lanatum	cow parsnip	Sp,Sc
Hypericum anagalloides	tinker's penny	Sp,Gr,Em
*Hypocheris radicata**	hairy cat's ear	Sp,Sc,Gr
Iris douglasiana	iris	Sp,Sc,Gr
Lilium occidentale	western lily	Sp,Sc,Gr
*Linum perenne**	flax	Sp,Gr
*Lotus corniculatus**	bird's foot trefoil	Gr
Lotus formosissimus	bird's foot trefoil	Gr,Em
Lythrum hyssopifolia	loosestrife	Em
Maianthemum dilitatum	false lily-of-the-valley	Sp,Sc,Gr
Maianthemum stellata	Nuttal's solomon seal	Sp,Sc
Marah oreganus	wild cucumber	Sp,Sc
*Medicago lupulina**	black medik	Gr
*Nasturtium officinale**	water-cress	Em
Oenanthe sarmentosa	oenanthe	Sp,Sc,Gr,Em
*Parentucellia viscosa**	yellow parentucellia	Gr,Em
Plantago hirtella	plantain	Sc.Sp
*Plantago lanceolata**	English plantain	Sp,Gr
Potentilla egedei	cinquefoil	Sp,Gr,Em
*Prunella vulgaris**	selfheal	Sp,Gr
*Ranunculus parviflorus**	buttercup	Sp,Sc,Gr
*Ranunculus repens**	creeping buttercup	Sp,Sc,Gr
*Rumex acetosella**	sorrel dock	Sp,Sc,Gr
*Rumex conglomeratus**	dock	Sp,Sc
*Rumex crispus**	curly dock	Sp,Sc
Sanicula crassicaulis	snakerrot	Sp,Sc
Scrophularia californica	figwort	Sc
Scrophularia californica	figwort	Sp,Sc
*Silybum marianum**	milk thistle	Gr
Sisyrinchium californicum	golden-eyed grass	Gr,Em
*Solanum nigrum**	nightshade	Sp,Sc
*Sonchus asper**	sow thistle	Sc,Gr
Stachys chamissonis	hedgenettle	Sp,Sc,Em
Stachys rigida	hedgenettle	Sp,Sc,Gr
*Stellaria media**	chickweed	Sp,Sc
Tellima grandiflora	fringecups	Sp,Sc

FORBS (continued)	COMMON NAME	HABITAT
Trientalis latifolia	star flower	Sp
Trifolium macraei	clover	Sp,Gr
*Trifolium repens**	white clover	Sp,Gr
Trifolium wormskioldii	clover	Sp,Gr
Urtica holosericea	stinging nettle	Sp,Sc,Gr
Veronica americana	speedwell	Sp,Sc
Veronica scutellata	speedwell	Em,Sp
*Vicia angustifolia**	vetch	Gr
*Vicia villosa**	vetch	Gr
Viola adunca	violet	Gr
FERNS		
Athyrium felix-femina	lady fern	Sp,Sc,Em
Polystichum munitum	sword fern	Sp,Sc,Gr
Pteridium aquilinum	bracken fern	Sp,Sc,Gr
GRASSES AND ALLIES		
*Agrostis alba**	bentgrass	Gr
*Aira caryophyllea**	hairgrass	Em
Alopecurus pallescens	foxtail	Sp
*Anthoxanthum odoratum**	vernal grass	Sp,Gr
*Briza minor**	little rattlesnake grass	Em
*Bromus mollis**	soft chess	Sp,Gr
*Bromus rigida**	ripgut brome	Sp,Gr
Calamagrostis nutkaensis	reedgrass	Sp,Gr
Carex gynodynama	sedge	Sp,Gr
Carex leptopoda	sedge	Sp,Sc,Gr
Carex obnupta	sedge	Sp,Sc,Gr,Em
*Dactylus glomerata**	orchard grass	Sp,Gr
Danthonia californica	California oatgrass	Gr
Elymus glaucus	western ryegrass	Sp,Gr
*Festuca arundinacea**	tall fescue	Gr
*Festuca myuros**	rattail fescue	Gr
Glyceria occidentalis	manna grass	Em
Heleocheris obtusa	spike-rush	Em
*Holcus lanatus**	velvet grass	Sp,Gr
*Hordeum jubatum**	foxtail barley	Sp,Gr
Juncus bufonius	toad rush	Em
Juncus effusus	rush	Sp
Juncus patens	rush	Gr
Juncus phaeocephalus	rush	Em
*Lolium multiflorum**	Italian ryegrass	Gr
*Lolium perenne**	perrenial ryegrass	Sp,Gr
*Poa trivialis**	rough stalked meadowgrass	Sp,Gr
*Scirpus setaceous**	bulrush	Em
Trisetum cernuum	nodding trisetum	Sp

APPENDIX C
WILDLIFE SPECIES ON THE TABLE BLUFF ECOLOGICAL PRESERVE

BIRDS[1,2]	PREFERRED HABITAT[3]	ABUNDANCE[4]	SEASONAL OCCURRENCE[5]
+Great Blue Heron*	Sp	C	Y
+Great Egret*	Sp	C	Y
+Turkey Vulture	G	C	S
+Osprey	G	C	S
+Northern Harrier	Gr	U	Y
Sharp-shinned Hawk	G	U	W
Cooper's Hawk	G	U	W
+Red-shouldered Hawk*	Sp	U	Y
+Red-tailed Hawk*	G	C	Y
Rough-legged Hawk	G	U	W
Ferruginous Hawk	G	R	W
+American Kestrel*	G	C	Y
Merlin	G	R	W
Peregrine Falcon	G	R	M,W
+California Quail*	G	C	Y
+Killdeer*	Gr	C	Y
+Band-tailed Pigeon*	Sp	C	S
+Mourning Dove*	Gr	C	S
+Common Barn-Owl	Gr	U	Y
+Great Horned Owl	Sp	U	Y
Northern Saw-whet Owl	Sp	R	S
+Vaux's Swift*	G	C	S
+Anna's Hummingbird*	G	C	S
+Allen's Hummingbird*	G	C	S
+Belted Kingfisher*	G	C	Y
Red-breasted Sapsucker	Sp	U	W
+Downy Woodpecker*	Sc	C	Y
+Hairy Woodpecker*	Sp	C	Y
+Northern Flicker*	G	C	Y
+Pileated Woodpecker	Sp	R	M
+Olive-sided Flycatcher*	Sp	C	S
+Western Wood-Pewee*	Sp	C	S
+Western Flycatcher*	Sp	C	S
+Black Phoebe*	Sc	C	Y
+Purple Martin	G	R	M
+Tree Swallow*	G	C	M,S
+Violet-green Swallow*	G	C	M,S
+Northern Rough-winged Swallow*	G	C	M,S
+Cliff Swallow*	G	C	M,S
+Barn Swallow*	G	C	M,S
+Steller's Jay*	Sp	C	Y

[1] Standard names and order of listing follows the American Ornithologists Union *Checklist of North American Birds*, 1983.
[2] + indicates field verified, * indicates nesting species.
[3] Habitat types: Sp = spruce forest; Sc = scrub or mixed spruce/scrub approaching riparian in character; Gr = grassland; G = generalist.
[4] Abundance symbols: C = common; U = uncommon; R = rare.
[5] Seasonal symbols: Y = year round; S = summer breeder; M = migrant; W = wintering species.

BIRDS[1,2] (continued)	PREFERRED HABITAT[3]	ABUNDANCE[4]	SEASONAL OCCURRENCE[5]
+Common Raven*	G	C	Y
+Chestnut-backed Chickadee*	Sp	C	Y
+Bushtit*	Sc	C	Y
+Red-breasted Nuthatch*	Sp	C	Y
+Brown Creeper*	Sp	U	Y
+Bewick's Wren*	Sc	C	Y
+Winter Wren*	Sp	C	Y
+Golden-crowned Kinglet*	Sp	C	Y
Ruby-crowned Kinglet	Sp	C	W
+Swainson's Thrush*	Sp	C	S
Hermit Thrush	Sp	C	W
+American Robin	Sp	C	Y
Varied Thrush	Sp	U	W
+Wrentit*	Sp	C	Y
Water Pipit	Gr	C	W
+Cedar Waxwing*	Sp	C	S
+European Starling*	Sp	C	Y
+Hutton's Vireo*	Sp	C	Y
+Warbling Vireo*	Sp	C	S
+Orange Crowned Warbler*	Sc	C	S
+Nashville Warbler	Sp	R	M
+Yellow Warbler	Sc	U	M
+Yellow-rumped Warbler*	Sp	C	W,S
+Black-throated Gray Warbler	Sc	U	M
+Townsend's Warbler	Sp	U	M
+MacGillivay's Warbler	Sp	U	M
+Common Yellowthroat	Sc	U	M
+Wilson's Warbler*	Sp	C	S
+Western Tanager*	Sp	U	S
+Black-headed Grosbeak*	Sp	C	S
+Lazuli Bunting	Gr	U	M
Rufous-sided Towhee	Sp	C	W
+Chipping Sparrow	Gr	R	M
+Savannah Sparrow*	Gr	C	S
+Grasshopper Sparrow	Gr	R	S
Fox Sparrow	Sp	C	W
+Song Sparrow*	Sp	C	Y
Lincoln's Sparrow	Sp	U	W
Golden-crowned Sparrow	Sp	C	W
+White-crowned Sparrow*	Sp	C	Y
Dark-eyed Junco	Sp	C	W
+Red-winged Blackbird	Sc	C	Y
+Western Meadowlark*	Gr	C	Y
+Brewer's Blackbird*	Gr	C	Y
+Brown-headed Cowbird	Gr	C	S
+Northern Oriole*	Sp	U	S
+Purple Finch*	Sp	U	Y
+House Finch*	Sp	C	Y
+Red Crossbill	Sp	C	Y
+Pine Siskin*	Sp	C	Y
+Lesser Goldfinch*	Gr	C	Y
+American Goldfinch*	Gr	C	S
+Evening Grosbeak	Sp	U	M
+House Sparrow*	G	U	Y

MAMMALS

COMMON NAME	SCIENTIFIC NAME[6]
Oppossum	*Didelphus marsupialis*
Trowbridge Shrew	*Sorex trowbridgei*
Pacific Shrew	*Sorex pacificus*
+Pacific Mole	*Scapanus orarius*
+California Myotis	*Myotis californicus*
Hoary Bat	*Lasiurus cinereus*
+Raccoon	*Procyon lotor*
+Long-tailed Weasel	*Mustela frenata*
Spotted Skunk	*Spilogale putorius*
+Striped skunk	*Mephitis mephitis*
+Coyote	*Canis latrans*
+Gray Fox	*Urocyon cinereoargenteus*
+Beechey Ground Squirrel	*Citellus beecheyi*
+Douglas Squirrel	*Tamiasciurus douglasii*
+pocket Gopher	*Thomomys bottae*
Deer Mouse	*Peromyscus maniculatus*
+Dusky-footed Woodrat	*Neotoma fuscipes*
Oregon Vole	*Microtus oregoni*
House Rat	*Rattus norvegicus*
House Mouse	*Mus musculus*
Pacific Jumping Mouse	*Zapus trinotatus*
+Brush Bunny	*Sylvilagus bachmani*
+Black-tailed Deer	*Odocoileus hemionus columbianus*

AMPHIBIANS AND REPTILES

COMMON NAME	SCIENTIFIC NAME[7]
Northwestern Salamander	*Ambystoma gracile*
Rough-skinned Newt	*Taricha granulosa*
+Ensatina	*Ensatina eschscholtzii*
+California Slender Salamander	*Batrachoseps attenuatus*
Clouded Salamander	*Aneides ferreus*
+Western Toad	*Bufo boreus*
+Pacific Tree Frog	*Hyla regilla*
+Red-legged Frog	*Rana aurora*
+Western Fence Lizard	*Sceloporus occidentalis*
Western Skink	*Eumeces skiltonianus*
+Southern Alligator Lizard	*Gerrhonotus multicarinatus*
Northern Alligator Lizard	*Gerrhonotus coeruleus*
Rubber Boa	*Charina bottae*
Gopher Snake	*Pituophis melanoleucus*
+Common Garter Snake	*Thamnophis sirtalis*
Western Terrestrial Garter Snake	*Thamnophis elegans*
+Western Aquatic Garter Snake	*Thamnophis couchii*

[6] Source: (Burt and Grossenheider 1965)
[7] Source: (Stebbins 1985).

APPENDIX D
WESTERN LILY PROPAGATION

The reproductive potential of the western lily in nature appears high. This is indicated by the apparent rapid recovery of the population at the Reserve, thought to be extirpated in 1974, estimated at >400 plants in 1984, and currently >900 plants (primarily seedlings). Similar recovery has been taking place at the Johnson site since elimination of cattle grazing, and has occurred periodically at the Barry site over the years during periods of low cattle activity. Nevertheless, artificial propagation can and should take a major role in building up the existing populations and establishing new colonies throughout the lily range. This section summarizes the current experience pertaining specifically to cultivation of the western lily. Elmsweller (1950b and 1986) provides a thorough discussion on propagation of lilies in general.

The western lily is characterized in the literature as both difficult and easy to propagate, but most often difficult (MacNeil and MacNiel 1946, Roderick 1984, Vollmer 1939, Wallace 1938). Successful propagation of seed at the Humboldt State University greenhouse and the Berry Botanical Garden in Portland indicate that seed viability is high, and that no special procedures are required. Most accounts on propagation of the western lily mention the need for moist conditions, a cold vernalization period, acid soil, and soil with little or no clay. Germination in the western lily is described as "hypogeal", in which top growth occurs only after the first year, and in this case, only after a period of mild cold stratification.

The plant can also be propagated by scaling, but this is not recommended for field application due to the fragility of the bulbs (Wallace 1938) and the potential for loss of the mother plant. Experience in propagation from both seed and bulbscales is summarized below:

(1) Plants were grown at the Humboldt State University greenhouse from seed collected at the Barry site on Table Bluff, in October 1982 (Lancaster 1987). About 100 seed were planted in a flat in July 1983. Planting media was 3 parts coarse peat, 2 parts vermiculite, and 1 part sand. Temperature was 70F for 6 mos, then 40F for 6 wks, and 70F for 4 wks, during which the seed germinated. Germination rate was not assessed, but was high. Plants were grown for the first year under glass with a maximum day temp of 80F, and min night temp of 60F until the top-growth (single leaves) died back. Bulbs at this time were microscopic. The plants were then given 4 mos at 40F (Jan-May 1985); after the second season's growth plants were moved to a lathhouse, where they remain. Bulbs were ~2 mm diameter at this time, and top- growth remained as single leaves. Only single leaves appeared during the third season (1986); a few plants produced one whorl of leaves, and one flower in 1987. The tallest plants were ~2 feet, and the bulbs remained generally less than 3-5 mm.

Lancaster suggests that fresh seed could probably be planted outdoors as soon as collected, and give good germination in the spring. For indoor culture, cold stratification only, or short (3 mos) warm stratification followed by cold should be tried. The long stratification in this trial was a result of the time of seed availability and lack of knowledge on germination requirements.

(2) The Berry Botanical Garden has successfully cultivated plants from seed collected at three sites on Table Bluff and several sites in southern Oregon, and from bulbscales collected in southern Oregon (Kierstead 1987).

Seed was planted to pots in lots of 10-20, on April 4, 1986. Media included 1 part partly seived peat, 1 part coarse sharp sand, and 1 part

pasteurized compost. Pots were put in a cold frame with natural light. In most cases, emergence was not until 10 mos after sowing; as of October 1987, germination rate ranged 45-100%, with 4 of the 6 trials having 90% or greater. The California and Oregon seed showed similar results.

Seed was also sown indoors on November 25, 1986, on filter paper in petri dishes, with darkness and constant 60F, and within bags to maintain the humidity. After 90 days, trials of the Table Bluff seed showed 30-60% germination. This test is continuing.

Bulbscales were treated with fungicide, and planted in a sand bench in the greenhouse in 1983. One plant flowered in 1987.

(3) Leslie Woodriff, local commercial lily grower, has grown many native lilies including the western lily. He has refined techniques for propagating both from seed and bulbscales (Woodriff *et al.* 1984).

Seed is placed in moist redwood sawdust, sealed in poly squares, and kept at room temperature until the root emerges, or two months. The seed are then refrigerated for 2 mos, after which the baby bulbs are transferred to flats in the greenhouse for 9-12 mos. and then transferred to the garden for two years. A 12-12-12 fertilizer and sulphur are used in the bottom of the garden hole, and covered with 1" soil before planting the bulb to avoid burn. Fertilizer is applied as a top dressing in the spring.

In scaling, scales are planted in the fall in moist redwood sawdust. After 2-3 mos, the bulbs are picked off the scales and scales replanted. Bulbs are refrigerated for two mos, then transferred to plastic-lined flats in the greenhouse with 3/4" of gravel in the bottom, covered with one teaspoon slow release Osmocote (14-14-14), and covered with 3 parts vermiculite to 1 part peat. Bulbs are placed 3/4" below the surface and watered once a week. A 3" X 11/2" plastic pipe is placed in the center of the flat to enable watering without wetting the soil surface, reducing the chance of *Botrytis* and damping off. The plants are kept in the greenhouse for 9-12 mos, then moved to the garden.

(4) Skinner (1987c) has successfully grown western lily from bulbscales to flowering in 4 years or less. Plants are given 2-3 mos at 36F to mimic Winter, on a 7 mo rotation. He reports a key factor is keeping the bulb moist during vernalization. Plants were also grown from seed collected on Table Bluff and in southern Oregon in 1983; as of Summer 1987 these plants had not flowered.

(5) Kline (1984) had good success with western lily in Medford, Oregon, with raised beds of pure coarse sand, and a 1" gravel topping. Plants were given an acid fertilizer and manzanita leaf mold to offset the poor nutrient status of the sand. The lilies responded so well he had to divide them. Kline reported earlier (1952) that growing from seed was relatively easy, and advised germination in the Spring, and leaving undisturbed for 3 years before transplanting.

(6) Brown (1984) claimed germination at 50-60F is best for the western lily and other hypogeal germinators, and that higher temperatures may impede germination. Soil pH should be <5.5. Good results followed planting seed in 10" pots in September, using sterile soil with lots of peat moss and a little bonemeal added. Soil was not allowed to dry out. Plants were kept in an unheated screenhouse for 2 years, and then transplanted to the garden. Another author (Anonymous 1960) planted seed in vermiculite at various temperatures. Germination occurred within 8 weeks in the 50F treatment; seedlings were then placed in vermiculite flats in the greenhouse at 65-75F.

APPENDIX E
TABLE BLUFF ECOLOGICAL RESERVE: WESTERN LILY DATA 1987

LILY COORDINATES (') (X)	(Y)	#PLANTS	FLOWER#	HEIGHT	PHENOLOGY
194	191	7		3	v
196	190	3		7	v
198	188	7		4	v
196	185	10		3	v
125	225	3		10	v
126	226	1		14	v
125	226	1	1	36	b
125.5	226.5	3		3	v
126.5	225	2		15	v
123	225	1		6	v
123	227	1		14	v
123.5	227	2		5	v
123	228	1		6	v
123	228.5	1		12	v
123	229	1		16	v
115	245	1		30	v
115.5	245	2		20	v
116	245	1		26	v
115	243	1	1	36	b
115	243.5	1		30	v
115	243	2		16	v
115.5	243	1		10	v
116	243	6		3	v
115	242	1	1	32	b
115.5	242	2		18	v
118	238	1		20	v
118	236	5		3	v
118	236.5	2		20	v
122	233	1		22	v
122	237	3		12	v
122.5	237	1		20	v
122	237.5	1		20	v
121	239	3		12	v
121.5	239	2		18	v
120	241	3		23	v
120.5	241	3		13	v
121	241.5	2		8	v
124	238	3		20	v
124.5	238	2		15	v
124	238.5	1		10	v
124	239	3		8	v
123	242	4		8	v
123	242.5	1		14	v
127	242	3		10	v
127	240	2		13	v
127	241	2		14	v
127.5	241	2		18	v
128	240	1		12	v
127	246	2		16	v
127	246.5	4		6	v
127.5	246	6		2	v
128	247	1		6	v

121	246.5	1		16	v
121	247	6		6	v
121	246	6		12	v
120	249	3		10	v
121	254	1		6	v
123	254	1		20	v
123	254.5	1		8	v
125	258	1		8	v
125	258.5	1		12	v
125.5	258	1		2	v
126	258	1		8	v
136	267	1		12	v
136	267.5	3		2	v
130	269	2		2	v
132	236	1		10	v
129	236	2		5	v
129	236.5	1		8	v
130	225	1		12	v
132	225	1		4	v
132	225.5	1		8	v
143	160	1		18	v
133	155	1	1	36	b
143	155	1		30	v
201	158	1		14	v
203	159	1		20	v
143	270	1		10	v
143	270.5	1		14	v
160	360	2		12	v
154	370	2		12	v
380	204	20		10	v
382	206	20		6	v
384	208	20		2	v
381	205	1	1	30	b
343	200	25		4	v
343	220	25		4	v
373	200	25		4	v
373	220	25		4	v
195	323	25		4	v
195	348	25		2	v
215	323	25		4	v
215	348	25		3	v
345	328	1		12	v
269	372	1		16	v
269.5	372.5	1		8	v
261	370	5		12	v
174	397	1		20	v
172	403	1		10	v
500	293	1		2	v
500	273	1		8	v
425	300	25		4	v
445	300	25		4	v
425	250	25		4	v
445	250	25		4	v
468	300	10		4	v
468	250	10		4	v
450	415	10		4	v
450	420	10		4	v
330	230	1	1	40	f1

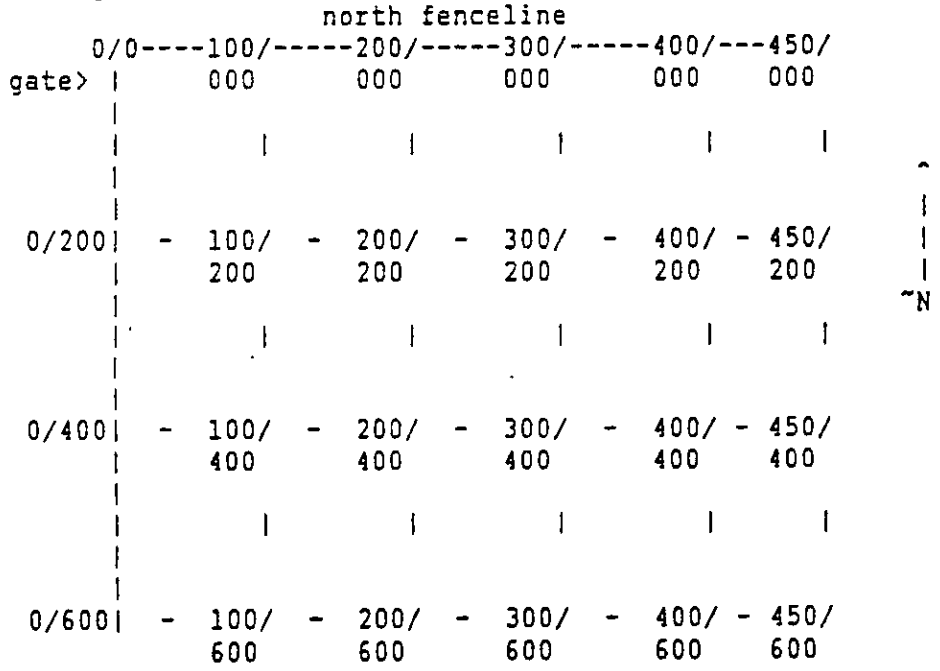
335	235	1		20	v
340	237	10		4	v
350	237	10		4	v
360	250	10		4	v
465	144	1	1	30	fl
465	145	1		20	v
459	144	1	3	48	b
459	143	1	2	46	b
461	146	1		25	v
462	146	1	2	30	fl
461	145	1	1	20	b
462	145	1		12	v
454	143	1		12	v
455	143	1	1	30	fl
460	152	1	1	30	fl
476	155	5		10	v
498	201	1		12	v
455	225	10		2	v
465	225	10		4	v
455	240	20		4	v
465	240	10		6	v
485	225	1	2	32	b
550	230	1	2	60	b
551	230	1	2	60	b
550	235	10		4	v
400	200	10		4	v
415	200	10		2	v
400	185	10		4	v
415	185	20		4	v
495	142	1	1	16	b
487	146	1	1	16	b
484	144	2		8	v
483	146	2	1	15	b
483	144	1		12	v
485	148	7		5	v
491	148	7		4	v
485	154	5		11	v
491	154	1	1	16	b
486	146	1		10	v
482	147	1	1	22	b
479	142	1		22	v
480	142	1		10	v
480	146	1	1	20	b
480	150	1	2	36	b
479	150	1	1	30	b
480	152	1	1	20	b
480	151	2		20	v
477	151	1		20	v
477	148	1		30	v
472	150	10		10	v
473	151	1	4	24	b
472	148	15		15	v
473	143	1		15	v
470	141	1	1	30	fl
468	141	1		30	v
466	148	1	2	40	b
465	148	3		12	v
471	153	1	3	55	b

472	153	1	3	68	b
471	152	1		49	v
472	152	2		25	v
473	152	1	2	68	b
472	153	1	1	30	b
473	153	1	1	30	b
470	154	1		12	v
486	127	1		12	v
475	122	1	1	20	fl
462	126	1	1	20	fl
408	155	5		4	v
458	138	1	2	42	b
462	137	1	2	25	b
462	138	1		20	v
464	135	1	1	20	b
465	134	1		20	v
468	131	1		20	v
468	132	1		20	v
468	135	1		15	v
469	140	1		20	v
475	139	1		25	v
472	134	1		25	v
475	134	1		20	v
473	130	1	4	36	b
473	129	1		20	v
333	193	3		5	v
333	192	2		2	v
361	197	10		4	v
370	200	20		5	v
390	194	5		2	v
400	194	5		4	v
390	200	5		2	v
400	200	5		4	v
448	98	1		12	v
450	97	1		6	v
451	94	1		12	v
440	98	1		8	v
403	108	1	1	18	b
474	111	3		8	v
335	102	1	1	40	b
336	102	1	1	40	b
335	101	1	1	40	b
334	97	1	1	20	b
403	108	1	1	25	b
392	149	2		16	v
384	150	1	2	48	b
367	155	1	1	48	b
367	150	1		16	v
367	151	1		12	v
373	140	1		12	v

Western lily--population

Monitoring of the western lily population is conducted on an biannual basis, in June when the plants are most visible, and in October after fruits are set. The permanent grid established on the Reserve is used as a reference to measure locational coordinates for each lily. Using these coordinates, the population can be mapped with a variety of computer graphics programs, which can be overlaid on the vegetation and 1987 population map (Figure 12). The coordinates will also enable comparison of individual plant characteristics from year to year. Refer to the attached sample data sheet in the following explanation of procedures and specific data collection:

Initial procedure. The reference grid is based at the north fenceline of the Reserve, with the northeast corner at the intersection of the cattle exclosure (new fence) and the old fence. The grid intersection points indicated below are staked with rebar (tagged and flagged) at ground level in the following format:



The reference point 0/0 is used as the point of origin in an x/y graph, if the first coordinate is used as y, and second as x. Measurement tapes are laid out along each leg of the grid sequentially; 200' tapes are required for the N/S legs, 100' tapes minimum for the E/W legs. Tapes are laid out at intervening distances as required by the investigator to adequately take locational measurements.

REFERence TRANSect (Y/X). The N/S leg that lies west of the block being inventoried is recorded; e.g., if sampling the block in the northwestern corner of the grid, 0/0 is recorded; for the next block east of this, 200/0 is recorded, and so on. In this way, measurements taken from the tape baseline (DISTANCE and ADD) only are added to the appropriate number in the REFER. TRANS. indicator to give overall coordinates in the grid. This can easily be done in a database or spreadsheet program, or hand calculated.

DISTANCE (X). This measurement is taken parallel to the N/S tapeline to each lily observed in the block. This is the x coordinate for the grid, and eventual map. Measurement to the nearest foot is sufficient.

ADD (Y). This measurement is taken at right angle to the reference N/S leg, and is the y coordinate for the grid. It does not matter which side of the leg the plant is on, i.e., if a plant was missed in the inventory of the previous block-west of the reference leg, measurement can still be made from the current reference leg, but with a negative sign.

#PLANTS. Often there are too many plants (seedlings) to record unique locational measurements for each plant. In this case, the DISTANCE and ADD measurements should be ranges within which the #PLANTS is recorded. Only plants having the same characteristics recorded later on the data sheet should be lumped (height, flower #, etc.).

HeiGHT ("). Height to the nearest inch for each lily, or group of lilies is recorded. This is most easily done with a yardstick.

FLOWeR#. Number of flowers in each plant inflorescence is recorded.

GRaZED/DISEASe. Indication is made whether the plant has been grazed, trampled, or suffers apparent disease. If disease or grazing is suspected, and not easily recognized, a sample of the affected part of the plant should be collected and submitted for identification to the County Extension Agent or other authority.

NOTES. The suspected cause of grazing or identity of disease, or any other characteristic of significance is noted.

With respect to the census of reproductive success, after the above data is entered into a spreadsheet or database program, a list of flowering plant coordinates and relevant data can be printed out, enabling easy relocation of plants. Census is made in late September or October. Number of fruits remaining on each plant is recorded, and notes on cause for reproductive failure if appropriate. These record sheets are kept with the field data sheets.

Western lily--habitat (specific)

A small amount of information concerning the environment of each plant detected in the annual population monitoring is recorded on the data sheet. This data includes:

HABITAT TYPE (See key). The general habitat type where the lily is rooted is recorded, according to the key at the bottom of the page. Openings refers to remnant patches of grassland within the young spruce forest.

COMPETITOR HeiGHT. This is an indication of the overall requirement placed on the plant to reach a successful reproductive state, and an indication of the competitive stress on the plant. In order to standardize the measurement, the height of the dominant competitor is recorded directly above the base of the lily, recognizing that often the lilies will bend to expose themselves outside the canopy of competitors. The spruce overstory, if present, is not included in this measurement.

% OVERHeaD CANOPY. This is another measure of competition, measured from

the top of the plant. Both under and overstory canopies, if present, are included in this subjective estimate. It should equal 100 - the % total exposure to open sky. The estimate may be the same for a plant within dense *Willow scrub*, or an isolated plant underneath a dense spruce canopy.

Western lily--habitat (general)

The purpose of this monitoring is to assess the trends occurring in the lily habitat, its overall suitability for lily growth and reproduction, and the potential for expansion of the present population. It will be performed before and after each phase of lily habitat manipulation, as called for in the Maintenance level management plan, and every three to five years thereafter, to assess the need for routine habitat maintenance.

This monitoring utilizes permanently marked transects that correspond to the reference grid encompassing the present lily habitat on the Reserve. The specific transects to be sampled include:

E/W direction starting coords.(x/y)	N/S direction starting coords.(x/y)
100/0	0/100
200/0	0/200
300/0	0/300
400/0	0/400
500/0	
end 450'	end 550'

Since the vegetation is continually disturbed along these lines in conjunction with annual population monitoring, and laying of the measurement tapes, actual measurements of vegetation are taken 5 feet south or east of the transect indicated above. Refer to the attached sample data sheet in the following explanation of procedures and specific data collection:

TRANSect DESIGnation. The point of origin is indicated by x/y coordinates.

DISTance. Dominant vegetation intercepts are recorded for the line 5 feet south or east of the transect. The DISTance measurement is the point at which the dominant understory vegetation changes to that described in the next data column. The objective is to identify the vegetation layer most directly competing with the western lily. Therefore, if a grass layer lies underneath a shrub layer, the shrub layer is the one concerned, since it most affects the (above ground) environment of the lily. Summation of the differences between distance measurements for a particular dominant, or group of dominant species, can be used to calculate overall dominance.

DOMINANT SPECIES (understory). The dominant species, or group of dominant species is recorded for the understory layer that most competes with the lily, as described in the last paragraph. A structural definition is used with regard to spruce to distinguish understory versus overstory, with the breakpoint arbitrarily set at 10 feet; i.e., spruce less than 10 feet tall is recorded as understory, and 10 feet tall or greater is recorded as overstory in the appropriate column.

AVeraGe HeiGHT (understory). The average height of the layer described in the previous two columns is recorded, only for this intercept.

SPRUCE OVERSTorY. Indication is made whether spruce overstory (>10 feet tall) is present over the specific transect interval described.

%COVER 3' ABOVE GRound. This is estimated at 10-foot intervals (d) along the transects, and estimates the availability of the specific microhabitat suitability for the western lily. The estimate of cover should integrate all of the canopy layers above the 3' point, and should equal 100 - the total exposure to open sky at the point concerned.

TBER: WESTERN LILY CENSUS DATA

SAMPLED BY_____ DATE_____

REFER. TRANS. (Y/X)	DIST-ANCE (X)	ADD (Y)	# PLANTS	HGHT (")	FLOWR #	GRZED/ DISEAS	HABITAT TYPE (See key)	HABITAT COMPE-TITOR HGHT	HABITAT % OVERHD CANOPY	NOTES

Habitat: G = grassland Sy = spruce (young) W = willow scrub
E = edge O = openings So = spruce (old)
Competitor height: measured directly above base of lily

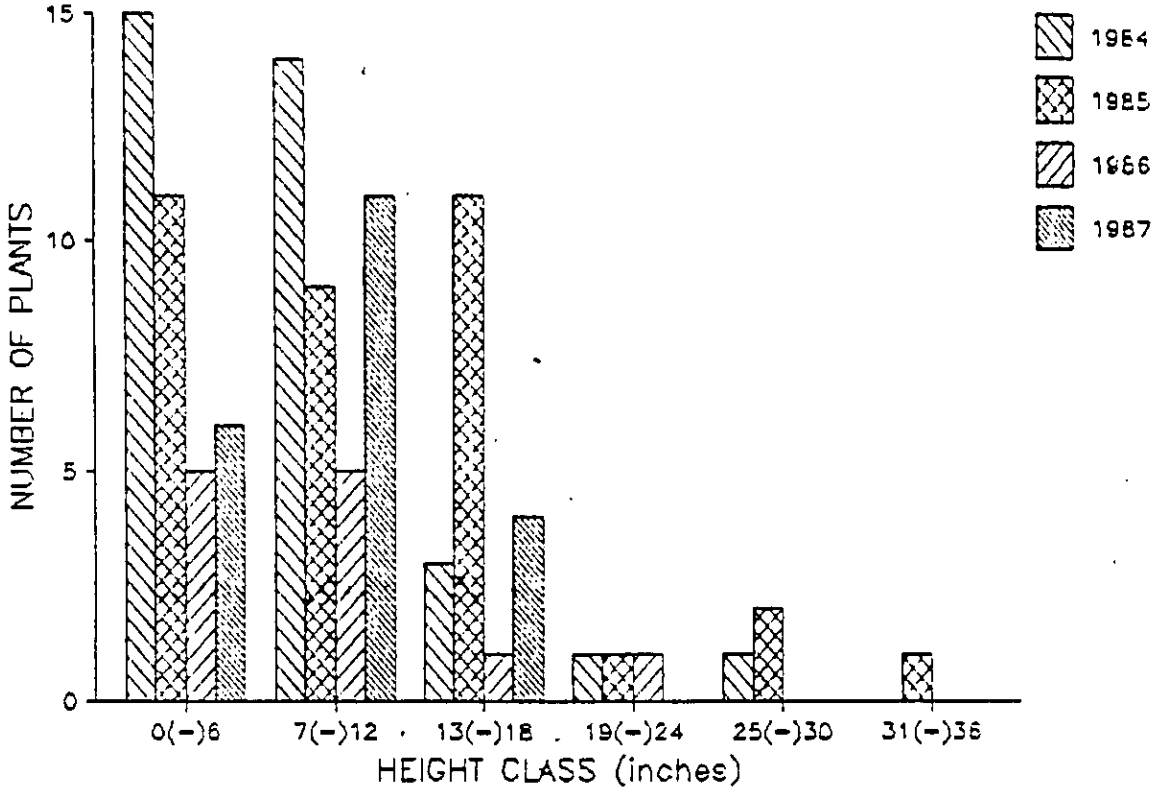


Figure 9. Frequency distribution of height-class for western lily at the Table Bluff Ecological Reserve, 1984-1987; six foot-square plot.

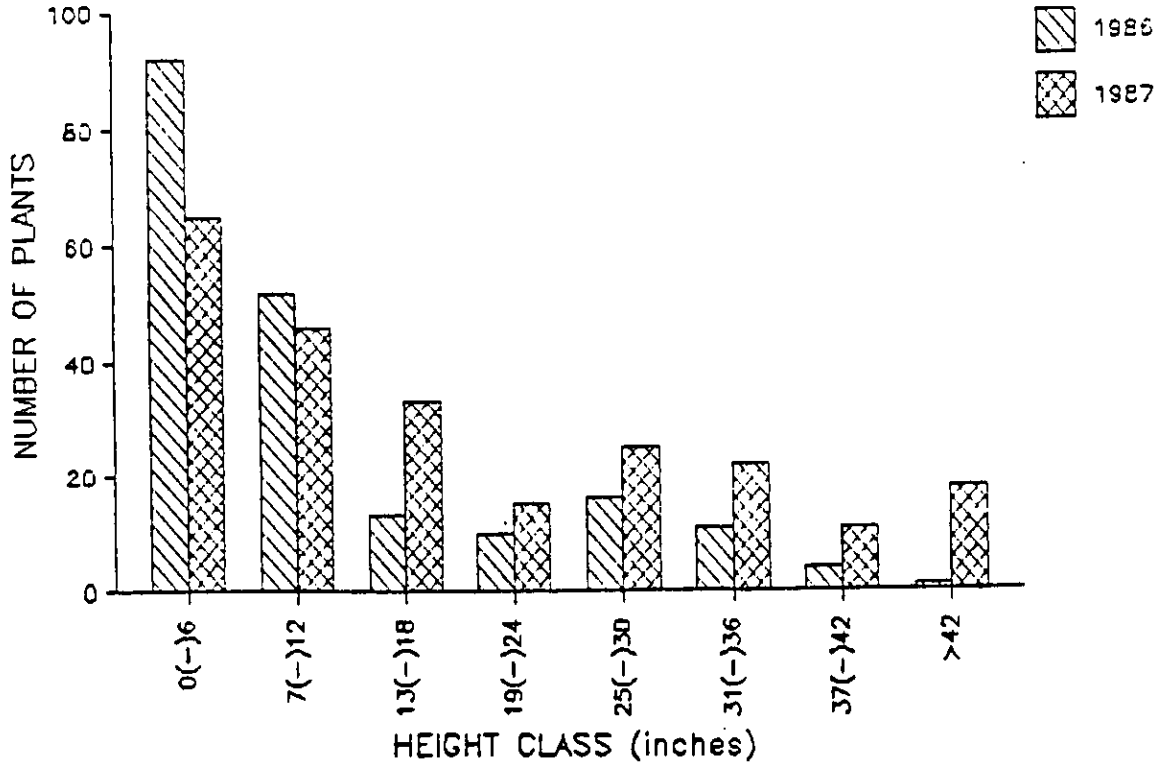


Figure 10. Frequency distribution of height-class for western lily at the Johnson site exclosure, 1986-1987.

TBER: WESTERN LILY HABITAT DATA

SAMPLED BY_____ DATE_____

TRANS. DESIG.	DIST.	DOMINANT SPECIES (understory)	AVG. HGHT. (understory)	SPRUCE OVERSTY?	d	%COVER at 3'	NOTES
					0		
					10		
					20		
					30		
					40		
					50		
					60		
					70		
					80		
					90		
					100		
					110		
					120		
					130		
					140		
					150		
					160		
					170		
					180		
					190		
					200		
					210		
					220		
					230		
					240		
					250		
					260		
					270		
					280		
					290		
					300		
					310		
					320		
					330		
					340		
					350		
					360		
					370		
					380		
					390		
					400		
					410		
					420		
					430		
					440		
					450		
					460		
					470		
					480		
					490		
					500		
					510		
					520		
					530		
					540		
					550		