A RESTORATION DESIGN FOR LEAST BELL'S VIREO HABITAT IN SAN DIEGO COUNTY[1]

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*Abstract: This paper describes the procedure for developing a specific habitat restoration model. Results of a detailed Least Bell's Vireo (*Vireo bellii pusillus*) habitat study on the Sweetwater River drainage, San Diego County California, generated the baseline vegetative and habitat data used. Mean percent cover, density, abundance, species composition, and expected mortality rates of vegetation were used to determine the specifications for the restoration design. Mapped nesting plots were used to determine the arrangement of the planting components.*

Restoration has become a common practice in mitigating for the loss of sensitive habitats in Southern California. Yet literature review reveals a paucity of empirical information on the fundamentals of revegetation. Nor can we collectively predict how successful revegetation in California will be (Odion and others 1988). Evaluating revegetation projects has often been difficult and confusing for both the implementing parties and the reviewing agencies involved.

This paper focuses on the development of a detailed habitat model employing quantitative information based on the current biological understanding of the target species, Least Bell's Vireo (*Vireo bellii pusillus*). Baseline studies and statistical analyses will allow for more consistency of projects, improved standards for evaluating restoration projects, and, hopefully, a greater understanding of the habitat being restored.

Model Development

The first step in designing any restoration project is to succinctly define the project's goals and constraints. The construction of State Route 76 requires 7 acres of successful mitigation before construction of 76 can begin. Success is defined as either a vireo pair nesting on site or no statistically significant differences between parameters on the mitigation site and those in the functioning Least Bell's Vireo habitat (Hendricks and Rieger 1989). The California Department of Transportation management aspires to begin construction in the third year, placing a two year time frame on the development of the mitigation site! The goal of this project is thus two-fold: one, to establish occupied Least Bell's Vireo (riparian) habitat within two years time and, two, to establish a habitat capable of long term growth and regeneration.

Once the goals have been established it is possible to design a sampling scheme for the collection of data to be used as the basis for the restoration design. A well-designed baseline study is a prerequisite to a successful plan (Bramlet 1988). The baseline study for this project included habitat analysis on 10 vireo nesting sites on the Sweetwater River drainage in San Diego County, California, contained in a larger vireo habitat study (Hendricks and Rieger this proceeding). The sampling method employed and the parameters chosen are dependent upon the project's goals and the habitat being studied. The following parameters were evaluated in this study: species composition and abundance, density, frequency, diversity, percent cover, plant height, and linear edge.

Determination of Model Specifications

Consultation with the U.S. Fish and Wildlife Service determined that 5.2 acres of the 7 acre mitigation site would be designated as nesting quality habitat with the remaining 1.8 acres to be foraging habitat. This model focuses on the 5.2-acre nesting type habitat.

Since this model is intended to create a habitat rather than simply revegetate an area, physical community structure as well as species composition is important. Plants were grouped according to their growth form: tree, shrub, or herb. Areas not covered by a canopy or an herbaceous layer (i.e. bare ground) were designated as open areas. Open areas occur fairly consistently throughout vireo habitat so were incorporated into the model. The area of each category was calculated according to equation 1 (Q1), with results presented in table 1.

Q1. Percent cover for category X Total nesting area = Total area per growth form.

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Table 1 — Mean percent cover values and area allocation for each category.

		Area	
Plant type	% Cover	(acres)	(hectares)
Trees	46.7	2.45	0.99
Shrubs	32.9	1.72	0.70
Herbs	7.8	0.41	0.17
Open	12.6	0.66	0.27

Density, diversity, frequency, and average shrub and tree heights were calculated from the original data base collected at each of the nest sites. Frequency, linear edge, and diversity values were not directly used to generate the revegetation model. However, frequency values are indicative of plant distribution patterns and diversity of species per unit area. Therefore, both parameters were used as a simple test on the final model. Density values were determined for each vegetation type (table 2).

Table 2 — Mean density values per plant growth form.

Growth form	No./ft^2	No./ac	No./ha
Tree	0.023	1000	2470
Shrubs	0.091	3966	9800
Herbs	0.060	2655	6560

A partial species list was developed from the field data. Several highly invasive species were removed from the field list with the idea that they would establish readily without artificial seeding(*). The quantity of each species required was determined using equation 2 (Q2), with results presented in table 3. The method of calculating seed poundage to approximate the composition observed is described in Schaff (1988).

Q2. (Density of plant form/acre) x (Abundance of species) = Number of individuals per acre.

To obtain vireo nesting habitat following two growth seasons, mature as well as young growth is required. Measured tree heights were converted into height categories, and percent composition calculated for each species (fig.1). This pattern of height distribution and the anticipated growth rates of riparian trees were used to determine the percentage of tree sizes planted. At 4-feet/year (Rieger 1988), seedlings should be in the critical 9 to 15 foot range in two growth seasons. However, planted seedlings will not be able to attain the more mature size and form within this time. For this reason it is necessary to transplant mature trees and *Baccharis glutinosa* shrubs to the site, using a technique previously conducted by Caltrans (Rieger 1988).

The incorporation of expected mortality rates into the model is an effort to eliminate the need for replanting, a difficult task for a large contracting agency and a potentially major disturbance to the habitat. Mortality values used in this design were estimates based on observations of previous riparian restoration sites, since documented values were unavailable. Post-planting maintenance should reduce the estimated mortality rates. Original seedling quantities were increased by the mortality percentage to obtain the adjusted planting quantities (tables 4, 5).

Time constraints on this project eliminated the incorporation of natural recruitment into the model. For projects with greater time flexibility the adjusted planting number can be reduced by the expected natural recruitment rate.

To determine the appropriate spacing for the trees and shrubs, the total number of square feet per acre available for each species was derived from equation 3 (Q3).

Q3. (Percent cover of plant form) x (Species abundance) X (43560 sqft/acre) = Species area in square ft./acre.

This value divided by the adjusted quantity of plants, yields the average area allocated per plant. The square root of this value is the average distance between each plant. To achieve fuller growth on the larger trees the 15 gallons seedlings will be planted at 6 foot intervals, the 5 gallon at 4 foot intervals and the 1 gallons at 3 foot intervals. Transplant trees will be planted independently of the other seedlings at 14.5 foot intervals from themselves. The smaller seedlings will be planted around the mature trees leaving a 5 foot clearance. Species are planted in small monotypic patches within the overall design, with similar size plants clumped together, approximating the field conditions.

Table 3 - Species list and quantities required per acre of mitigation.

		# per unit area	
Species	% abundance	acre	hectare
Trees			
Salix lasiolepis	40.0	400	988
S. gooddingii	36.3	363	897
S. hindsiana	11.3	113	279
S. laevigata	10.2	102	252
Populus fremontii	1.3	13	32
Platanus racemosa	0.7	7	17
	Total	1000	2471
Shrubs			
Baccharis glutinosa	92.0	3650	9019
Isocoma veneta	4.6	180	445
Artemisia palmeri	3.4	130	321
	Total	3960	9785
Herbs			
Ambrosia psilostachya	33.2	882	2179
Artemisia douglasiana	13.0	345	852
Anemopis californica	29.1	773	1910
Pluchea purperescens	1.9	52	128
*Heliotropium curvassavicum**	2.7	72	178
*Heterotheca grandiflora**	7.2	67	166
Urtica holosericea	9.7	258	638
Galium sp.	2.5	67	166
	Total	2516	6217

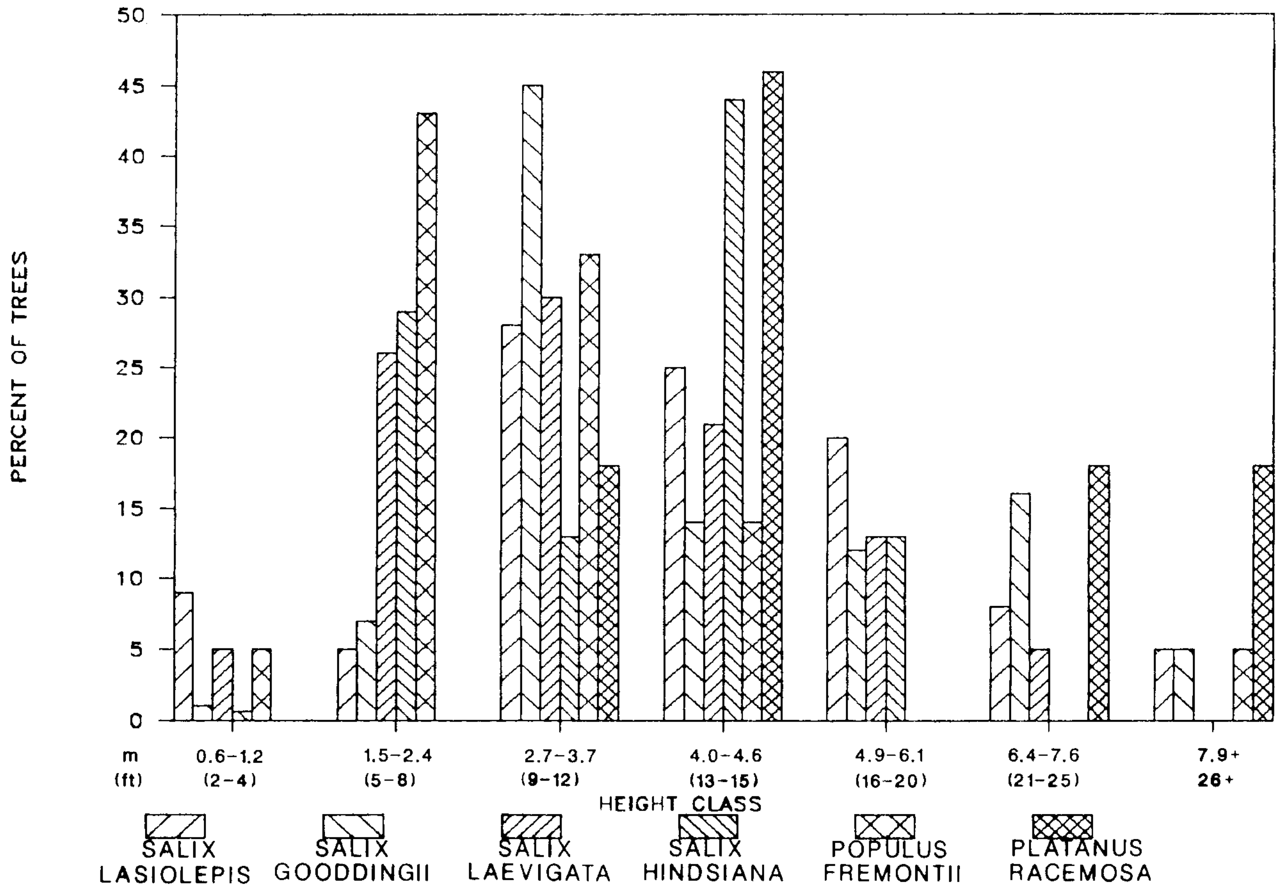

Figure 1- Height class distribution of riparian trees in Least Bell's Vireo habitat.

Table 4 - Tree specifications per acre of mitigation.

Tree ht.(ft)	Planting size	% trees	# trees	% mort.	Adjusted # trees	Planting dist.(ft)	Area (ft^2)
S. lasiolepis (47% tree cover) (40% species cover) (43560 ft^2/acre) =8190 ft^2 planted in S. lasiolepis.							
1-2	1 gal	30	120	25	150	3	1350
3-4	5 gal	40	160	10	176	4	2816
4-5	15 gal	20	80	5	84	6	3024
15+	transplant	10	40	1	40	14.5	1000
Total		100	400		450		8190
S. laevigata (47 pct trees) (10.2 pct sp) (43560 ft^2/acre) = 2047 ft^2							
1-2	1 g	30	31	25	39	3	351
3-4	5 g	40	41	10	45	4	720
4-5	15 g	20	20	5	21	6	756
15+	transplant	10	10	1	10	14.5	250
Total			102		115		2077
S. hindsiana (.47 pct trees) (.11 pct sp) (43560 ft^2/acre)= 2312 ft^2							
1-2	1 g	30	34	25	43	3	387
3-4	5 g	40	45	10	50	4	800
4-5	15 g	20	23	5	24	6	864
15+	transplant	10	11	1	11	14.5	275
Total			113		128		2326
S. gooddingii (.47 pct trees) (.36 pct sp) (43560 ft^2/acre)= 7432 ft^2							
1-2	1 g	20	73	25	91	3	819
3-4	5 g	30	109	10	120	4	1920
4-5	15 g	40	145	5	152	5	3800
15+	transplant	10	36	1	36	14.5	900
Total			363		399		7439

Table 5 — Shrub specifications per acre of mitigation.

B. glutinosa (32.9 % shrub)(92 % sp)(43560 ft/acre) = 13184.74 ft2

Planting size	Plants per clump	% shrubs	No. shrubs	% mort	Adj no. shrubs	Planting dist. (ft.)
1 gal	1	20	548	25	639	2
	2	50	1370	25	1712	2
	3	30	821	25	1026	2
	Total	75 %	2739			
2 gal	1	50	427	10	470	3
	2	50	427	10	470	3
	Total	23 %	854			
transplant		2	57	0	57	15

Baccharis glutinosa will be planted in clumps of 1, 2 and 3 seedlings per one gallon container and in clumps of 1 and 2 per container in the 2 gallon size. All 1 gallon size *B. glutinosa* containers will be planted a 2 foot intervals and the 2 gallons at 3 foot intervals. All 48 *Platanus racemosa* and 130 *Populus fremontii* will be planted as 5 gallon container plants and will be scattered throughout the site.

Designing the Layout

Following the calculations of plant specifications, the question becomes: What type of planting arrangement best matches Least Bells Vireo habitat? Habitat maps had been delineated from each of the nesting plots. Four successful nest sites were chosen as models. These four maps were joined together connecting similar areas forming a primary layout design. Areas (percent cover) of trees, shrubs, herbs and open space and linear edge were measured and checked against calculated values. Small adjustments were made yielding a mosaic nesting area design which can be repeated, fitting edges together to accommodate any size restoration area (fig. 2). The layout design was reviewed by several biologists familiar with the Least Bells Vireo.

To increase the amount of edge habitat, and intersperse foraging area into the design, the nesting habitat was divided into five irregular blocks each surrounded by foraging area. The foraging area consists of young *Salix gooddingii, Baccharis glutinosa,* open area and a few scattered *Populus fremontii* as requested by U.S. Fish and Wildlife Service. Figure 2 shows a portion of the design.

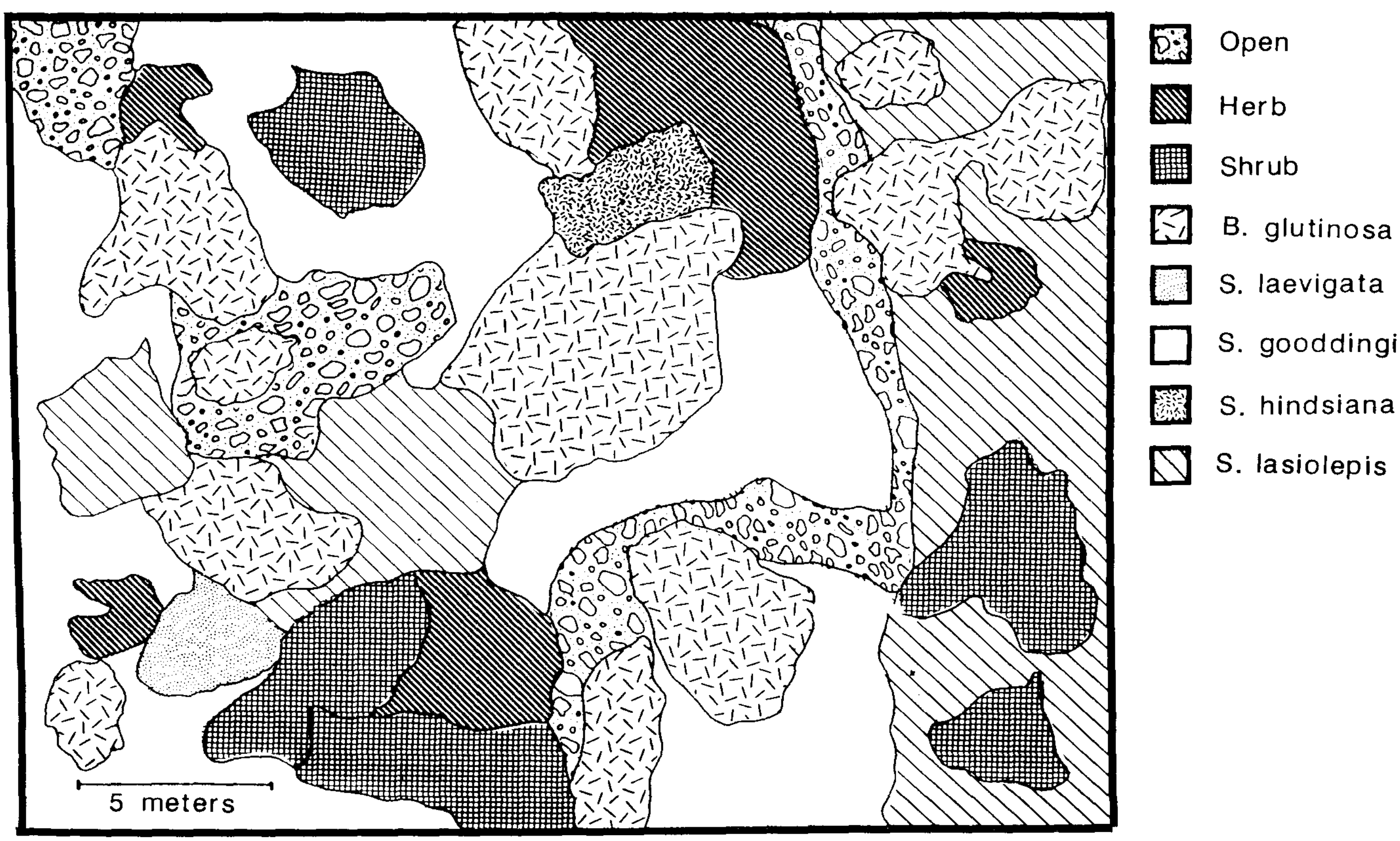

Figure 2— Primary design illustrating the mosaic pattern of growth forms and vegetation.

Leaf litter and deadfall have proven to be an important component in riparian systems, yet 5 year old restoration sites lack sufficient accumulation of either. To rectify this, deadfall and leaf litter will be distributed throughout the site.

Competition from exotic or native weedy species is a major problem in the establishment of most restoration projects. No soil fertilizers will be applied since they are known to suppress the development of mycorrhizal fungi (Hayman 1983), and may favor exotic or non-mycorrhizal weedy species over native species (St. John 1987). The effects of mycorrhizal inoculation on riparian seedling survivorship, growth rate and competitive ability is currently being tested.

The probability of a successful revegetation effort is maximized when conditions that promote the establishment of the desired vegetation are provided (Odion and others 1988). Therefore, the mitigation site should match the hydrology and physiography of a natural riparian area as closely as possible. The surface elevation of a riparian restoration site should be no more than to 2 to 4 feet above the normal water table. This allows the vegetation more accessibility to the water table, as many of the riparian species have evolved shallow spreading root systems rather than deep penetrating systems. Although auguring down to the water table in ungraded sites works well for the initial plants (Anderson and Ohmart 1985), the increased elevation may have a negative influence on natural replacement. Species composition may be altered by the selection for drier habitat species. A lower surface elevation may permit natural flooding, a key component in maintaining an earlt to mid-successional riparian community (Granholm and others 1988).

The microtopography of riparian floodplains consists of ridges and swales. This variation in elevation and surface features leads to considerable differences in drainage conditions (Strahan 1984). In response, the grading plan calls for several larger channels with smaller finger-like projections to traverse the seven acre mitigation site. The actual surface will be left in a roughened condition to provide an increase in microtopography.

Conclusions

The method and extent of data collection used to describe the Least Bell's Vireo nesting habitat was easily transformed into a quantitative description of Vireo habitat. This approach yields a design which approximates the natural situation more closely than other methods. The design process presented in this paper can be applied to most habitats or species. It was not designed as a cookbook procedure, but as a general procedure or process for the creation of a restoration design. Depending upon the specific goals and constraints, the process can be modified to fit the requirements of most projects. Documentation of mortality and recruitment rates of riparian species would strengthen the model. Having specific criteria, based upon the current understanding of the biology of the target species or habitat, should allow for more consistency and improve standards for evaluating restoration projects helping to eliminate the confusion among project designers and reviewing agencies.

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