DEVELOPMENT OF THE SANTA ROSA VERNAL RESERVE SYSTEM.

III. FIRST-YEAR RESPONSE OF MARGIN AND UPLAND HABITATS TO MOWING AND PHYTOMASS REMOVAL

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ABSTRACT

The first goal of the Santa Rosa Vernal Reserve System (SRVRS, Sonoma County, California) is to develop management prescriptions for improving the habitat quality of native plant populations, especially those of conservation interest (Pavlik, Smith and Miller 1998). This report describes the first year results of experiments for restoring vernal pools and swales on the Santa Rosa Plain, and includes the following components: 1) the use of mowing and phytomass removal as ecologically sound and practical manipulations for shifting plant cover from exotic to native (for dominant species) and from sparse to abundant (for rare species), 2) the responses of cover, phytomass production and soil chemistry to mowing and removal, and 3) a review of problems of, and potential partners for, long-term management of the SRVRS (Appendix I).

The first field experiment was installed during the spring and summer of 1999 to determine if seasonal mowing and phytomass removal can improve habitat quality for native plants in vernal pool and adjacent grassland habitats. A total of 90 permanent plots were established on three SRVRS properties (Cramer, FEMA and Haroutunian), marked, sampled and treated. Five blocks at each site included 2 habitats (coastal prairie uplands and vernal pool/swale margin) and each habitat-sub-block (5 X 30 m) had 3 treatment plots; control, mowed with phytomass removal (Mr), and mowed without phytomass removal (mulched - Mm). We tested the hypothesis that seasonal mowing with phytomass removal reduces annual grass cover and thus improves habitat quality in the long-term for native plants, especially those of conservation interest. This treatment could work by depleting soil nitrogen levels (a disadvantage for non-native annual grasses with low nitrogen use efficiencies), improving soil surface microenvironment (e.g. light, temperature), and prolonging soil moisture for native species that are more nitrogen-use efficient. We also collected phytomass and soil chemistry data during Fall 1999 and Spring 2000 in all 90 plots.

One year after a single experimental treatment there were several significant changes observed in the composition and structure of SRVRS vegetation. These few significant changes in % native cover, % cover by certain taxa, standing phytomass, and soil chemistry were generally in the right direction, of sufficient magnitude, and consistent with our operational ecosystem model. At this early stage we feel guarded but encouraged about mowing and phytomass removal for improving habitat quality for native plants.

Dominant species richness was the same in control and treatment plots within each habitat. When plant cover was analyzed by overall quality or by management guild, there were no significant treatment effects, nor were there any consistent trends, detected in the margin habitat. There were some significant treatment effects and consistent trends detected in the upland habitat, especially at the hydrologically-similar Cramer and Haroutunian properties. Treatment tended to increase cover by native species in the uplands, especially with Mr treatment. At Cramer there was also a significant, corresponding decrease in nitrate, suggesting that non-native graminoids favored high nitrate soils. Mr treatment decreased cover by the non-native *Lolium multiflorum* in the upland habitat at two of the three properties. The trend toward decreasing cover by this high priority target may reflect a dependence on high nitrate soils and a sensitivity to nitrate depletion by Mr treatment. The lack of response in the margin habitat may reflect greater abundance of availability of nitrate in margin soils. Native grasses responded to Mr treatment by increasing cover at the same two properties. These preliminary trends support the supposition that native graminoids have a higher nitrogen-use efficiency than non-native graminoids .

We found no response of VPC taxa to treatment at this time. Dispersal is probably limiting intra-pool distributions, while seed bank quality is probably limiting the strength of response to treatment. The significant, positive correlation between the densities of *Limnanthes vinculans* and *Lasthenia glabberima* suggests a lack of competition among some forbs of the margin habitat and may portend similar responses to restoration treatment (i.e. what favors one also favors the other).

When margin and upland plots were initially mowed and mulched (Mm), the standing phytomass was reduced by approximately 65% and shifted to thatch, with no reduction in total phytomass. When plots were mowed and raked, standing phytomass was reduced by 65%, thatch remained equivalent to controls, but total phytomass was significantly reduced by about 50%. These treatment-induced changes were consistent across all properties in fall 1999 and largely the result of shifting graminoid material.

Treated plots in 2000 had the same amounts of total, graminoid and dicot phytomass as control plots regardless of habitat and property. Only the thatch fraction was significantly reduced, especially in Mr plots of the margin. Otherwise, the treatments did not constrain productivity after one year of treatment. The observed taxon-specific changes in cover could be in response to the reductions in thatch, either because of its impacts on nutrient availability (e.g. less thatch, less nitrogen available) or because of its impacts on soil surface microenvironment for germination (e.g. less thatch, more light, higher temperature, greater moisture penetration).

Baseline soil chemistry data confirmed several essential features of our operational ecosystem model. First, organic matter, organic C, total nitrogen, ammonium nitrogen and nitrate nitrogen were all significantly higher in the margin habitat than in the upland across all properties. Second, high nitrate concentrations were positively and significantly correlated with high cover by non-native graminoids. Cover by native graminoids appeared to have a negative relationship with nitrate concentrations. Differences between properties were mostly small and insignificant. Finally, mowing and raking can deplete soil nitrate, but not in the margin soils after one year.

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INTRODUCTION

The first goal of the Santa Rosa Vernal Reserve System is to develop management prescriptions for improving the habitat quality of native plant populations, especially those of conservation interest. Such prescriptions require data collected using scientific approaches and statistical analyses of outcomes. For example, an experiment designed to uncover limitations on population growth by implementing practical manipulations of habitat quality can be a very effective tool for reintroducing a species or enhancing its abundance or distribution (Pavlik 1994, Sutter 1996, Guerrant and Pavlik 1998). Treatment variables (e.g. controlled fire, selective herbicides) are chosen according to the best available information for the taxa or habitat in question. Field observations, greenhouse studies, or inference from related ecosystems, provide testable hypotheses for the first round of experimental trials. These initial choices may only provide incomplete data sets for restoring a target population or community, but the experiments will provide new information and identify additional variables or treatments to test in subsequent trials. Restoration is, therefore, an iterative process that benefits from "failure" as well as "success" (Pavlik 1996) and requires a long-term commitment to do the experimental data collection required for developing management prescriptions.

During the first phase of this project (Pavlik et al. 1998) we met three major objectives. First, we integrated CDFG properties into a single, scientifically-based planning, management and public service system. Biological, logistical and security information was collated into a database, using CDFG file records, property acquisition documents, California Natural Diversity Database (CNDDB) records, and all available "gray literature", supplemented with field visits. We then suggested a system of short-term management regimes that would help organize and prioritize restoration activities. Each property was placed in one of four categories (experimental, ecosystem enhancement, intensive care or quiescent) to guide management decisions over the next 5 to 10 years. Finally, we designed an initial management experiment to provide practical prescriptions for maintaining plant species richness and ecosystem integrity with respect to vernal pools and swales.

The second phase of this project (Pavlik et al. 2000) provided a quantitative description of baseline vegetation at three SRVRS properties (Cramer, FEMA and Haroutunian). A total of 360 samples (720 subsamples using a bipartite quadrat) were collected from 15 pools or swales and included bottom, margin and upland habitats. The samples were used to provide species composition and structural data that could help focus restoration efforts on the most important target taxa. We also installed the first management experiment (using 90 permanent plots in two habitats on three properties) to determine the effects of mowing and phytomass (mostly graminoid) removal. Mowing with phytomass removal (i.e. hay baling) is a practical, potentially profitable management tool that could improve native vegetation and water quality while reducing fire hazard in many wildland areas of the state. It was chosen as the first treatment to be tested because it is easiest to do logistically (compared to replicated, meso-scale controlled burns or grazing) and because others have reported benefits to native grasses and vernal pool plants (Danielsen 1996, Muller *et al.* 1998, Collins et al. 1998, J. Menke pers. comm. 9/98, M. Waaland pers. comm. 5/98) throughout the state. Anecdotal evidence suggests that local mowing on a regular basis (e.g. Sonoma County Airport) minimizes annual grass cover and favors populations of native plants, especially *Lasthenia burkei* (Pavlik et al. 1998).

This report describes the first year responses to mowing and phytomass removal treatments within 90 permanent plots on the Santa Rosa Plain, including the following major components: 1) Measurement of post-treatment vegetation responses to mowing with mulching (Mm) and mowing with phytomass removal (Mr). Point frames were used to document cover dominants, supplemented with quadrat-based estimates of absolute cover, density and frequency for vernal pool characteristic (VPC) taxa, including the federally-endangered *Limnanthes vinculans.* The objective is to detect shifts in plant cover from non-native to native (for dominant species) and from sparse to abundant (for rare species). 2) Quantitative description of how Mm and Mr treatments affect phytomass and soil chemistry after treatment (Fall 1999) and after the first growing season (Spring 2000). 3) An initial set of recommendations regarding Mm and Mr treatments for restoring vernal pool and swale vegetation on the Santa Rosa Plain. Appendices to this report give additional information on sampling techniques, the raw data on vegetation, phytomass and soils, and a review of potential partners for the long-term management of the SRVRS

OPERATIONAL MODEL

Current efforts to preserve the vernal wetlands of the Santa Rosa Plain must compensate for the effects of fragmentation, degradation, and invasion on biological diversity, even after preserves have been established. For example, populations of *Limnanthes vinculans* and *Lasthenia burkei* have apparently declined by several orders of magnitude at the Todd Road Reserve (Figure 1 in Pavlik et al. 2000) after removal of domestic livestock and no active vegetation management. *L. burkei* may be effectively extirpated from the site (B. Guggolz, pers. comm. 5/98). Invasive Mediterranean grasses and other weedy plants could be responsible (Patterson *et al.* 1994), especially when they develop dense, competitive swards in the absence of grazing or periodic fire. Light- to moderate-levels of grazing and low-intensity burns are generally thought to favor the maintenance of high native species richness in grasslands around the globe (Meurk *et al.* 1989, Parker 1989, Rosentreter 1994, Schlising 1996, Fensham 1998, Muller *et al.* 1998, Davison and Kindscher 1999). But these management techniques are becoming difficult to implement in a rapidly suburbanizing landscape. Mowing has also been shown to favor native perennial grasses over exotic annuals in California (Danielsen 1996) and to increase species diversity in the chalk grasslands of France (Fensham 1998). Hence, we have chosen to investigate the use of mowing and phytomass removal as ecologically sound and practical manipulations for shifting plant cover from exotic to native (for dominant species) and from sparse to abundant (for rare species).

How will mowing affect changes in vegetation quality? Mowing with phytomass removal in late spring could favor perennial grasses in margin and upland habitats by collecting and removing a high proportion of this year's crop of annual grass and weed seed (e.g. *Lolium*). Perennial grasses will also be cut and have seeds removed, but established individuals should have improved growth and/or survivorship over the first summer (higher soil moisture) and next growing season (higher light, soil moisture).

Removal of phytomass could also lower available soil nitrogen, thus favoring species with high nitrogen-use efficiency (e.g. native perennial grasses) over species with low nitrogen-use efficiency (often non-native annuals, Claassen and Marler 1998). We speculate that more than a century of eutrophication has occurred across the Santa Rosa Plain because of agricultural inputs, sewage water discharge and atmospheric deposition. Transport of nutrients, especially nitrogen, by water would promote growth of plants with high nitrogen requirements (and low nitrogen-use efficiency). This could differentially affect pools, swales and their margins where non-native grasses invade and come to dominate in the absence of grazing. Depletion of nitrogen, either by removal with phytomass or promotion of denitrifying bacteria could possibly shift the "competitive balance" back towards a higher diversity of less aggressive plant species (Wedin and Tilman 1996, Choi and Pavlovic 1998). Lowering annual grass cover and competition in the upland could also allow the spread of native margin plants because adjacent soils would be relatively moister and the canopy more open. To the extent that annual grasses are also mowed in the upper part of the margin, direct competition with rare annuals such as *Limnanthes vinculans* and perennials, such as *Pleuropogon,* will be reduced and native plant growth could be improved. Removal of material that adds to the thatch and inhibits germination of annuals in the margins may also benefit the natives, but could possibly benefit annual weeds as well.

The mowing treatments attempt to indirectly manipulate soil nitrogen levels. We suppose that during the first year after mulching the germination of all annuals, both native and non-native could be inhibited, leading to a short-term decrease in *Limnanthes vinculans*, as well as *Avena, Lolium* and other non-native grasses. If the native seed bank is any more long-lived than that of the non-natives, the native seeds should persist. However, mulching will provide a readily-decomposed, immediate carbon source for soil bacteria, including denitrifiers. The population of denitrifying bacteria should grow and effectively compete with the plants for available soil nitrogen and eventually release it to the atmosphere (Keller and Friese 1998). Thus, the soil should have reduced availability of nitrogen, putting annual plants in drier (e.g. upland) habitats at a disadvantage relative to perennials. This could eventually retard the growth of non-natives, and open the canopy to native perennials. If vernal pool characteristic (VPC) species, such as *Limnanthes vinculans* are adapted to more open, low-nitrogen soils, they should benefit from lower competition microsites that lack high nitrogen and aggressive non-native grasses.

We see a clear need for site-specific management prescriptions that mitigate the effects of fragmentation, disruption, degradation, and invasion, and thus enhance conditions that conserve native plant species richness and ecosystem integrity within the SRVRS. Our operational model attempts to link management techniques (e.g. mowing, mowing with phytomass removal) with ecosystem functions (e.g. productivity, nitrogen availability) and the maintenance of biological diversity (e.g. population performance of rare plants, structure of natural vegetation).

METHODS AND MATERIALS

First-Year Results of the Primary Restoration Experiment: Effects of Mowing and Phytomass Removal on Vegetation Composition

Description of the Listed Plants of the SRVRS

A total of nine plant taxa of conservation concern are known from ephemeral wetlands of the Santa Rosa Plain (CH2MHill 1995, taxonomy follows Hickman 1993). These include three state and federally-listed endangered species (*Blennosperma bakeri* - Sonoma sunshine, *Lasthenia burkei* - Burke's goldfields, and *Limnanthes vinculans* - Sebastopol meadowfoam), one state endangered and federally-proposed endangered subspecies (*Navarretia leucocephala* ssp. *plieantha* - many-flowered navarretia) and five uncommon and unlisted taxa (*Downingia pusilla* - dwarf downingia, *Navarretia leucocephala* ssp. *bakeri* - Baker's navarretia, *Perideridia gairdneri* ssp. *gairdneri* - Gairdner's yampah, *Pogogyne douglasii* var. *parviflora* - Douglas's pogogyne, and *Ranunculus lobbii* - Lobb's aquatic buttercup). Of these, all but two (Gairdner's yampah and Lobb's aquatic buttercup) could potentially benefit from restoration of pool and swale margin habitat (the yampah and buttercup utilize grassland and aquatic habitats, respectively). The main focus of these restoration efforts, however, will be the three listed plants, emphasizing the most abundant and evenly distributed; *Limnanthes vinculans* (see Pavlik et al. 2000 for additional descriptions of the species and their habitats).

Selection and Description of Experimental SRVRS Properties

Three SRVRS properties were chosen to represent a broad range of habitat qualities found on the Santa Rosa Plain; Cramer (174 acres, relatively unaltered pool and swale system, mostly diverse native vegetation), FEMA (69 acres, hydrologically altered pools and swales, extensive weed cover), and Haroutunian (30 acres, unaltered swale system, mix of native and weed cover). All are located on Wright clay-loam soils and have supported multiple *Limnanthes vinculans* (Sebastopol meadowfoam) subpopulations (see Pavlik et al. 2000 for additional descriptions of the properties).

Design and Establishment of a Block Design

A randomized block design was selected for this first restoration experiment because of the anticipated ecological heterogeneity, both natural and anthropogenic, among selected SRVRS properties. Power analysis was performed for three properties having equal quantities of blocks (Holmes 1998, T. Holmes, pers. comm. 2 Feb 1999). In order to detect a treatment effect of 0.39 with at least 80% power (Type I error rate = 5%, the probability of missing a difference between treatments and controls when there was one, Type II error rate = 20%, the probability of falsely concluding there was a difference between treatments and controls when there was none), a minimum of four blocks would be needed per property. The treatment effect could be reduced to 0.33 with five blocks and to 0.26 with six. Given the large effort needed to perform the sampling, mowing, and raking, we decided to use five blocks per property (15 total), each consisting of 2 habitat sub-blocks. Consequently, our experiment on three properties using five blocks each will be able to detect a 33% difference between control and treatments with a Type I error rate of 5% and a Type II error rate of 20% (power = 80%).

An individual block was a single vernal pool or vernal swale locality, each encompassing a margin sub-block (the apparent edge of vernal pool or swale vegetation) and an upland sub-block (coastal prairie). Block locations were determined by assigning numbers to every pool or swale feature on a wetlands delineation map for each property. We excluded numbered pools/swales in areas that had less than 50% live cover during 1997 and 1998, such as corrals, holding paddocks, barn areas, pavement, and compacted road beds. Random numbers were then used to select a subset of numbered pools/swales for block locations.

The start location for establishing a block *in situ* used a random number between one and four (inclusive) that corresponded to a quarter of a circle (for a pool) or a quarter of the total linear dimension (swale). During field work in mid-April 1999, a marking stake was established by blindly tossing a survey arrow behind the back within the pre-determined quarter. From the arrow a path perpendicular to the pool/swale margin was established (Figure 1). A 2 foot section of 2" white PVC pipe was driven into the wet (low) end of the path, at a point that centered the pool margin vegetation (at least 50% cover by wetland species, especially *Pleuropogon californicus*) within a 5 m width (presumably the perennial vegetation integrates variations in water level from year to year). This permanently marked point is hereafter referred to as the "initial boundary" of the block. Another PVC pipe was driven in at the 5 m (upslope) point. A meter tape pulled parallel to the margin for 90 meters delineated the pool margin strip (= sub-block) of the block. The upland portion was another 5 X 90m strip, marked with PVC, at least 5 m from the upper edge of the margin and usually (but not always) parallel to it. The upland strip could deviate from the 5 m spacing in order to avoid wet depressions and maintain its grassland character. Within each margin or upland strip, 0.5 m along all edges was designated as a buffer zone to be treated but not sampled for vegetation, phytomass or soil characteristics.

Mowing and Phytomass Removal

Each 5 X 90 m margin or upland strip within a given block contained three 5 X 30 m long plots that were randomly assigned one of three treatments; 1) an unmowed control (C), 2) mowed with clippings left as mulch (Mm), and 3) mowed and raked to remove the clippings from the plot (Mr). A Bauchtold 8 horsepower "Whipper" (Chicago, Illinois), with a 24" cut width and a 3" cut height was used to mow the entire 5 X 30m Mm and Mr plots on seven days between 25 June and 22 July 1999. The machine was self-powered, lightweight, and fit with large diameter, narrow tires that had no apparent effect on the soil surface (i.e. no compaction or erosive spinning). In general, a single passage of the mower was sufficient to cut down all plant cover, whether it be dense pockets of *Juncus*, thick swards of grass, or tall stems of *Dipsacus*. Missed or partially-cut spots were, however, mowed again to ensure consistency across all plots. The blade was disengaged manually so the mower could be run throughout control plots without cutting. An extra can of fuel was usually required to finish all plots on a single property and gloves and safety glasses were essential for protection of the operator. A factory-installed spark arrester apparently did a very good job (considering the amount of surrounding dry grass), but we also made sure the blade avoided hitting rocks and other hard objects.

Immediately after mowing, a light gauge leaf rake was used to remove cut phytomass from the Mr plots. The material was moved towards the downwind (usually north) edge of the plot, where it was lifted and dispersed across adjacent, untreated areas at least 1 m away. Gray, unrooted thatch from the previous year was also raked away, but only if it could be moved with little disturbance to the soil surface. Care was taken to ensure evenness of raking among and within blocks. Raking was by far the most time-consuming and arduous part of the treatment process. A total of 80 person-hours was required to mow and rake all 15 blocks on all properties.

Post-Treatment Vegetation Sampling

At each of the three properties, the post-treatment vegetation in the plots was sampled in two habitat zones; the pool/swale margin, and the upland (the term "pool" will be used herein to refer to both pool and swale features). We defined the pool margin as the sloping edge zone adjacent to the pool bottom, submerged during early to mid-spring (February to early April) but dry later on. The margin tended to be the primary habitat of the perennial grass *Pleuropogon californicus* and a mixture of wetland and upland taxa. The upland habitat was found on the undulating hillocks between pools and was never submerged in water. It supported coastal prairie or valley oak woodland, dominated by a grassy mixture of exotic annuals (e.g. *Lolium multiflorum* and *Bromus hordeaceus*) and natives (e.g. *Vulpia octoflora* and *Danthonia californica*).

All field assistants received advanced training or had expertise in the identification of plants and vegetation sampling (see Appendix A). We conducted on-site recognition drills each morning new assistants arrived at a property. These activities included quizzes on fresh material and examination of variations in our field herbaria. Quizzes were repeated until all responses were correct. In addition, we assembled the plot frames and practiced sampling to ensure similar, high levels of competency among the assistants. At the end of each sampling day we again conducted quizzes to check identifications and make any necessary corrections to data sheets.

A team of two trained field assistants (a reader and a writer) was assigned a block to sample, each with upland and margin strips containing three plots each (control (C or Con), mowed-mulched (Mm) and mowed-raked (Mr)). Teams were instructed to approach the strips carefully so as not to step into them before sampling. A measuring tape (50 or 100 m length) was staked with its 0 m mark at the upslope pvc marker (at the initial boundary) for the margin strip. Walking on the outside of the strip, a team member laid the tape taut using other pvc stakes or colored flags to carefully define the upslope edge.

Plot maps were double checked to determine if the first 30m plot of the margin was a control, Mm or Mr plot. The writer removed the proper set of preprinted datasheets (Appendix B) from a property notebook and secured them to a clipboard. The writer told the reader the position and upper/lower designation on the datasheet (filled out ahead of time using a set of random numbers), beginning with the lowest position number (e.g. 7 m). The reader carried a 10-pin, pvc sampling frame along the upper plot edge and located the position (e.g. 7 m) on the tape. If the designation was U (upper), then the frame was carefully set into the plot a short distance (0.75 m) from the tape (marked with a knot on the locator string). If the designation was L (lower), then the frame was set into the plot 1.5 m from the tape (end of the knotted locator string). The line of vertical pins were perpendicular to the tape and all pins (each 1.0 mm in diameter) were initially raised. The reader always entered and stood in the plot on the side of the frame facing the lowest position numbers (e.g. 6 m side, not the 8 m side) so that unsampled vegetation was not disturbed.

Beginning with the upslope pin (# 1, the one furthest from the pool), the reader slowly lowered it until it made first contact with a leaf, stem, or flower. The reader called out the scientific name of the species contacted and the writer recorded its four letter abbreviation (e.g. *Limnanthes vinculans* is recorded as LIVI in the data slot for pin #1). If there was wind, the reader waited until she or he could determine which leaf/flower would be touched if there was no motion. If the species could not be identified, the writer could ask a roving expert, or designate it as unknown "A". In case of the latter, the writer took a complete specimen, taped it to a blank unknown card and labeled it. The same "name" was used throughout the team's sampling and the specimens were kept until collected as a voucher for later identification or cross-checks between teams. If the pin hit bare ground the record was "BARE" and if it hit thatch or wood it was recorded as "THAT". Fallen leaves resting on the canopy were removed and the pin trajectory was maintained until contact. This was repeated for all 10 pins in the subsample.

If the area between the legs of the pin frame contained any rooted vernal pool characteristic (VPC) taxa (e.g. *Limnanthes vinculans, Blennosperma bakeri, Pogogyne douglasii* ssp. *parvifolia, Downingia concolor,* and Lasthenia *glabberima*), a 0.5 m^2 pvc quadrat was used to provide additional information on their density and cover. If there were only a few, scattered VPC individuals inside the quadrat, all were counted and total % cover was visually estimated for each species. If there were many individuals, a representative 10% of the quadrat was selected (its area was marked on the quadrat for reference) for count and cover estimates.

When a subsample was finished the downslope locator string was stretched and the pin frame positioned to get the second subsample (pins 11-20) for that position along the upper edge. All steps were repeated and the frame moved to the next position along the tape. A total of 10 positions (20 subsamples) were used per plot. Before moving to the other two plots in the margin habitat and the other three plots in the upland habitat, the writer would check to see that all data sheets were filled out completely before returning them to the property notebook. All unknown vouchers were sealed in bags until all teams met at the end of the day to cross-check names and to be retested on identification of all species encountered. Corrections to datasheets, if any, were made immediately to ensure the highest possible consistency among teams.

A total of 18,000 pin "hits" were recorded in the spring of 2000 (3 properties X 5 blocks/property X 2 habitats/block X 3 plots/habitat X 20 subsamples/plot X 10 pin hits/subsample. Field sampling occurred at the apparent peak of vegetative growth and during maximum floral display of most plant taxa. Haroutunian was sampled by 5 teams in two full days (16-17 May), Cramer by 6 teams in 3 days (21-23 May) and FEMA by 6 teams in 3 days (24-25 May and 1 June), for a total of 688 person-hours in the field.

<u>Data Handling and Analysis</u>

A relational database for the Santa Rosa Vernal Reserve System was constructed to hold vegetation and rare plant data gathered with the pin-point sampling method. Based on this sampling method, the database was constructed to record each hit separately by using the four letter taxon name abbreviation. A data entry form mirrored the field data sheets to simplify data-entry. It took a team of two people approximately 30 hours each to enter and quality check the data.

The database was designed using Microsoft Access to reduce repetitive entry and storage of complex information. Access employs multiple, single topic tables that can be linked to create data entry forms, complex queries, and allows for additional fields to be added to the database in the future. The database currently contains eight separate tables of which only two contain field data. The other six are "look-up tables" used to track characteristics of each species, site, pool, and property. The two data entry tables are for cover (TBLCOVER) and density (TBLDENSITY). The six look-up tables include habitat (TBLKHABITAT), pool (TBLKPOOL), property (TBLKPROP), species (TBLKSPECIES), treatment (TBLTREAT), and location (TBLLOCATION).

We queried the database for data summaries by asking for pin hits of species stratified according to property, block, habitat, and treatment. This "first cut" would allow computation of live relative cover (% of 200 total hits, Mueller-Dombois and Ellenberg 1973) for a given species in each of the 90 permanent plots (e.g. % cover by *Limnanthes vinculans* in the Mr plot of the margin habitat in block 2 at Cramer). The measurement of live relative cover (referred to as "cover" in this report) using a point frame is widely regarded as the most consistent and objective method available (Barbour et al. 1980). Species richness was determined by tallying the number of taxa per site or habitat regardless of how many pin hits each represented. Often the point frame method might not detect low-growing and extremely sparse taxa that are recorded in ocular quadrats by observant field botanists. Therefore, we distinguish species richness estimates from point frame data as SR_d (species richness by canopy dominants). Both cover and SR_d data were exported into Microsoft Excel for statistical analysis by creating a "worksheet" for each property. We also entered the quadrat data for density, absolute cover (live) and frequency data for VPC's and calculated another set of abundance indicators.

The stratified analysis presented in this report never combines data from different habitats. Properties are kept separate because each has different initial vegetation and hydrological features (see above) that would result in differential responses to treatment. This is also true for blocks within each property, some of which lack seed banks of target species (e.g. *Limnanthes vinculans*) and could not be expected to produce target species cover within the first year regardless of treatment (i.e. dispersal is limiting). Therefore, the probability of having a statistically-significant, across-property response to treatment, or even a significant across-block response is low at this early stage of our restoration experiment. We believe that similar trends within and between properties constitute some evidence of treatment effects and so the analysis and display of this first-year data will emphasize the search for such trends. It begins with 1) species richness of canopy dominants, then 2) determines the proportion of canopy cover that is contributed by native taxa (a measure of vegetation quality), 3) further divides cover into four "management guilds" (non-native graminoids, non-native forbs, native graminoids and native forbs), 4) displays the cover by taxon (the 14 taxa that contribute >80% of the total relative cover), and 5) ends with the quadrat-based estimations of density, absolute cover, and frequency by VPC taxa.

Effects of Mowing and Phytomass Removal on Post-treatment Phytomass and Soil Chemistry

Above ground phytomass samples were collected in each plot (C, Mr, Mm) during the fall of 1999 prior to the onset of major winter rains (October-November) and in late spring-early summer 2000 after vegetation sampling (May to June). The 1 m^2 PVC frames (0.5 x 2 m) were placed at two positions along the top edge (long) of each plot: 1

m downslope at the 8 m position, and 2 m downslope at the 23 m position. A total of 180 phytomass samples were thus collected in the fall and in the spring: 2/plot X 3 plot/habitat X 2 habitats/block X 5 blocks/property X 3 properties. Canopy height was estimated in the two halves of each frame by randomly dropping a petri dish on a string and measuring the distance between the dish center and the firm soil surface.

Most of the phytomass was removed by clipping (usually 2-4 cm above the soil) and sorted into three categories; standing, thatch, and dicot. Phytomass rooted within the frame was considered standing if it was yellow (1998-1999 production) and attached to the roots. Any plant material that was unattached to the roots (it was often gray) was considered thatch. The majority of standing and thatch material was composed of grasses or graminoids (e.g. *Juncus*) so that all broadleaf forbs and windborne leaves (e.g. *Quercus*) constituted the dicot fraction. The phytomass fractions were put in separate, labeled paper bags taken back to the lab and dried to constant weight in a warm room at 40°C.

Soil samples were taken next to each frame at the time of phytomass sampling. FEMA and Haroutunian samples were taken in October before any measurable precipitation, but Cramer samples were collected in November during the first few inches of seasonal rain. They were taken as cylindrical cores (5 cm deep, 5 cm diameter) using a bulb planter driven into the soil surface. The two cores from each plot were combined into a single ziplock bag (n = 90 with pooled subsamples), labeled and sealed. They were immediately taken back to the lab and refrigerated (4°C). Within a month 100-150 g was frozen (-20°C) in a labeled ziplock bag and the remainder of the sample was air dried (5-7 days if wet, 2 days if drier) and then stored at room temperature in a dry, dark cupboard. Dried samples were taken to the DANR Analytical Laboratory at U.C. Davis for analysis of organic matter (% dry weight), organic carbon (% dry weight), total nitrogen (% dry weight), ammonium nitrogen (ppm) and nitrate nitrogen (ppm).

RESULTS

First-Year Results of the Primary Restoration Experiment: Effects of Mowing and Phytomass Removal on Vegetation Composition

Dominant Species Richness

Dominant species richness (SR_d) was greatest in the pool margin plots (Table 1), averaging about 13 taxa/plot regardless of property or treatment. There was no consistent effect of either treatment (Mm or Mr). In the upland plots, SR_d averaged 10 taxa/plot and did not show any consistent response to treatment. A total of 49 taxa were recorded by pin hits in the margin habitat (24 of which were native (49%)), compared to 40 (17 native (42%)) in the upland (for all three properties combined, see Appendices C and D).

Canopy Cover by Native Taxa (Vegetation Quality)

Native taxa contributed an average of 34% of the cover in margin plots (Table 2) and 26% in upland plots on the three properties. There was no apparent treatment effect in margins when values for all properties or the two most hydrologically similar properties (Cramer and Haroutunian) were combined. In the uplands, however, there was a progressive increase in native species cover (control to Mm to Mr plots) when all properties were combined (nonsignificant, $P<0.14$, ANOVA) and when Cramer and Haroutunian were combined (significant, $F=4.74$, $P<0.04$, ANOVA). Upland Mr plots averaged 44% more native cover than control plots with all properties combined and 77% more for Cramer and Haroutunian combined.

When properties were considered separately, pool margins at Cramer had the lowest and most consistent native cover among treatments. Still, there were no patterns or significant differences with treatments in this habitat at any property. But the upland response to treatment was most pronounced at Cramer, where native cover was increased 46% by mowing (Mm) and 100% with mowing and raking (Mr, $F = 5.87$, $P<0.04$, ANOVA). No pattern or significant differences were seen in uplands at FEMA or Haroutunian.

Analysis by Management Guild

Grouping the 14 most dominant taxa from each habitat into four "management guilds" allows a non-specific analysis of treatment effects. The "non-native graminoid" guild contributed the largest proportion (39-60%) of the margin habitat cover at all properties (Table 3), and was usually twice as large as the "native graminoid" proportion. The exception was at FEMA where the two guilds were nearly equal, owing to the large contributions of native *Juncus* spp. and *Eleocharis* spp. (see next section). The "native forb" guild contributed only about 3% of the margin cover. There was no apparent pattern or significant differences among management guilds of the margin habitat with respect to treatment at this time.

The proportion of the "non-native graminoid" guild for upland habitat was greater (42-75%) compared to margin habitat, while large variations in the "native graminoid" and "non-native forbs" categories occurred. The proportion of cover contributed by the "native forb" guild fell below 5% overall. Management guilds of the upland habitat, however, showed consistent decreases in non-native graminoids in response to treatment at Cramer and Haroutunian, with nearly corresponding increases in native graminoids. For example, non-native graminoids declined from 65 to 42 % and native graminoids increased from 25 to 49% at Cramer. At FEMA there were notable decreases in non-native forbs and increases in native graminoids in Mr plots, but trends were not consistent or statistically significant.

Taxon-Specific Responses

Margin Habitat

The non-native graminoid guild in the margin habitat was dominated by *Lolium multiflorum* at all three properties (Table 4), contributing more than 90% of the cover within the guild and over 40-60% of the cover of all species. The only other taxon to achieve a level of 5% cover in this guild was *Polypogon maritimus* at FEMA. Among the non-native forbs cover was more evenly shared at a level of 6% or below. *Convolvulus arvensis* was present in most plots on all properties with 1-5% cover, while *Mentha pulegium* was abundant only at FEMA (3-6%). Higher ranges of cover (up to 20%) were documented among the native graminoids, led by *Juncus phaeocephalus* and *Pleuropogon californicus*. These two taxa were especially abundant at FEMA, as was *Eleocharis macrostachya*. The only native forb with more than 3% cover was *Eryngium aristulatum*, with *Limnanthes vinculans* always below 1%. Thatch cover was usually 2-4%, but got as high as 7% at Haroutunian. Raw vegetation data (pin hits for all taxa and thatch) and plot-specific cover data (for taxa with >1% cover and thatch) are contained in Appendices D and E, respectively.

There were no consistent or significant trends of margin taxa in response to treatment. Weak patterns, perhaps better developed in the future, include decreases of mean cover of *Convolvulus arvensis* and *Dipsacus fullonum* at FEMA in Mm and Mr plots compared to controls, decreases of mean cover of *Vulpia octoflora* at Haroutunian in Mm and Mr plots compared to controls, increases of mean cover of Vulpia *octoflora* at Cramer in Mm and Mr plots compared to controls, and increases of mean cover of *Pleuropogon californicus* at Haroutunian in Mm and Mr plots compared to controls. In general, thatch cover decreased with mowing and raking at all properties relative to controls.

Upland Habitat

The non-native graminoid guild in the upland habitat was also dominated by *Lolium multiflorum* at all three properties (Table 4), contributing more than 70% of the cover within the guild and over 35-65% of the cover of all species. Three other taxa in the guild added more than 5% cover (*Avena barbata, Bromus diandrus,* and *B. hordeaceus*), but only at Haroutunian. Non-native forb cover was more evenly shared among taxa at a level of 6% or less, with one exception. *Vicia sativa* (mostly ssp. *sativa*) contributed up to 25% cover at FEMA. *Convolvulus arvensis* was present in all plots on all properties with 1-3% cover, while *Dipsacus fullonum* was abundant only at FEMA (1-6%). Higher ranges of cover (up to 39%) were documented among the native graminoids, led by *Vulpia octoflora* and *Danthonia californica* These two taxa were especially abundant at Cramer and least abundant at FEMA. The only native forb with greater than 1% cover was *Chlorogalum pomeridianum* at FEMA. Thatch cover was usually 0.5-1%, but reached 4% at FEMA.

There were four taxa in the uplands that demonstrated consistent, nearly significant, responses to treatment (Figures 2 and 3). Mowing and removal reduced Lolium *multiflorum* cover to 36% from 57% at Cramer ($F = 4.63$, $P<0.06$, ANOVA Mr vs. control, respectively) and to 39% from 65% at Haroutunian ($F = 3.45$, $P<0.10$, ANOVA Mr vs. control, respectively). The Mm treatment produced intermediate or equivalent reductions. There was no apparent pattern at FEMA. Conversely, mowing and removal increased *Danthonia californica* cover to 9% from 0.4% at Cramer ($F = 6.47$, $P<0.04$, ANOVA Mr vs. control, respectively) and to 7% from 2% at Haroutunian ($F = 2.60$, $P<0.15$, ANOVA Mr vs. control, respectively). Similarly, *Vulpia octoflora* cover increased to 39% from 24% at Cramer and to 18% from 14% at Haroutunian (Mr vs. Control, respectively). The *Vulpia* trends, however, were less pronounced due to higher variability in the estimates. *Vicia sativa* cover increased to 25% from 10% at

FEMA (F = 9.93, P<0.06, ANOVA Mr vs. control, respectively). Weak patterns, perhaps better developed in the future, include decreases of mean cover of *Convolvulus arvensis* and *Dipsacus fullonum* at FEMA in Mm and Mr plots compared to controls, and increases of mean cover of *Avena barbata* and *Bromus diandrus* at Haroutunian in Mm and Mr plots compared to controls. In general, thatch cover did not show any consistent response to treatments.

<u>Quadrat-based Assessments of VPC Taxa</u>

Density, absolute cover and frequency of *Limnanthes vinculans, Blennosperma bakeri, Downingia concolor*, and *Lasthenia glabberima* (the VPC, vernal pool characteristic, taxa) were highest at Cramer, followed by FEMA and Haroutunian (Table 5). Block 1 at Cramer had no VPC taxa and appeared to be almost devoid of vernal wetland taxa in general (e.g. *Juncus phaeocephalus, Eryngium aristulatum*). Block 4 had no VPC occurrences in our samples, even though both *L. vinculans* and *Pogogyne douglasii* ssp. *parviflora* were present (the latter in pool bottom habitat). FEMA had either *Limnanthes vinculans* or *Lasthenia glabberima* in samples from all blocks, whereas Haroutunian had no occurrences of the former in any samples (but the three other VPC taxa were present in samples from blocks 4 and 5). In general, the ranges of density and cover were great (0-260 plants/m2, 0-22% absolute live cover) and included large variations around mean estimates. Density counts and visual estimates of absolute cover were poorly correlated (r=0.40, P< .30) for *Limnanthes vinculans* and *Lasthenia glabberima* (data not shown).

There was no obvious or consistent pattern of treatment effects on quadrat-based measures of VPC abundance. Peak density values, however, were never associated with control plots at Cramer (0/20 times, 5 control plots X 4 VPC taxa), occurring instead in Mm or Mr plots without consistent pattern. This was also true at Haroutunian (but no samples contained any *Limnanthes vinculans* in any treatment), but at FEMA peak density values were associated with control plots occasionally (4/20 times). There were also significant correlations between densities of *Limnanthes vinculans* and *Lasthenia glabberima* at Cramer and FEMA (r>0.70, P<0.01) with treatments pooled (Figures 4 and 5).

Effects of Mowing and Phytomass Removal on Post-treatment Phytomass and Soil

Characterizing the First Treatment (1999)

Prior to the onset of seasonal rains in the fall of 1999, mowed-mulched plots (Mm) in the margin habitat had significant amounts of their standing phytomass (graminoid and dicot fractions) shifted to thatch when compared to controls at all three sites (Figure 6). Mm thatch was, on average, twice that found in control plots (170.4 $\pm$ 13.3 vs. 90.7 $\pm$ 13.3 g m^{-2}, P < 0.01, ANOVA). Total phytomass was reduced (P< 0.06, ANOVA), probably because of haphazard removal by wind during the dry July to October post-cut period. Mow-raked plots (Mr) had significantly reduced total phytomass (including graminoid and dicot fractions) and similar amounts of thatch when compared to controls, indicating that raking removed about 48% of the standing crop on average. Similar patterns were observed in the upland habitat, with Mm plots with standing graminoid phytomass shifted to thatch, and Mr plots with significant removal of total phytomass (about 45%, mostly graminoid).

Site-specific patterns generally conformed to those described above (graphs for all properties and habitats presented in Appendix F). Control plots in the margin habitat at Cramer had the lowest amount of total phytomass of all three properties (251.8 $\pm$ 86.7 g m^{-2}, mean $\pm$ SE). Mowing and mulching (Mm) significantly reduced the standing graminoid fraction and shifted it to thatch (with presumed removal by wind). Mowing and raking (Mr) significantly reduced total phytomass (104.9 $\pm$ 77.2 g m^{-2}) and the graminoid and dicot fractions without increasing the thatch fraction relative to controls. Control plots at Haroutunian had the highest amount of total phytomass of all three properties (390.9 ± 48.8 g m^{-2}). The Mm treatment significantly reduced the standing graminoid fraction and shifted it to thatch (with presumed removal by wind). Treatment in Mr plots significantly reduced total phytomass (205.5 ± 43.7 g m^{-2}) and the graminoid fraction without increasing the thatch fraction relative to controls. Control plots at FEMA had intermediate total phytomass in the margin plots (271.2 ± 35.8 g m^{-2}). Mm plots had significantly reduced graminoid and dicot fractions, most of which was shifted to thatch. Mr plots reduced total phytomass (almost significantly, $P < 0.06$) and the graminoid fraction, again without increasing the thatch fraction relative to controls.

In the upland habitat, the site-specific patterns were virtually the same as in the margin (also Appendix F). Control plots at Cramer and FEMA had similar amounts of total phytomass (about 300 g m^{-2}) while Haroutunian had significantly more (410 ± 43.0 g m^{-2}). Mm plots had the standing graminoid fraction shifted to thatch (usually a doubling relative to controls, but not always significantly) and Mr plots removed the graminoid fraction and significantly reduced total phytomass (usually by 45-50%).

Phytomass Production in Spring 2000

Comparison Between Control Plots in 2000 and 1999

Phytomass in control plots of the margin habitat tended to increase in 2000 relative to 1999, but there was a dependence upon site-specific factors (Table 6 and Appendix G). Consistent increases were observed in the graminoid fraction, averaging 66% higher in spring 2000 (100% higher at Haroutunian) than in 1999. Graminoids accounted for 52-85% of the total phytomass, depending on site (highest proportions at FEMA) and year (highest in 2000). Standing dicot phytomass did not significantly change between the two years and remained below 20% of the total at all sites. Thatch, however, was uniformly lower by an average of 49% (79% lower at Cramer) and contributed 12-38% of the total phytomass. Overall, total phytomass at Cramer and FEMA was statistically equivalent between the two years, but increased by 56% at Haroutunian.

In the upland habitat there were also consistent increases in the graminoid fraction, averaging 80% higher in spring 2000 (113% higher at Haroutunian). Graminoids accounted for 36-80% of the total phytomass, depending on site (highest proportions at FEMA) and year (highest in 2000).Standing dicot phytomass did not significantly change between the two years and remained below 26% of the total at all sites. Thatch, however, was uniformly lower by an average of 47% (79% lower at Cramer) and contributed 16-62% of the total phytomass. Overall, total phytomass at all three sites was statistically equivalent between the two years, with a small increase (23%) at Haroutunian.

Treatment Effects in Spring 2000 Phytomass

There was one significant treatment effect on phytomass produced during the winter and spring of 1999-2000. Thatch was significantly reduced in Mr plots in both habitats and in Mm plots of the upland ($P<0.01$, ANOVA). The reduction in Mr plots of the margin was greatest (a loss of 81% relative to controls), leaving only 7.2 ± 2.7 g m^{-2} on the ground. The reduction in Mr plots of the upland was 62%, leaving 21.0 ± 8.2 g m^{-2} on the ground. Total, graminoid and dicot phytomass in margin and upland habitats were not altered by either Mm or Mr treatments (Figures 8 and 9, sites combined).

Only a few site-specific patterns were significantly affected by treatment. At Cramer, significant reductions in thatch occurred in both the Mm and Mr plots of the margin, but not in the upland (see Appendix G for graphs of all properties and habitats).

There was some stimulation of total and standing graminoid phytomass in both habitats relative to controls, but it was not significant. At Haroutunian the reduction in thatch was significant only in Mr plots of the upland habitat. Otherwise, no other consistent effects could be detected at any of the three sites.

Soil Chemistry, Fall 1999

Baseline soil chemistry prior to the onset of winter rains indicated that there were usually no significant differences between treatment blocks within a single habitat on a single property (Table 7, Appendix H). At Cramer, there was no significant treatment effects with respect to organic matter content, organic C, total Kjeldahl nitrogen, ammonium or nitrate in the margin habitat. Upland soils at Cramer, however, had lower quantities of all soil components relative to the margin, and there was a significant decline in nitrate levels in Mm and Mr plots. At FEMA, there were no differences within or between habitats and no consistent trends in soil components, which tended to be at lowest levels overall. Haroutunian margin soils were more similar to Cramer than to FEMA, with corresponding levels of organic matter, carbon, nitrogen, ammonium and nitrate. Haroutunian upland soils had intermediate levels of nitrate.

Given the overall lack of significant property differences, data were pooled to allow comparisons of treatments within the two habitats (n=5 for each soil component). Mean values showed no consistent or significant trends among treatments, although Mr plots in the margin always had the highest values (Table 8). In contrast, control plots in the uplands always had the highest values. If treatment data were combined, however, every soil component of the margin habitat had significantly higher values ($P<0.001$, ANOVA) than those of upland habitat.

Soil chemistry data were also used to conduct an initial search for correlations with vegetation characteristics. Only nitrate values (for fall 1999) within each habitat (means for a treatment at property) had a wide range that appeared to vary by treatment at least at one property (Cramer, Table 7), so it was chosen as the independent variable. Native cover values (spring 2000 means for a treatment at a property, Table 2) and management guild values (means for a treatment at a property, Table 3) were chosen as the dependent variables. A significant, positive correlation ($P<0.05$, $n = 9$ with properties combined) was found between nitrate and cover by non-native graminoids in the margin habitat (Figure 10). Similar data for the uplands appeared to fall on a different curve, but the correlation was not significant at this time. No significant relationships were detected between nitrate and mean % native cover, % non-native forbs, % native forbs or % native graminoids, but the latter had a nearly significant ($P<0.07$), negative curvilinear slope for the margin habitat (Figure 11).

DISCUSSION

One year and one growing season after a single experimental treatment there were some significant changes observed in the composition and structure of vegetation at these three properties of the Santa Rosa Vernal Reserve System (SRVRS). Further data collection will reveal trends but it is, after all, unrealistic to expect that more than a century of hydrological and biological alterations could be reversed by a single application of an experimental restoration method. However, the few significant changes we did detect in % native cover, % cover by certain taxa (e.g. *Lolium multiflorum*, *Vulpia octoflora* and *Danthonia californica*), standing phytomass, and soil chemistry demonstrated the early indications of a vegetation shift in the right direction (e.g. from non-native towards native), of sufficient magnitude (e.g. a doubling of native cover in upland Mr plots at Cramer), and consistent with our operational ecosystem model (e.g. upland soils with less nitrate which could be depleted by treatment, and shifted towards native species cover at Cramer). We feel guarded but optimistic and encouraged at this early stage about our attempts to use mowing and phytomass removal for improving habitat quality in the SRVRS.

Dominant species richness (SR_d, that which is detected by point-frame sampling) was the same in control and treatment (mow-mulched, Mm and mow-raked, Mr) plots within each habitat. Plots from the margin habitat averaged 13 taxa/plot, while those from the upland habitat averaged 10 taxa/plot, regardless of property (Table 1). Across all three properties, a total of 49 taxa registered pin hits in the margin compared to 40 in the upland, both of which compared well with species richness in the previous year (44 vs. 41, respectively) obtained from ocular estimates of cover from fewer total quadrat samples (Table 1 of Pavlik et al. 2000). This suggests that despite differences in what is being measured by point frames and ocular quadrats (Mueller-Dombois and Ellenberg 1973), our sample size and technique can produce an overall similar result from the standpoint of detecting the presence of rare and common taxa, as well as taxa with very different growth forms (e.g. tall and erect vs. short and prostrate).

When plant cover was analyzed by overall quality (% native cover) or by management guild (% cover by non-native graminoids, native graminoids, non-native forbs, and native forbs), there were no significant treatment effects, nor were there any consistent trends, detected in the margin habitat (Tables 2 and 3). Non-native graminoids were strongly dominant in our samples this year, with two or three-times the cover detected by ocular quadrats in 1999 (Table 4 of Pavlik et al. 2000). This could be the result of a different ecological response between the two years (i.e. promoted by differences in temperature patterns or hydrology), or it could be the result of differences in sampling techniques that especially affect estimates of cover. Future point frame sampling (planned for the spring of 2002) will allow us to analyze which scenario is most likely. There were some significant treatment effects and consistent trends detected in the upland habitat, especially at the hydrologically-similar Cramer and Haroutunian properties. Treatment tended to increase cover by native species in the uplands, especially with phytomass removal. This was largely due to a decline in non-native graminoids and an increase in native graminoids. At Cramer, there was also a significant, corresponding decrease in nitrate (Table 7), suggesting that non-native graminoids favored high nitrate soils (discussed below).

Taxon-specific responses to treatment were best observed in the upland habitat among grasses with high relative cover. Mowing with phytomass removal decreased cover by the non-native *Lolium multiflorum* at two of the three properties, although the differences were not statistically significant ($P<0.10$) at this time (Figures 2 and 3). The trend toward decreasing cover by this high priority target (Pavlik et al. 2000) may reflect a dependence on high nitrate soils and a sensitivity to nitrate depletion by phytomass removal. The lack of response in the margin habitat may reflect greater abundance or availability of inorganic nitrogen in margin soils (Table 8). The native grasses *Danthonia californica* and *Vulpia octoflora* , however, responded to mowing with phytomass removal by increasing cover at the same two properties (sometimes significantly). These preliminary trends support the hypothesis that native graminoids have a higher nitrogen-use efficiency than non-native graminoids (Figures 10 and 11). Native and non-native forbs did not have any significant responses or trends with respect to treatment or levels of soil nitrate, except that the nitrogen-fixing *Vicia sativa* increased cover in Mr plots at FEMA.

We found no response of VPC taxa to treatment at this time. Control plots tended to have the lowest density of *Limnanthes vinculans* and *Lasthenia glabberima*, but mowed-mulched and mowed-raked plots often had no occurrence or statistically equivalent densities (Table 5). The could indicate that dispersal is limiting intra-pool distributions or that seed banks were spatially heterogeneous among plots prior to treatment (i.e. there is no treatment response for lack of propagules). The significant, positive correlation between the densities of these two ecologically-similar taxa (Figures 4 and 5) is interesting because it suggests a lack of competition within forbs of the margin habitat and is important because it may portend similar responses to restoration treatment (i.e. what favors one also favors the other). If so, *Lasthenia glabberima* may be an excellent surrogate for the rare *Lasthenia burkei* which does not occur in our plots.

When margin and upland plots were mowed and mulched, the standing phytomass was reduced by approximately 65% and shifted to thatch, with insignificant losses to wind (Figures 6 and 7). Therefore, total phytomass remains about the same as in control plots. When plots were mowed and raked, standing phytomass was reduced by 65%, thatch remained equivalent to controls, but total phytomass was significantly reduced by about 50%. These treatment-induced changes were consistent across all properties and largely the result of shifting graminoid material (Appendices F and G). Consequently, we are confident that mowing-mulching and mowing-raking can cause significant, distinctive and easily repeatable effects on the distribution of standing phytomass, and by inference, on the distribution of phytomass-bound mineral nutrients.

A comparison of standing phytomass in control plots indicated that total phytomass was equivalent between 1999 and 2000 in both habitats at most of the properties (Table 6). Total rainfall in these two years was exactly the same (66.3 cm by 30 March), with minor differences in seasonal distribution. Graminoid production, however, was at least 65% greater in 2000 while thatch was about 50% lower in both habitats. We speculate that 1999 graminoid production was constrained by the large amount of residual grass thatch from the 1998 El Nino rainfall event (200% of annual precipitation). The persistent thatch delayed germination and growth until mid-spring of 1999 (less than 5% live cover with 95% thatch observed on 30 March 1999). It is also likely that undecomposed thatch retained mineral nutrients making them unavailable for plant growth. By 2000 this thatch was largely degraded, allowing a germination response in fall and vigorous growth of the grasses in winter.

Treated plots in 2000 had the same amounts of total, graminoid and dicot phytomass as control plots regardless of habitat and property. Only the thatch fraction was significantly reduced, especially in Mr plots of the margin (-80%). Otherwise, the treatments did not constrain productivity after one year of treatment. The observed taxon-specific changes in cover (e.g. decreases in *Lolium multiflorum*, increase in *Vulpia octoflora* and *Danthonia californica*) could be in response to the reductions in thatch, either because of its impacts on nutrient availability (e.g. less thatch, less nitrogen available) or because of its impacts on soil surface microenvironment for germination (e.g. less thatch, more light, higher temperature, greater moisture penetration).

Baseline soil chemistry data confirmed several essential features of our operational ecosystem model. First, organic matter, organic C, total nitrogen, ammonium nitrogen and nitrate nitrogen were all significantly higher in the margin habitat than in the upland across all properties (Table 8). This would support the supposition that high nutrient availability (especially nitrogen) is promoting phytomass production to the detriment of nitrogen-use efficient native taxa of the vernal pool and swale habitat. Second, high nitrate concentrations were positively and significantly correlated with high cover by non-native graminoids, presumably with low nitrogen-use efficiency (Figure 10). Cover by native graminoids appeared to have a negative relationship with nitrate concentrations (Figure 11), and while the relationship was not statistically significant it could signal an incipient trend. Third, differences between properties were mostly small and insignificant, although Cramer and Haroutunian most closely resembled each other and FEMA was the outlier (Table 7). In general, FEMA is altered hydrologically compared to the other two properties, with dikes and drains that affect several pools and swales. Finally, mowing and raking can deplete soil nitrate. It is possible that November rains stimulated microbial decomposition of thatch and promoted rapid nitrification (ammonium to nitrate) and some denitrification prior to sampling. We did not detect depleted nitrate levels in margin soils where baseline levels were higher and more variable. Additional data from spring 2000 and subsequent years will help to develop these patterns.

SUMMARY AND MANAGEMENT RECOMMENDATIONS

1) One year after a single experimental treatment there were some significant changes observed in the composition and structure of SRVRS vegetation. The significant changes we did detect in % native cover, % cover by certain taxa, standing phytomass, and soil chemistry were generally in the right direction, of sufficient magnitude, and consistent with our operational ecosystem model. At this early stage we feel optimistic and encouraged about mowing and phytomass removal for improving habitat quality for native plants.

The treatments and monitoring should, therefore, be continued in subsequent years to allow responses to temporal and spatial environmental variation.

2) Dominant species richness was the same in control and treatment plots within each habitat. Plots from the margin habitat averaged 13 taxa/plot, while those from the upland habitat averaged 10 taxa/plot, regardless of property. Despite differences in what is being measured by point frames and ocular quadrats, our sample size and technique produced an overall similar result by detecting the presence of rare and common taxa and taxa with very different growth forms.

3) When plant cover was analyzed by overall quality or by management guild, there were no significant treatment effects, nor were there any consistent trends, detected in the margin habitat. There were some significant treatment effects and consistent trends detected in the upland habitat, especially at the hydrologically-similar Cramer and

Haroutunian properties. Treatment tended to increase cover by native species in the uplands, especially with phytomass removal (Mr). At Cramer, there was also a significant, corresponding decrease in nitrate, suggesting that non-native graminoids favored high nitrate soils.

Additional treatments and/or more time are required to lower nitrogen levels in the margin habitat and produce the corresponding shift in cover towards native guilds.

4) Mowing with phytomass removal decreased cover by the non-native *Lolium multiflorum* in the upland habitat at two of the three properties. The trend toward decreasing cover by this high priority target may reflect a dependence on higher soil nitrogen, particularly nitrate, and a sensitivity to inorganic nitrate depletion by mowing with phytomass removal (Mr). The lack of response in the margin habitat may reflect greater abundance of availability of nitrogen in margin soils. Native grasses responded to mowing with phytomass removal by increasing cover at the same two properties. These preliminary trends support the supposition that native graminoids have a higher nitrogen-use efficiency than non-native graminoids .

5) We found no response of VPC taxa to treatment at this time. Dispersal is probably limiting intra-pool distributions, while seed bank quality is probably limiting the strength of response to treatment. The significant, positive correlation between the densities of *Limnanthes vinculans* and *Lasthenia glabberima* suggests a lack of competition within forbs of the margin habitat and may portend similar responses to restoration treatment (i.e. what favors one also favors the other). If so, *Lasthenia glabberima* may be an excellent surrogate for the rare *Lasthenia burkei* which does not occur in our plots.

6) When margin and upland plots were mowed and mulched (Mm), the standing phytomass was reduced by approximately 65% and shifted to thatch, with no reduction in total phytomass. When plots were mowed and raked, standing phytomass was reduced by 65%, thatch remained equivalent to controls, but total phytomass was significantly reduced by about 50%. These treatment-induced changes were consistent across all properties and largely the result of shifting graminoid material. Consequently, we are confident that mowing-mulching and mowing-raking can cause significant, distinctive and easily repeatable effects on the distribution of standing phytomass, and by inference, on the distribution of phytomass-bound mineral nutrients.

7) We speculate that 1999 graminoid production was constrained by the large amount of residual grass thatch from the 1998 El Nino rainfall event. The persistent thatch delayed germination and growth until mid-spring of 1999. It is also likely that release of mineral nutrients (e.g. nitrate) from decomposing thatch was also delayed or inhibited and were unavailable for plant growth. By 2000 this residual thatch was largely decomposed, allowing a germination response in fall 1999 and vigorous growth of the grasses in winter.

8). Treated plots in 2000 had the same amounts of total, graminoid and dicot phytomass as control plots regardless of habitat and property. Only the thatch fraction was significantly reduced, especially in Mr plots of the margin. Otherwise, the treatments did not constrain productivity after one year of treatment. The observed taxon-specific changes in cover could be in response to the reductions in thatch, either because of its impacts on nutrient availability (e.g. less thatch, less nitrogen available) or because of its impacts on soil surface microenvironment for germination (e.g. less thatch, more light, higher temperature, greater moisture penetration).

9) Baseline soil chemistry data confirmed several essential features of our operational ecosystem model. First, organic matter, organic C, total Kjeldahl nitrogen, ammonium nitrogen and nitrate nitrogen were all significantly higher in the margin habitat than in the upland across all properties. Second, high nitrate concentrations were positively and significantly correlated with high cover by non-native graminoids. Cover by native graminoids appeared to have a negative relationship with nitrate concentrations. Differences between properties were mostly small and insignificant. Finally, mowing and raking can deplete soil nitrate, but not in the margin soils after one growing season.

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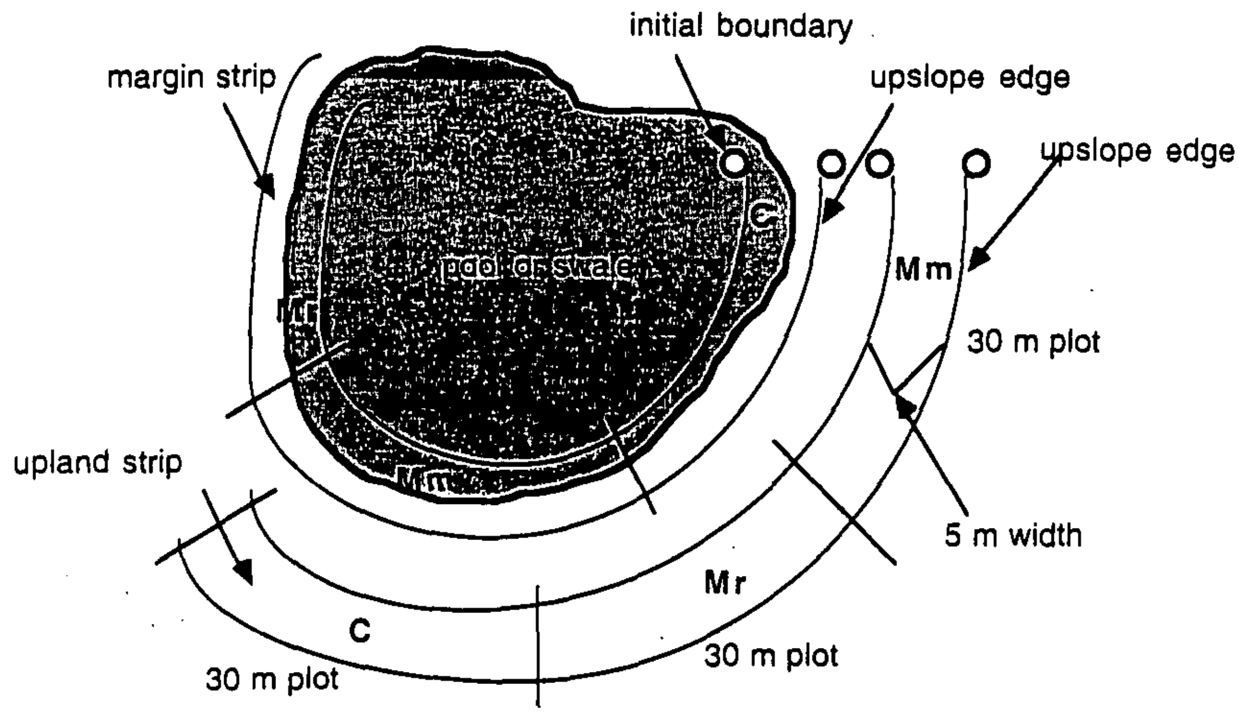


Figure 1. Block design for a vernal pool consisting of two habitat strips (pool margin and upland) each 90 m long. Position of the initial boundary was randomly assigned and each treatment (C= control, Mm= mowed and mulched, Mr=mowed and raked) was randomly assigned.

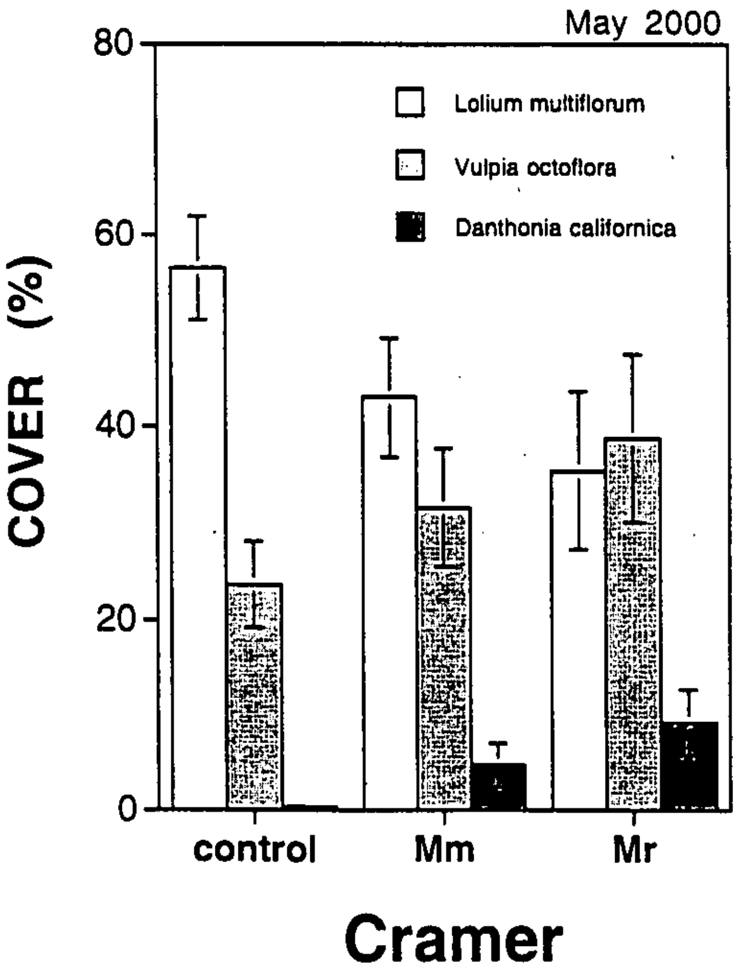


Figure 2. Effects of mowed-mulched (Mm) and mowed-raked (Mr) treatments on point-frame estimates of cover by one non-native (*Lolium multiflorum*) and two native (*Vulpia octoflora* and *Danthonia californica*) grasses in the upland habitat at the Cramer property, Spring 2000.

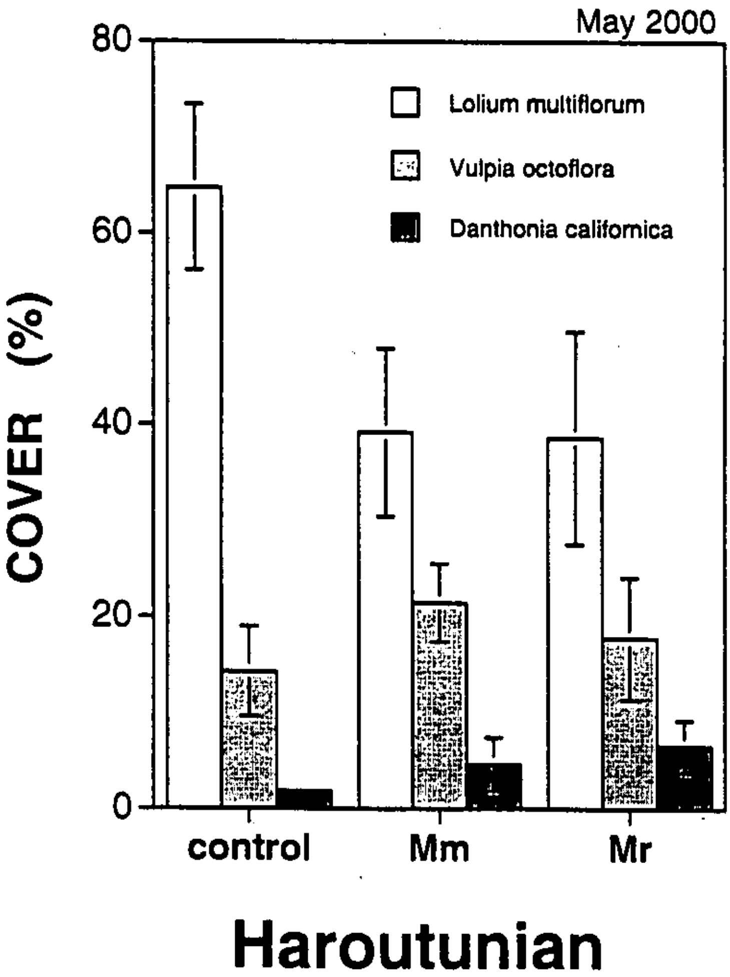


Figure 3. Effects of mowed-mulched (Mm) and mowed-raked (Mr) treatments on point-frame estimates of cover by one non-native (*Lolium multiflorum*) and two native (*Vulpia octoflora* and *Danthonia californica*) grasses in the upland habitat at the Haroutunian property, Spring 2000.

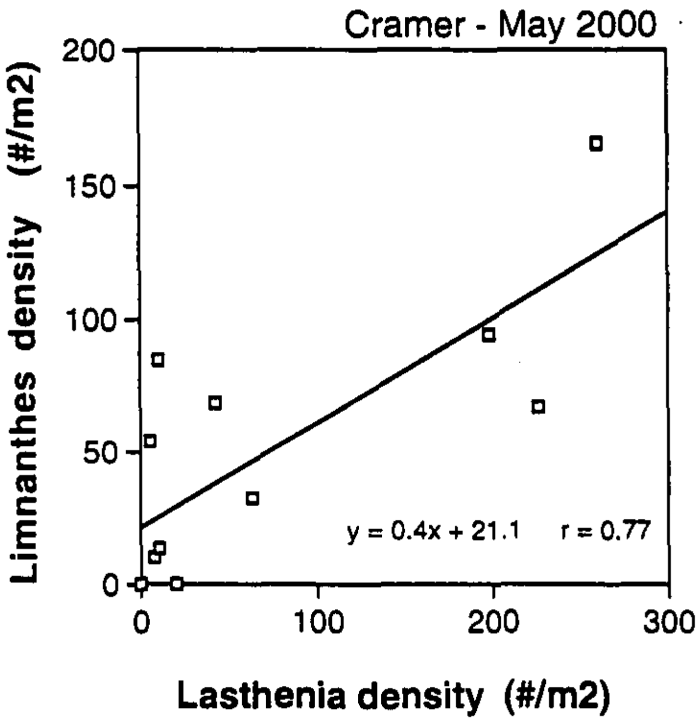


Figure 4. Correlation of densities of two vernal pool characteristic (VPC) species (*Lasthenia glabberima*, common and *Limnanthes vinculans* , rare) in the margin habitat at the Cramer property, Spring 2000. Correlation is significant at $P < 0.05$.

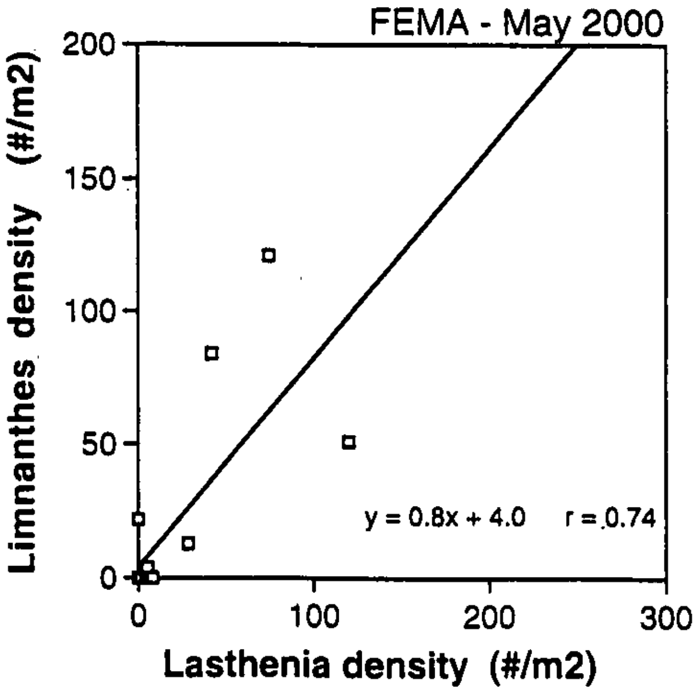


Figure 5. Correlation of densities of two vernal pool characteristic (VPC) species (*Lasthenia glabberima*, common and *Limnanthes vinculans* , rare) in the margin habitat at the FEMA property, Spring 2000. Correlation is significant at $P < 0.05$.

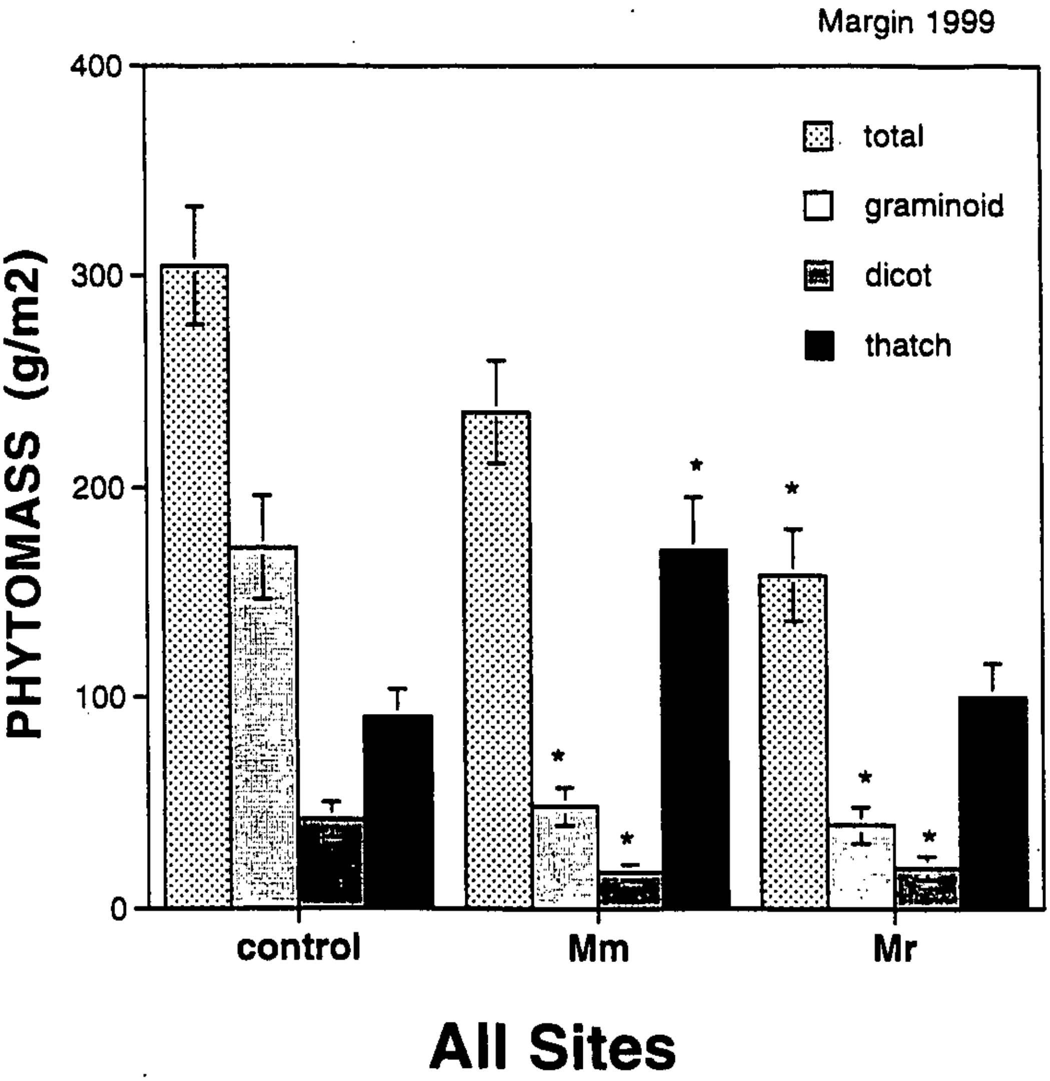


Figure 6. Effects of mowed-mulched (Mm) and mowed-raked (Mr) treatments on 4 categories of phytomass (total, graminoid, dicot and thatch) in the margin habitat for all three properties (Cramer, FEMA and Haroutunian) combined, Fall 1999 (post-treatment, prior to onset of winter rains). * = significantly different from the same control fraction ($P < 0.05$, ANOVA).

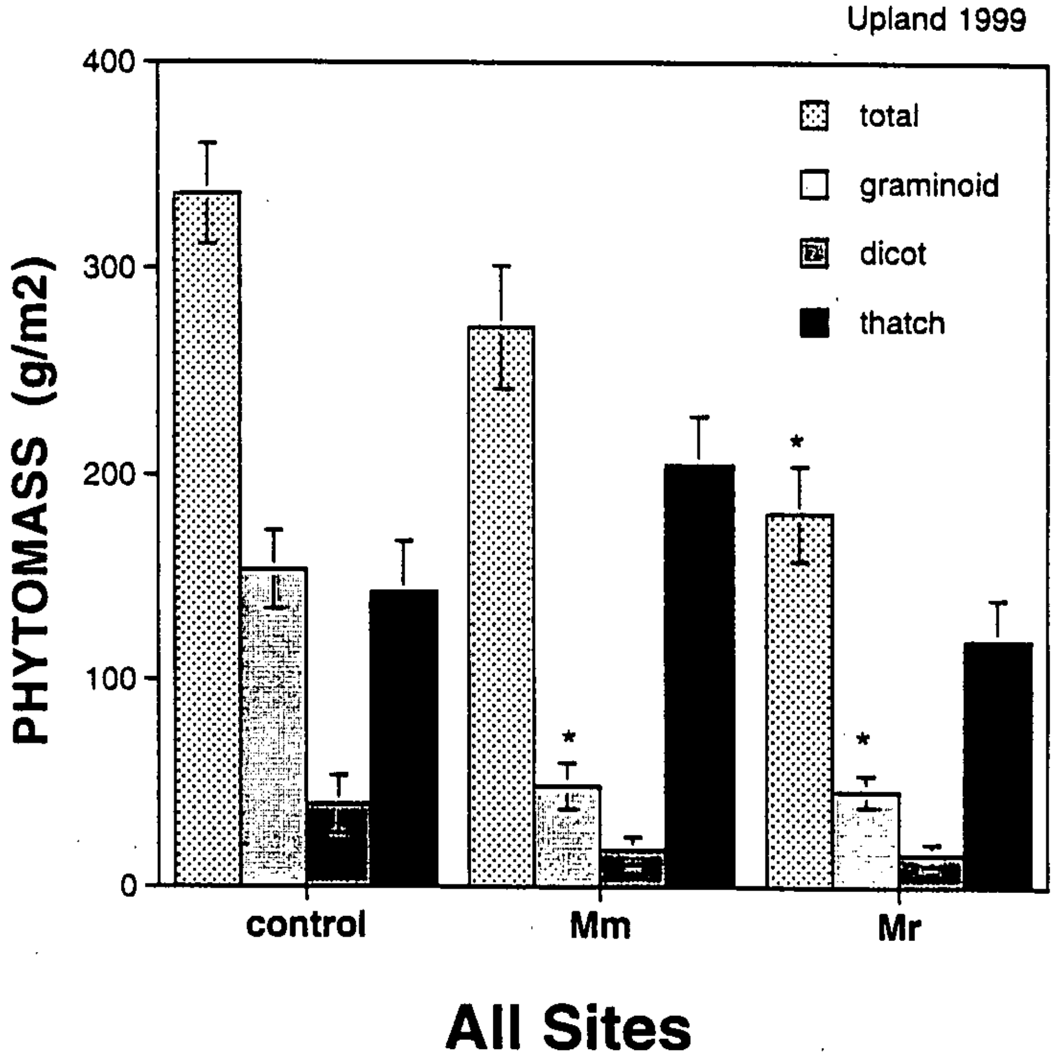


Figure 7. Effects of mowed-mulched (Mm) and mowed-raked (Mr) treatments on 4 categories of phytomass (total, graminoid, dicot and thatch) in the upland habitat for all three properties (Cramer, FEMA and Haroutunian) combined, Fall 1999 (post-treatment, prior to onset of winter rains). * = significantly different from the same control fraction ($P < 0.05$, ANOVA).

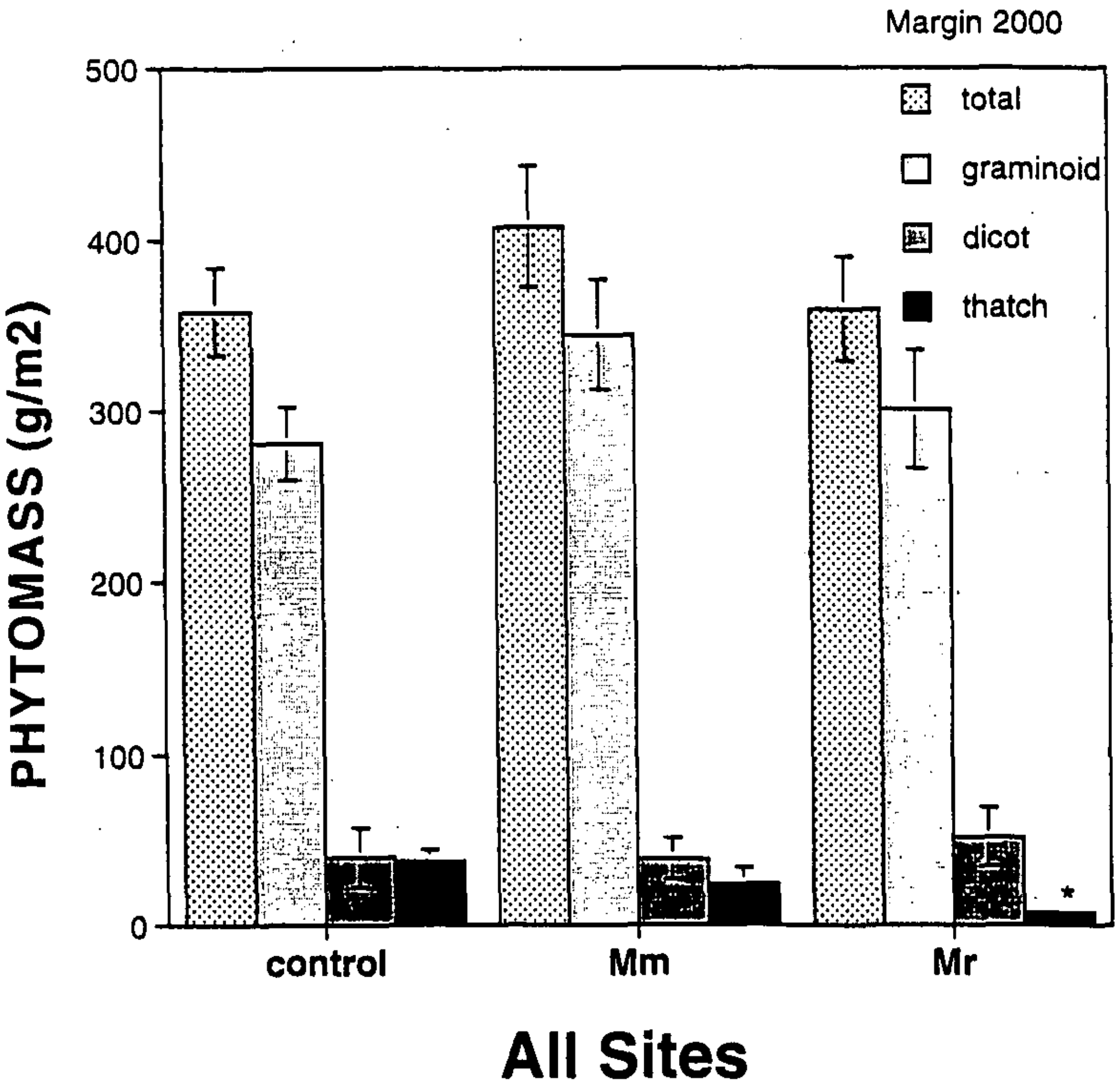


Figure 8. Effects of mowed-mulched (Mm) and mowed-raked (Mr) treatments on 4 categories of phytomass (total, graminoid, dicot and thatch) in the margin habitat for all three properties (Cramer, FEMA and Haroutunian) combined, Spring 2000 (post-growing season). * = significantly different from the same control fraction ($P < 0.05$, ANOVA).

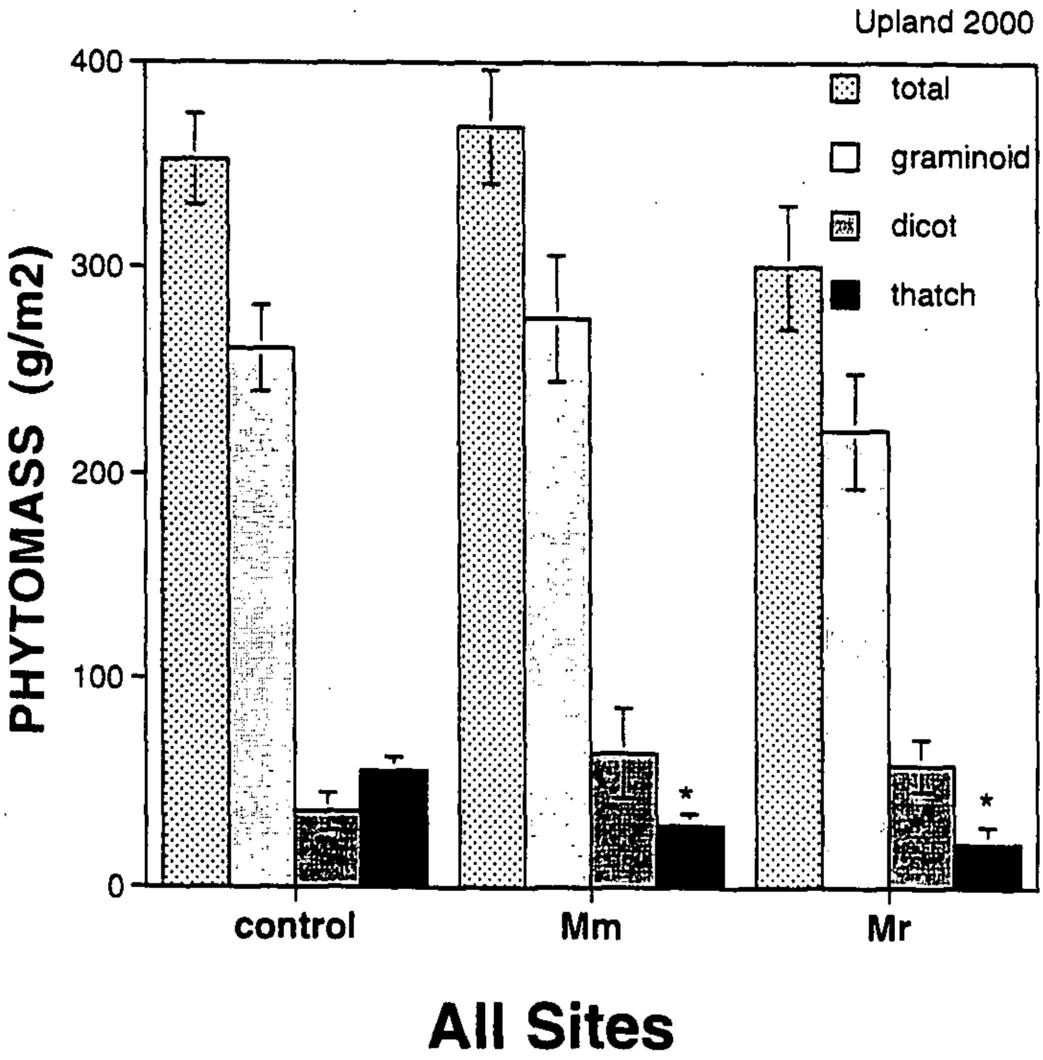


Figure 9. Effects of mowed-mulched (Mm) and mowed-raked (Mr) treatments on 4 categories of phytomass (total, graminoid, dicot and thatch) in the upland habitat for all three properties (Cramer, FEMA and Haroutunian) combined, Spring 2000 (post-growing season). * = significantly different from the same control fraction ($P < 0.05$, ANOVA).

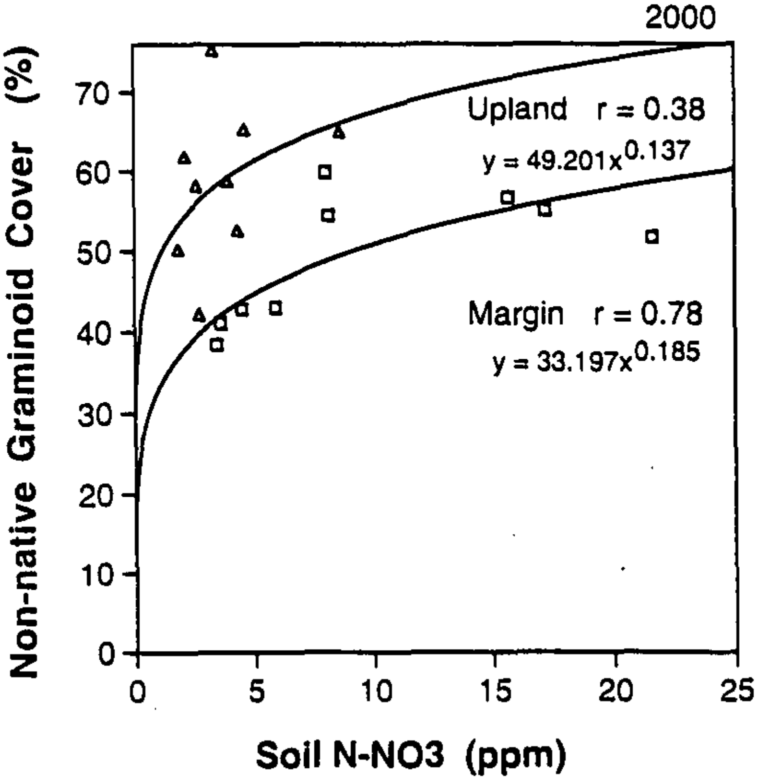


Figure 10. Correlation of soil nitrate (Fall 1999) and cover of non-native graminoids (spring 2000) in the margin habitat (treatment means kept separate by habitat and property, n = 9 for each line). Correlation for the margin habitat) is significant at P < 0.05.

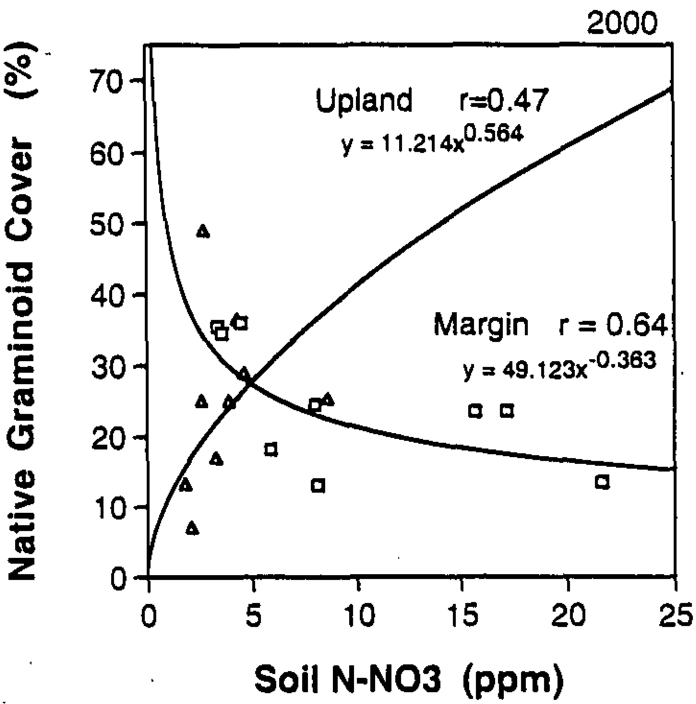


Figure 11. Correlation of soil nitrate (Fall 1999) and cover of native graminoids (spring 2000) in the margin habitat (treatment means kept separate by habitat and property, n = 9 for each line). Correlations not significant.

Table 1. Dominant species richness (SRd) within two habitats (margin and upland) on three properties (Cramer, FEMA and Haroutunian) of the SRVRS, May 2000. Treatments (control, Mm, Mr) were made in June and July, 1999. Mean and standard errors shown (n=5, 1000 pin hits), all = properties combined for each treatment (n=15, 3000 hits).

margin

	Cramer	SE	**FEMA**	SE	**Hart**	SE	**All**	SE
control	12.0	1.0	13.2	1.2	12.2	1.1	12.5	0.6
Mm	11.2	2.6	13.8	1.5	13.2	1.4	12.7	1.1
Mr	10.2	1.4	12.4	1.3	15.0	1.4	12.5	0.9

upland

	Cramer	SE	**FEMA**	SE	**Hart**	SE	**All**	SE
control	9.2	0.7	11.4	1.0	10.4	1.4	10.3	0.6
Mm	8.8	0.6	9.8	1.2	10.8	0.7	9.8	0.5
Mr	8.8	0.7	11.4	1.4	12.2	0.8	10.8	0.7

Table 2. Vegetation quality (% native cover) within two habitats (margin and upland) on three properties (Cramer, FEMA and Haroutunian) of the SRVRS, May 2000. Treatments (control, Mm, Mr) were made in June and July, 1999. Mean and standard errors shown (n=5, 1000 pin hits). All = properties combined for each treatment (n=15, 3000 hits). C+H = Cramer and Haroutunian combined for each treatment (N=10, 2000 hits). Values in column with a "*" are significantly different (ANOVA, P<0.05).

margin

	Cramer	SE	**FEMA**	SE	**Hart**	SE	**All**	SE	**C+H**	SE
control										
% native	26.1	8.1	40.7	9.1	29.3	3.4	32.2	4.2	28	4.2
Mm										
% native	29.7	8.9	39.1	9.6	41.4	10.4	36.7	5.3	35.6	6.7
Mr										
% native	30.1	9.3	40.6	8.8	32.7	9.2	34.5	5	31.4	6.2

upland

	Cramer	SE	**FEMA**	SE	**Hart**	SE	**All**	SE	**C+H**	SE
control										
% native	25.7*	5.3	22.0	6.9	17.5	5.0	21.7	3.2	21.6*	3.7
Mm										
% native	37.4	8.9	8.0	1.4	29.0	2.2	24.8	4.4	33.2	4.5
Mr										
% native	51.1*	9.0	16.7	4.6	25.8	6.8	31.2	5.4	38.4*	6.7

Table 3. Cover (%) by management guilds within two habitats (margin and upland) on three properties (Cramer, FEMA and Haroutunian) of the SRVRS, May 2000. Mean are shown (n=5, 1000 pin hits).

margin

	Cramer	FEMA	Hart
control			
% non-native graminoid	55.1	41.1	54.5
% non-native forb	7.3	9.9	1.1
% native graminoid	23.6	34.6	13.0
% native forb	1.1	5.1	1.3
Mm			
% non-native graminoid	59.9	38.5	43.0
% non-native forb	5.1	6.6	2.8
% native graminoid	24.5	35.5	18.2
% native forb	1.4	2.0	4.2
Mr			
% non-native graminoid	56.7	42.8	51.7
% non-native forb	2.8	9.3	1.9
% native graminoid	23.5	36.1	13.5
% native forb	3.2	4.1	3.6

upland

	Cramer	FEMA	Hart
control			
% non-native graminoid	65.0	50.2	75.3
% non-native forb	3.4	19.6	2.6
% native graminoid	25.4	13.3	17.1
% native forb	0.0	1.6	0.0
Mm			
% non-native graminoid	52.6	61.9	65.3
% non-native forb	2.6	26.0	1.8
% native graminoid	36.7	7.1	29.1
% native forb	0.0	0.0	0.0
Mr			
% non-native graminoid	42.3	58.3	58.8
% non-native forb	1.9	2.4	2.4
% native graminoid	49.0	25.2	25.2
% native forb	0.2	3.2	0.0

Table 4. Cover (%) by dominant taxa within each management guild for two habitats (margin and upland) on three properties (Cramer, FEMA and Haroutunian) of the SRVRS, May 2000. Means and SE are shown (n=5, 1000 pin hits).

Margin - control	**Cramer**	SE	**FEMA**	SE	**Haroutunian**	SE
Non-Native Graminoid						
Hordeum marinium ssp. g	0.4	0.2	0.4	0.2	2.4	0.8
Lolium multiflorum	53.5	9.1	37.8	12.5	52.1	7.7
Polypogon maritimus	1.2	1.2	2.9	1.4	0.0	
Non-Native Forb						
Convolvulus arvensis	5.0	5.0	3.7	1.9	0.7	0.3
Dipsacus fullonum	0.0		1.6	1.2	0.0	
Mentha pulegium	1.7	0.9	2.7	1.1	0.0	
Rumex crispus	0.6	0.2	1.9	0.6	1.1	0.4
Native Graminoid						
Eleocharis macrostachya	4.1	1.5	9.8	5.9	2.2	1.4
Juncus phaeocephalus	6.9	3.0	10.8	4.1	0.0	
Pleuropogon californicus	8.5	4.2	12.9	5.4	2.1	0.9
Vulpia octoflora	4.1	2.0	1.1	0.6	8.7	3.9
Native Forb						
Downingia concolor	0.0		0.0		0.2	0.2
Eryngium aristulatum	0.0		4.7	1.9	0.6	0.2
Lasthenia glabberima	0.2	0.2	0.2	0.2	0.5	0.5
Limnanthes vinculans	0.9	0.7	0.2	0.2	0.0	
Thatch	4.8	2.0	3.7	1.4	7.2	3.4

Table 4. Cover (%) by dominant taxa within each management guild for two habitats (margin and upland) on three properties (Cramer, FEMA and Haroutunian) of the SRVRS, May 2000. Means and SE are shown (n=5, 1000 pin hits).

Margin - Mm	**Cramer**	SE	**FEMA**	SE	**Haroutunian**	SE
Non-Native Graminoid						
Hordeum marinium ssp. g	0.2	0.2	0.0		2.2	1.6
Lolium multiflorum	59.5	7.8	33.5	12.9	39.8	10.0
Polypogon maritimus	0.2	0.2	5.0	2.0	0.0	
Non-Native Forb						
Convolvulus arvensis	5.1	5.1	1.3	1.1	0.8	0.4
Dipsacus fullonum	0.0		1.2	0.6	0.0	
Mentha pulegium	0.0		2.6	1.4	0.0	
Rumex crispus	0.0		1.5	0.6	2.0	1.5
Native Graminoid						
Eleocharis macrostachya	7.0	2.6	7.5	4.5	7.1	4.9
Juncus phaeocephalus	1.7	0.9	19.1	11.1	2.9	2.4
Pleuropogon californicus	10.4	6.1	4.9	2.3	5.5	3.6
Vulpia octoflora	5.4	2.7	4.0	2.3	2.7	1.4
Native Forb						
Downingia concolor	0.0		0.0		0.2	0.2
Eryngium aristulatum	0.2	0.2	1.8	0.5	4.0	2.5
Lasthenia glabberima	0.5	0.3	0.2	0.2	1.5	1.5
Limnanthes vinculans	0.7	0.4	0.0		0.0	
Thatch	2.3	1.4	2.8	1.3	3.3	1.4

Table 4. Cover (%) by dominant taxa within each management guild for two habitats (margin and upland) on three properties (Cramer, FEMA and Haroutunian) of the SRVRS, May 2000. Means and SE are shown (n=5, 1000 pin hits).

Margin - Mr	Cramer	SE	FEMA	SE	Haroutunian	SE
Non-Native Graminoid						
Hordeum marinium ssp. g	0.5	0.3	0.4	0.4	2.0	0.6
Lolium multiflorum	56.2	12.0	39.0	12.7	49.7	6.8
Polypogon maritimus	0.0		3.4	2.6	0.0	
Non-Native Forb						
Convolvulus arvensis	2.8	2.8	0.6	0.2	1.6	0.5
Dipsacus fullonum	0.0		0.2	0.2	0.3	0.3
Mentha pulegium	0.0		6.3	4.0	0.0	
Rumex crispus	0.0		2.2	1.0	0.0	
Native Graminoid						
Eleocharis macrostachya	4.9	1.6	5.6	2.6	1.4	0.6
Juncus phaeocephalus	4.8	2.7	20.4	9.5	0.4	0.2
Pleuropogon californicus	7.5	4.6	7.1	3.1	8.8	4.6
Vulpia octoflora	6.3	4.0	3.0	2.3	2.9	2.0
Native Forb						
Downingia concolor	0.0		0.0		0.2	0.2
Eryngium aristulatum	0.0		3.7	2.8	2.2	1.3
Lasthenia glabberima	2.2	1.7	0.2	0.2	1.2	1.2
Limnanthes vinculans	0.8	0.6	0.2	0.2	0.0	
Thatch	1.1	0.6	4.4	1.8	3.3	1.4

Table 4. Cover (%) by dominant taxa within each management guild for two habitats (margin and upland) on three properties (Cramer, FEMA and Haroutunian) of the SRVRS, May 2000. Means and SE are shown (n=5, 1000 pin hits).

Upland - control	**Cramer**	SE	**FEMA**	SE	**Haroutunian**	SE
Non-Native Graminoid						
Avena barbata	0.7	0.4	0.5	0.5	2.3	1.3
Briza minor	2.3	1.4	2.1	1.2	0.4	0.4
Bromus diandrus	1.0	0.5	0.2	0.2	1.8	0.8
Bromus hordeceus	3.9	1.1	2.3	1.1	5.6	1.9
Hordeum marinium ssp. g	0.6	0.4	0.0		0.4	0.2
Lolium multiflorum	56.5	5.5	43.7	5.1	64.8	8.7
Non-Native Forb						
Convolvulus arvensis	2.6	2.6	2.8	2.0	2.2	0.5
Dipsacus fullonum	0.0		6.5	3.0	0.0	
Rumex crispus	0.2	0.2	0.4	0.2	0.4	0.2
Vicia sativa	0.6	0.6	9.9	4.4	0.0	
Native Graminoid						
Danthonia californica	0.4	0.2	0.3	0.3	1.9	0.8
Hordeum brachyanthemum	1.0	0.8	0.0		0.9	0.6
Vulpia octoflora	23.7	4.5	13.0	4.4	14.3	4.7
Native Forb						
Chlorogalum pomeridianum	0.0		1.6	1.4	0.0	
Ranunculus pusillus	0.0		0.0		0.0	
Thatch	0.9	0.4	1.1	0.6	3.2	1.3

Table 4. Cover (%) by dominant taxa within each management guild for two habitats (margin and upland) on three properties (Cramer, FEMA and Haroutunian) of the SRVRS, May 2000. Means and SE are shown (n=5, 1000 pin hits).

Upland - Mm	**Cramer**	SE	**FEMA**	SE	**Haroutunian**	SE
Non-Native Graminoid						
Avena barbata	1.7	1.3	0.6	0.4	6.7	3.4
Briza minor	4.7	1.5	0.2	0.2	0.2	0.2
Bromus diandrus	0.2	0.2	1.5	0.8	11.6	4.8
Bromus hordeceus	2.4	1.2	3.3	1.2	5.8	1.1
Hordeum marinium ssp. g	0.6	0.4	2.1	1.9	1.8	1.0
Lolium multiflorum	43.0	6.1	54.2	8.9	39.2	8.7
Non-Native Forb						
Convolvulus arvensis	1.9	1.9	1.3	0.9	1.8	0.2
Dipsacus fullonum	0.0		0.3	0.3	0.0	
Rumex crispus	0.0		0.0		0.0	
Vicia sativa	0.7	0.7	24.4	5.2	0.0	
Native Graminoid						
Danthonia californica	4.8	2.3	0.6	0.4	4.7	2.8
Hordeum brachyanthemum	0.2	0.2	0.3	0.3	2.9	2.6
Vulpia octoflora	31.7	6.1	6.2	1.5	21.5	4.1
Native Forb						
Chlorogalum pomeridianum	0.0		0.0		0.0	
Ranunculus pusillus	0.0		0.0		0.0	
Thatch	1.0	0.6	0.4	0.2	0.9	0.4

Table 4. Cover (%) by dominant taxa within each management guild for two habitats (margin and upland) on three properties (Cramer, FEMA and Haroutunian) of the SRVRS, May 2000. Means and SE are shown (n=5, 1000 pin hits).

Upland - Mr	**Cramer**	SE	**FEMA**	SE	**Haroutunian**	SE
Non-Native Graminoid						
Avena barbata	1.0	0.5	0.4	0.2	6.3	1.6
Briza minor	0.4	0.2	1.0	0.5	0.4	0.2
Bromus diandrus	2.8	2.8	0.7	0.5	8.2	4.3
Bromus hordeceus	2.4	0.8	2.0	0.3	4.3	1.3
Hordeum marinium ssp. G	0.2	0.2	0.4	0.2	0.9	0.7
Lolium multiflorum	35.5	8.1	45.2	6.7	38.7	11.0
Non-Native Forb						
Convolvulus arvensis	1.9	1.9	0.9	0.7	2.2	0.6
Dipsacus fullonum	0.0		3.0	2.0	0.0	
Rumex crispus	0.0		0.2	0.2	0.2	0.2
Vicia sativa	0.0		24.7	5.0	0.0	
Native Graminoid						
Danthonia californica	9.3	3.5	0.5	0.3	6.6	2.7
Hordeum brachyanthemum	0.9	0.7	0.2	0.2	0.8	0.6
Vulpia octoflora	38.8	8.6	12.5	3.7	17.8	6.4
Native Forb						
Chlorogalum pomeridianum	0.0		3.2	2.2	0.0	
Ranunculus pusillus	0.0		0.0		0.0	
Thatch	0.4	0.4	4.0	0.2	1.1	0.5

Table 5. Quadrat-based measures of density (#/m2), cover (% abs live) and frequency (# subsample occurences/20 subsamples X 100) for VPC taxa, SRVRS, May 2000.

Cramer 5/21-23/2000		Limnanthes vinculans					Blennosperma bakeri					Downingia concolor					Lasthenia glabberima				
		Den / SE		Cov /SE		Freq	Den / SE		Cov / SE		Freq	Den / SE		Cov / SE		Freq	Den / SE		Cov /SE		Freq
Block 1	Control	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0
	Mm	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0
	Mr	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0
Block 2	Control	84.8	13.2	21.4	2.4	75	0.0		0.0		0	0.0		0.0		0	10.5	4.3	1.8	0.5	20
	Mm	68.6	7.5	22.2	4.9	65	0.0		0.0		0	0.0		0.0		0	43.1	17.5	11.1	2.7	45
	Mr	94.3	30.1	7.9	1.8	75	0.0		0.0		0	0.0		0.0		0	198.3	79.8	10.5	4.2	65
Block 3	Control	53.9	12.3	4.5	0.9	65	0.0		0.0		0	0.0		0.0		0	5.5	1.6	1.0	0.0	40
	Mm	165.4	49.9	2.7	1.0	50	0.0		0.0		0	31.0	9.0	1.1	0.1	10	260.0	55.1	2.5	0.8	55
	Mr	13.4	5.1	2.4	0.7	35	0.0		0.0		0	0.0		0.0		0	10.9	3.6	2.7	0.9	35
Block 4	Control	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	20.0	0.0	7.0		5
	Mm	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0				0
	Mr	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0				0
Block 5	Control	10.0		1.0		5	0.0		0.0		0	0.0		0.0		0	8.0		1.0	0.0	5
	Mm	32.5	18.8	2.2	1.1	40	0.0		0.0		0	0.0		0.0		0	63.5	27.1	1.2	0.2	40
	Mr	67.0	53.0	1.1	0.0	10	0.0		0.0		0	0.0		0.0		0	226.7	37.1	3.7	0.7	15

Table 5. Quadrat-based measures of density (#/m2), cover (% abs live) and frequency (# subsample occurences/20 subsamples X 100) for VPC taxa, SRVRS, May 2000.

FEMA

5/24-25, 6/1 2000

		Limnanthes vinculans					Blennosperma bakeri					Downingia concolor					Lasthenia glabberima				
		Den / SE		Cov /SE		Freq	Den / SE		Cov / SE		Freq	Den / SE		Cov / SE		Freq	Den / SE		Cov /SE		Freq
Block 1	Control	51.0	49.0	5.5	4.5	10	0.0		0.0		0	0.0		0.0		0	120.0		20.0		5
	Mm	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	6.0		1.0		5
	Mr	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0				0
Block 2	Control	121.0	27.5	2.1	0.5	45	0.0		0.0		0	0.0		0.0		0	74.7	29.8	1.8	0.6	30
	Mm	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	2.0		1.0		5
	Mr	84.3	46.0	2.5	1.0	30	0.0		0.0		0	8.0		1.0		5	42.0	38.0	1.5	0.5	10
Block 3	Control	0.0		0.0		0	0.0		0.0		0	5.0	3.0	1.0	0.0	10	2.0	0.0	1.0	0.0	10
	Mm	0.0		0.0		0	0.0		0.0		0	2.0		1.1	0.1	5	4.0		1.0		5
	Mr	0.0		0.0		0	0.0		0.0		0	21.2	7.6	1.0	0.0	50	6.5	1.9	1.0	0.0	20
Block 4	Control	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0
	Mm	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0
	Mr	22.0	14.0	1.5	0.5	10	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0
Block 5	Control	4.0		1.0	0.0	5	0.0		0.0		0	0.0		0.0		0	5.3	1.8	1.5	0.5	15
	Mm	13.0	1.0	7.0	2.0	10	0.0		0.0		0	2.0		1.0		5	28.5	13.1	10.5	6.6	20
	Mr	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	8.0	0.9	2.0	1.0	25

Table 5. Quadrat-based measures of density (#/m2), cover (% abs live) and frequency (# subsample occurences/20 subsamples X 100) for VPC taxa, SRVRS, May 2000.

Haroutunian
5/16-17, 2000

		Limnanthes vinculans					Blennosperma bakeri					Downingia concolor					Lasthenia glabberima				
		Den / SE		Cov /SE		Freq	Den / SE		Cov / SE		Freq	Den / SE		Cov / SE		Freq	Den / SE		Cov /SE		Freq
Block 1	Control	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0
	Mm	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0
	Mr	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0
Block 2	Control	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0
	Mm	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0
	Mr	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0
Block 3	Control	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0
	Mm	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0
	Mr	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0
Block 4	Control	0.0		0.0		0	0.0		0.0		0	7.6	2.0	1.2	0.2	25	69.8	25.2	5.6	2.8	40
	Mm	0.0		0.0		0	6.0		1.0		5	9.0		3.0		5	215.0	80.6	18.3	4.0	45
	Mr	0.0		0.0		0	28.0	16.0	19.0	8.0	15	19.7	7.2	2.5	0.6	30	50.0		5.0		5
Block 5	Control	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0	0.0		0.0		0
	Mm	0.0		0.0		0	0.0		0.0		0	22.6	8.8	3.8	0.9	65	45.3	13.6	4.2	1.0	45
	Mr	0.0		0.0		0	0.0		0.0		0	4.2	1.2	1.0	0.0	40	127.1	17.7	3.8	0.8	100

Table 6. Phytomass (g/m2/yr) in control plots in two habitats (margin and upland) on three properties of the SRVRS, Fall 1999 and Spring 2000. Shown with means ± SE (n= 10)

site	**Cramer**		**FEMA**		**Haroutunian**	
year	F 1999	S 2000	F 1999	S 2000	F 1999	S 2000
margin						
graminoid	205.5 ± 43.7	314.5 ± 13.7	164.8 ± 54.8	237.4 ± 37.5	144.9 ± 31.4	290.2 ± 50.3
dicot	34.8 ± 15.2	24.9 ± 5.0	32.0 ± 8.2	13.2 ± 8.2	59.9 ± 18.1	82.0 ± 49.9
thatch	150.6 ± 14.4	31.9 ± 10.5	55.1 ± 13.6	31.2 ± 9.3	66.4 ± 9.6	50.7 ± 16.0
total	390.9 ± 48.8	371.2 ± 20.9	251.8 ± 38.8	281.8 ± 45.6	271.2 ± 35.8	422.9 ± 34.2
upland						
graminoid	147.9 ± 14.4	294.7 ± 11.3	206.8 ± 46.6	261.6 ± 58.6	105.9 ± 15.4	225.8 ± 20.1
dicot	8.4 ± 5.2	21.6 ± 6.3	32.1 ± 11.3	13.4 ± 4.0	78.7 ± 34.1	72.6 ± 11.8
thatch	253.9 ± 33.5	54.0 ± 6.4	65.3 ± 21.1	52.2 ± 15.3	108.7 ± 13.4	61.7 ± 14.6
total	410.2 ± 43.0	370.3 ± 17.5	304.1 ± 25.5	327.2 ± 59.5	293.3 ± 40.7	360.0 ± 36.1

Table 7. Summary of soil characteristics for two habitats (margin and upland) on three properties (Cramer, FEMA, Haroutunian)of the SRVRS, Fall 1999. No significant differences were found among treatment means within a habitat, except those that have a "*" in a column (P<0.02, ANOVA). OM = organic matter, C-Org = organic carbon, TKN = total Kjeldahl nitrogen, NH4-N = ammonium, NO3-N = nitrate.

margin

	OM (%)	SE	C-Org (%)	SE	TKN (%)	SE	NH4-N (ppm)	SE	NO3-N (ppm)	SE
Cramer										
control	5.23	1.25	3.03	0.73	0.250	0.050	14.8	3.6	17.2	6.2
Mm	4.88	0.24	2.84	0.14	0.238	0.006	13.2	3.2	8.0	1.0
Mr	5.66	0.95	3.28	0.55	0.242	0.040	21.5	7.3	15.7	4.7
FEMA										
control	3.67	0.34	2.13	0.20	0.170	0.020	10.2	1.6	3.6	1.5
Mm	3.50	0.43	2.03	0.25	0.169	0.007	9.4	1.2	3.4	1.3
Mr	3.09	0.36	1.79	0.21	0.170	0.020	11.0	1.1	4.5	1.3
Haroutunian										
control	3.93	0.49	2.28	0.28	0.191	0.030	19.3	1.5	8.1	4.2
Mm	4.58	0.43	2.66	0.25	0.268	0.044	24.8	5.2	5.9	2.3
Mr	4.77	0.30	2.77	0.18	0.276	0.027	21.8	1.9	21.6	8.9

upland

	OM (%)	SE	C-Org (%)	SE	TKN (%)	SE	NH4-N (ppm)	SE	NO3-N (ppm)	SE
Cramer										
control	3.99	0.62	2.32	0.36	0.206	0.040	7.8	0.7	8.6*	1.8
Mm	3.75	0.44	2.18	0.26	0.175	0.029	9.0	0.9	4.3*	1.1
Mr	3.35	0.38	1.94	0.22	0.150	0.021	7.8	0.6	2.7*	0.3
FEMA										
control	3.73	0.34	2.16	0.20	0.173	0.030	7.9	1.2	1.8	0.2
Mm	3.68	0.32	2.13	0.19	0.172	0.016	7.9	0.6	2.1	0.5
Mr	4.03	0.34	2.34	0.20	0.180	0.014	9.8	1.4	2.6	0.8
Haroutunian										
control	3.94	0.25	2.28	0.14	0.174	0.014	18.6	4.2	3.3	0.9
Mm	2.89	0.42	1.68	0.25	0.126	0.020	12.5	1.7	4.6	2.4
Mr	3.14	0.16	1.82	0.09	0.127	0.015	14.3	1.5	3.9	0.6

Table 8. Summary of soil characteristics (means) for combined sites (Cramer + FEMA+Haroutunian) of the SRVRS, Fall 1999. No significant differences were found among treatments within a habitat, but differences between habitats (treatments combined) were all significant (P<0.005, ANVOA). OM = organic matter, C-Org = organic carbon, TKN = total Kjeldahl nitrogen, NH4-N = ammonium, NO3-N = nitrate. Values within a column followed by a "*" are significantly different.

	OM (%)	C-Org (%)	TKN (%)	NH4-N (ppm)	NO3-N (ppm)
margin					
control	4.28	2.48	0.204	14.8	9.6
Mm	4.32	2.51	0.225	15.8	5.8
Mr	4.50	2.61	0.229	18.1	13.9
mean	4.37*	2.53*	0.219*	16.2*	9.8*
upland					
control	3.89	2.26	0.184	11.4	4.6
Mm	3.44	2.00	0.158	9.8	3.7
Mr	3.51	2.03	0.152	10.6	3.1
mean	3.61*	2.1*	0.164*	10.6*	3.8*

Restoring Vernal Pool Vegetation at the SRVRS

Team: 2 people - a reader and a writer

Equipment:
- 1 pin frame sampler
- 1 quadrat sampler
- 1 50 m tape
- 4 survey arrows
- # 2 pencil
- clip board
- unknown specimen kit

Paperwork:
- block data sheet notebook
- plot maps
- species list

Organization:

Each team will be assigned a block to sample. A block is a pool or swale already marked and treated as part of our restoration experiment. Each block contains two habitats, upland and margin (Figure 1). Each habitat has a 90 m long strip that has already been divided into three plots: a control plot (C or Con), a mowed-mulched plot (Mm) and a mowed-raked plot (Mr). Plots are 30 m long and 5 m wide. The start of the 90 m strip is called the "initial boundary" and is marked by 4 two inch pvc stakes permanently driven into the ground. Other pvc stakes mark the location of the upslope edge of each strip. You will sample all plots in your block (3 margin + 3 upland).

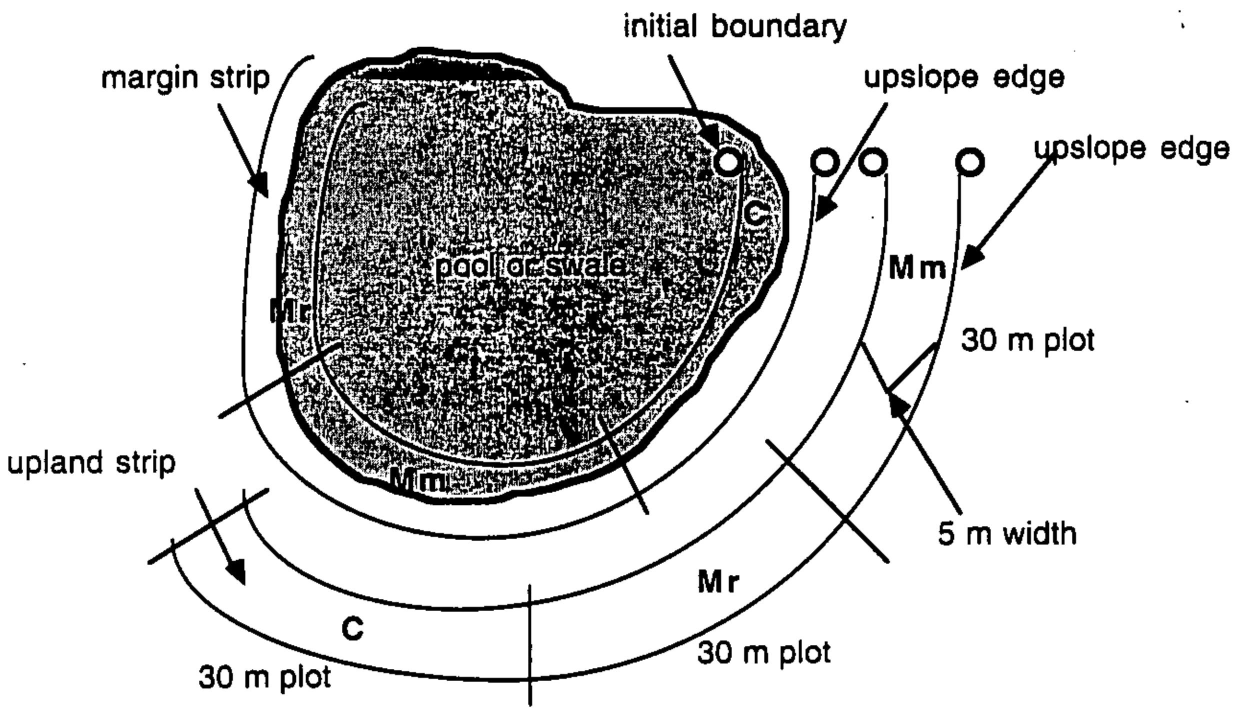


Figure 1. Block design for a vernal pool consisting of two habitat strips (pool margin and upland) each 90 m long. Position of the initial boundary was randomly assigned and each treatment (C= control, Mm= mowed and mulched, Mr=mowed and raked) was randomly assigned.

To Begin:

1) Approach the strips carefully so as not to step into them before sampling. Locate the initial boundary and all four pvc markers. Remember that the lowest two (with respect to the pool topography) are 5 m apart and define the margin strip, and the upper two are also 5 m apart and define the upland strip (Figure 1).

2) Stake the tape with its 0 m mark at the upslope pvc marker for the margin strip. Walking on the outside of the strip, lay the tape out to define the upslope edge using the other pvc stakes or the colored flags. When you come to 30 m, pull the slack out of the tape and stake it down.

3) Consult your maps to determine if this first 30m plot of the margin is a control plot, Mm plot or Mr plot. **Double check.**

4) The writer will remove the proper set of datasheets from the notebook and clip them to the clipboard. **Double check.**

To Sample:

5) The writer tells the reader the position and upper/lower designation on the datasheet, beginning with the lowest position number (e.g. 7 m).

6) The reader carries the pin frame along the upper edge and finds the position (e.g. 7 m) on the tape. If the designation is U (upper), then the frame is carefully set into the plot a short distance from the tape (knot on the locator string). The line of pins are perpendicular to the tape and all pins are raised .

7) **The reader always enters the plot and stands on the side of the frame facing the lowest position numbers** (e.g. 6 m side, not the 8 m side). That way unsampled vegetation does not get stomped.

8) Beginning with the upslope pin (# 1, the one furthest from the pool), the reader slowly lowers it until it makes first contact with a leaf, stem, or flower. The reader calls out the scientific name of the species contacted and the writer records its abbreviation. (e.g. *Limnanthes vinculans* is recorded as LIVI in the slot for pin #1). If there is wind, wait until you can determine which leaf/flower would be touched if it were not in motion.

9) What if you don't recognize the species? Ask a rovering expert, or designate it as unknown "A". Immediately take a complete specimen, tape it to the unknown card and label it. Use the same "name" throughout your sampling and show your specimen to a rover when possible.

10) What if the pin hits bare ground? Record "BARE". Thatch or wood? Record "THAT" A fallen leaf, just resting on the canopy? Remove it and record the next pin hit.

11) Repeat for all 10 pins in this subsample. Raise the pins when done.

12) If between the legs of the pin frame there are any vernal pool endemics (e.g. LIVI, DOCO, PODO), lay the quadrat sampler in there.

a) If there are only a few, scattered individuals inside the quadrat, count them all and tell the writer the species, the number of individuals, that the whole area of the quadrat was counted and the total % cover for the species. The writer writes the number of individuals on the inset of the datasheet for that species, puts a "W" under "area" and writes the cover estimate.

b) If there are many individuals, choose a representative 10% of the quadrat (its' marked on the quadrat for reference) and estimate the % cover contributed by that species in the quadrat. The writer writes the number of individuals on the inset of the datasheet for that species and records its % cover.

13) Stretch the downslope locator string (the one with the taped end). Now move the pin frame so it is in place to get the second subsample for that position (pins 11-20).

14) Repeat steps 7-12.

15) Move to the second position along the 50 m tape. Put a red flag into the ground to mark this position along the tape and leave it in place when you leave. If the designation is L (lower), then the frame is carefully set into the plot a longer distance from the tape (end of the knotted locator string).

16) Repeat steps 6-14.

17) Do a total of 10 positions (20 subsamples) in a plot. Put another red flag into the ground to mark the position of the second-to-last sample along the tape and leave it in place when you leave.

18) **Writer does a check when a plot is finished:**

a) All datasheets completely filled out for the plot and returned to block notebook.

b) Two red flags in the second and second-to-last position.

19) Move on the the next plot in the same strip. You will need to reposition the tape so that the new 0m is at the previous 30 m position.

20) Repeat steps 2-18 for the other two plots in the margin habitat and the other three plots in the upland habitat

21) **Writer checks to see that when a block is completely sampled there should be six sets of data sheets (margin C, Mm, Mr and upland C, Mm, Mr).**

APPENDIX B:

Field datasheets for point frame sampling

Property: C F H

Block: 1 2 3 4 5

SRVRS 2000

Date ______________

Data by ___________

habitat | treat | position | U/L | pin # | pin hit species

---

margin **Con** _____ _____

sp #ind area %cov

LiVi

Podo

DoCo

Lagl

pin #:
1 uphill ___
2 ___
3 ___
4 ___
5 ___
6 ___
7 ___
8 ___
9 ___
10 ___

sp #ind area %cov

LiVi

Podo

DoCo

Lagl

11 uphill ___
12 ___
13 ___
14 ___
15 ___
16 ___
17 ___
18 ___
19 ___
20 ___

margin **Con** _____ _____

sp #ind area %cov

LiVi

Podo

DoCo

Lagl

1 uphill ___
2 ___
3 ___
4 ___
5 ___
6 ___
7 ___
8 ___
9 ___
10 ___

sp #ind area %cov

LiVi

Podo

DoCo

Lagl

11 uphill ___
12 ___
13 ___
14 ___
15 ___
16 ___
17 ___
18 ___
19 ___
20 ___

Property: C F H **SRVRS 2000** **Date** ____________
Block: 1 2 3 4 5 **Data by** ____________

habitat treat position U/L pin # pin hit species

---

margin **Mm** ____ ____

1 uphill ____
2 ____
3 ____
4 ____
5 ____
6 ____
7 ____
8 ____
9 ____
10 ____

sp	#ind	area	%cov
LiVi			
Podo			
DoCo			
Lagl			

11 uphill ____
12 ____
13 ____
14 ____
15 ____
16 ____
17 ____
18 ____
19 ____
20 ____

sp	#ind	area	%cov
LiVi			
Podo			
DoCo			
Lagl			

margin **Mm** ____ ____

1 uphill ____
2 ____
3 ____
4 ____
5 ____
6 ____
7 ____
8 ____
9 ____
10 ____

sp	#ind	area	%cov
LiVi			
Podo			
DoCo			
Lagl			

11 uphill ____
12 ____
13 ____
14 ____
15 ____
16 ____
17 ____
18 ____
19 ____
20 ____

sp	#ind	area	%cov
LiVi			
Podo			
DoCo			
Lagl			

Property: C F H SRVRS 2000 Date ______________
Block: 1 2 3 4 5 Data by ___________

habitat	treat	position	U/L	pin #	pin hit species
margin	**Mr**	_____	____	1 uphill	____________
				2	____________
				3	____________
				4	____________
sp #ind area %cov				5	____________
LiVi				6	____________
Podo				7	____________
DoCo				8	____________
Lagl				9	____________
				10	____________
				11 uphill	____________
				12	____________
				13	____________
				14	____________
sp #ind area %cov				15	____________
LiVi				16	____________
Podo				17	____________
DoCo				18	____________
Lagl				19	____________
				20	____________
margin	**Mr**	_____	____	1 uphill	____________
				2	____________
				3	____________
				4	____________
sp #ind area %cov				5	____________
LiVi				6	____________
Podo				7	____________
DoCo				8	____________
Lagl				9	____________
				10	____________
				11 uphill	____________
				12	____________
				13	____________
				14	____________
sp #ind area %cov				15	____________
LiVi				16	____________
Podo				17	____________
DoCo				18	____________
Lagl				19	____________
				20	____________

Property: C F H **SRVRS 2000** **Date** ______________
Block: 1 2 3 4 5 **Data by** ___________

habitat treat position U/L pin # pin hit species

---

upland Con _____ ____

pin #	pin hit species
1 uphill	
2	
3	
4	
5	
6	
7	
8	
9	
10	

sp	#ind	area	%cov
LiVi			
Podo			
DoCo			
Lagl			

pin #	pin hit species
11 uphill	
12	
13	
14	
15	
16	
17	
18	
19	
20	

sp	#ind	area	%cov
LiVi			
Podo			
DoCo			
Lagl			

upland Con _____ ____

pin #	pin hit species
1 uphill	
2	
3	
4	
5	
6	
7	
8	
9	
10	

sp	#ind	area	%cov
LiVi			
Podo			
DoCo			
Lagl			

pin #	pin hit species
11 uphill	
12	
13	
14	
15	
16	
17	
18	
19	
20	

sp	#ind	area	%cov
LiVi			
Podo			
DoCo			
Lagl			

Property: C F H **SRVRS 2000** **Date** ______________
Block: 1 2 3 4 5 **Data by** ___________

habitat treat position U/L pin # pin hit species

---

upland **Mr** _____ _____

sp	#ind	area	%cov
LiVi			
Podo			
DoCo			
Lagl			

pin #: 1 **uphill**, 2, 3, 4, 5, 6, 7, 8, 9, 10

sp	#ind	area	%cov
LiVi			
Podo			
DoCo			
Lagl			

pin #: 11 **uphill**, 12, 13, 14, 15, 16, 17, 18, 19, 20

upland **Mr** _____ _____

sp	#ind	area	%cov
LiVi			
Podo			
DoCo			
Lagl			

pin #: 1 **uphill**, 2, 3, 4, 5, 6, 7, 8, 9, 10

sp	#ind	area	%cov
LiVi			
Podo			
DoCo			
Lagl			

pin #: 11 **uphill**, 12, 13, 14, 15, 16, 17, 18, 19, 20

Property: C F H **SRVRS 2000** **Date** ______________
Block: 1 2 3 4 5 **Data by** ____________

habitat treat position U/L pin # pin hit species

---

upland **Mm** ____ ____

pin #	pin hit species
1 uphill	
2	
3	
4	
5	
6	
7	
8	
9	
10	

sp	#ind	area	%cov
LiVi			
Podo			
DoCo			
Lagl			

pin #	pin hit species
11 uphill	
12	
13	
14	
15	
16	
17	
18	
19	
20	

sp	#ind	area	%cov
LiVi			
Podo			
DoCo			
Lagl			

upland **Mm** ____ ____

pin #	pin hit species
1 uphill	
2	
3	
4	
5	
6	
7	
8	
9	
10	

sp	#ind	area	%cov
LiVi			
Podo			
DoCo			
Lagl			

pin #	pin hit species
11 uphill	
12	
13	
14	
15	
16	
17	
18	
19	
20	

sp	#ind	area	%cov
LiVi			
Podo			
DoCo			
Lagl			

APPENDIX C:

Dominant species richness by property, habitat and plot

Dominant Species Richness - Block data by property

Cramer -margins

	Block 1	2	3	4	5
c	13	11	15	12	9
mm	6	15	19	11	5
mr	7	14	12	11	7

Cramer-uplands

	1	2	3	4	5
c	10	11	9	9	7
mm	10	7	10	8	9
mr	9	10	10	9	6

FEMA -margins

	Block 1	2	3	4	5
c	17	13	12	10	14
mm	19	11	15	11	13
mr	12	13	16	8	13

FEMA-uplands

	1	2	3	4	5
c	13	12	9	14	9
mm	11	9	13	6	10
mr	11	10	14	7	15

Hart -margins

	Block 1	2	3	4	5
c	10	16	11	13	11
mm	11	16	9	16	14
mr	14	17	14	19	11

Hart-uplands

	1	2	3	4	5
c	14	9	6	10	12
mm	9	10	13	11	11
mr	10	11	12	14	14

APPENDIX D:

Raw post-treatment vegetation data from point frame samples

1. Pin hit data by property
2. Pin hit data by treatment
3. Pin hit data by plot

FLORA FOR MARGIN - FOR ALL THREE PROPS

		Total-All
ANAR	Anagallis arvensis	1
AVBA	Avena barbata	25
BAGR	Bare Ground	37
BRCA	Bromus carinatus	65
BLBA	Blennosperma bakeri	11
BRDI	Bromus diandrus	9
BRMI	Briza minor	143
BRHO	Bromus hordeaceus	111
CADE	Carex densa	48
CAPR	Carex praegracilis	1
CASP	Carex species	21
COAR	Convolvulus arvensis	212
DACA	Danthonia californica	92
DICA	Dichelostemma capitatum	10
DIFU	Dipsacus fullonum	31
DISP	Distichlis spicata	12
DOCO	Downingia concolor	4
ELAC	Eleocharus acicularis	59
ELMA	Eleocharus macrostachya	493
ERAR	Eryngium aristulatum	175
ERBO	Erodiom botrys	38
ERCI	Erodium cicutarium	2
HOBR	Hordeum brachyantherum	288
HOMA	Hordeum marinum ssp.gussoneanum	76
HOMU	Hordeum murinum	1
JUME	Juncus mexicanus	1
JUOC	Juncus occidentalis	27
JUPH	Juncus phaeocephalus	663
LAGL	Lasthenia glaberrima	61
LASP	Lactuca species	2
LIVI	Limnanthes vinculans	26
LOMU	Lolium multiflorum	4217
MEPU	Mentha pulegium	157
OEOV	Oenothera ovata	1
PHAQ	Phalaris aquatica	20
PLCA	Pleuropogon californicus	675
PLLA	Plantago lanceolata	6
POMA	Polypogon maritimus	129
RAMU	Ranunculus muricatus	5
RAPU	Ranunculus pusillus	14
RUAC	Rumex acetocella	1
RUCO	Rumex conglomeratus	3
RUCR	Rumex crispus	101
RUPU	Rumex pulchra	1
SOAS	Sonchus asper	18
THCH	Thatch	327
TRSP	Trifolium species	9
TRVA	Trifolium variegatum	23
TRVE	Tryphysaria versicolor ssp. faucibarbata	2
UNFO	Forb species	90
UNGR	Grass species	14
VISA	Vicia sativa ssp. sativa	63
VUOC	Vulpia octoflora var. octoflora	379

Total Hits 9000

FLORA FOR UPLAND - FOR ALL THREE PROPS

		Total-All
ANAR	Anagallis arvensis	8
AVBA	Avena barbata	199
BAGR	Bare Ground	18
BRCA	Bromus carinatus	59
BRDI	Bromus diandrus	286
BRMI	Briza minor	111
BRHO	Bromus hordeaceus	318
CADE	Carex densa	2
CASP	Carex species	43
CHPO	Chlorogalum pomeridianum	48
COAR	Convolvulus arvensis	174
DACA	Danthonia californica	287
DIFU	Dipsacus fullonum	97
DISP	Distichlis spicata	1
ELAC	Eleocharus acicularis	1
ELMA	Eleocharus macrostachya	5
ERAR	Eryngium aristulatum	3
ERBO	Erodium botrys	70
ERCI	Erodium cicutarium	101
HOBR	Hordeum brachyantherum	68
HOMA	Hordeum marinum ssp.gussoneanum	63
HOMU	Hordeum murinum	4
JUME	Juncus mexicanus	2
JUOC	Juncus occidentalis	23
JUPH	Juncus phaeocephalus	31
LASP	Lactuca species	7
LIVI	Limnanthes vinculans	2
LOMU	Lolium multiflorum	4211
LUSP	Lupinus species	11
PAVI	Parentucellia viscosa	9
PHAQ	Phalaris aquatica	5
PLCA	Pleuropogon californicus	3
PLLA	Plantago lanceolata	6
POMA	Polypogon maritimus	5
RUAC	Rumex acetocella	49
RUCO	Rumex conglomeratus	1
RUCR	Rumex crispus	8
SOAS	Sonchus asper	45
THCH	Thatch	89
TRSP	Trifolium species	27
UNFO	Forb species	63
UNGR	Grass species	12
VISA	Vicia sativa ssp. sativa	603
VUOC	Vulpia octoflora var. octoflora	1805
Total Hits		8983

FLORA BY TREATMENT - CRAMER MARGIN

		CONTROL	MOWED/MULCHED	MOWED/RAKED
BAGR	Bare Ground	4	1	0
BRMI	Briza minor	41	15	24
BRHO	Bromus hordeaceus	10	0	2
CAPR	Carex praegracilis	1	0	0
COAR	Convolvulus arvensis	50	51	28
DACA	Danthonia californica	9	4	15
DISP	Distichlis spicata	3	0	0
ELAC	Eleocharus acicularis	2	6	2
ELMA	Eleocharus macrostachya	41	70	48
ERAR	Eryngium aristulatum	0	11	1
ERBO	Erodiom botrys	1	0	0
HOBR	Hordeum brachyantherum	4	14	12
HOMA	Hordeum marinum ssp.gussoneanum	3	1	4
HOMU	Hordeum murinum	0	1	0
JUME	Juncus mexicanus	0	1	0
JUOC	Juncus occidentalis	4	2	5
JUPH	Juncus phaeocephalus	68	17	46
LAGL	Lasthenia glaberrima	1	4	20
LASP	Lactuca species	2	0	0
LIVI	Limnanthes vinculans	8	7	8
LOMU	Lolium multiflorum	535	595	562
MEPU	Mentha pulegium	16	7	21
OEOV	Oenothera ovata	1	0	0
PLCA	Pleuropogon californicus	85	104	75
POMA	Polypogon maritimus	12	3	4
RAPU	Ranunculus pusillus	0	3	4
RUCR	Rumex crispus	3	2	9
RUPU	Rumex pulchra	1	0	0
SOAS	Sonchus asper	3	0	0
THCH	Thatch	46	23	11
TRSP	Trifolium species	0	2	0
TRVA	Trifolium variegatum	0	0	23
TRVE	Tryphysaria versicolor ssp. faucibarbata	0	0	2
UNFO	Forb species	5	2	5
UNGR	Grass species	0	0	6
VISA	Vicia sativa ssp. sativa	1	0	0
VUOC	Vulpia octoflora var. octoflora	40	54	63
TOTAL PER TREATMENT		1000	1000	1000

FLORA BY TREATMENT - CRAMER UPLAND

		CONTROL	MOWED/MULCHED	MOWED/RAKED
AVBA	Avena barbata	7	17	9
BAGR	Bare Ground	0	3	1
BRDI	Bromus diandrus	9	2	28
BRHO	Bromus hordeaceus	39	24	24
BRMI	Briza minor	23	47	2
COAR	Convolvulus arvensis	26	19	19
DACA	Danthonia californica	3	48	93
ELMA	Eleocharus macrostachya	1	0	0
ERAR	Eryngium aristulatum	0	2	0
ERBO	Erodiom botrys	7	19	13
ERCI	Erodium cicutarium	6	14	10
HOBR	Hordeum brachyantherum	9	1	9
HOMA	Hordeum marinum ssp.gussoneanum	5	5	1
JUOC	Juncus occidentalis	6	2	2
JUPH	Juncus phaeocephalus	1	14	7
LIVI	Limnanthes vinculans	0	0	2
LOMU	Lolium multiflorum	566	430	355
LUSP	Lupinus species	1	0	0
PLLA	Plantago lanceolata	0	1	0
POMA	Polypogon maritimus	0	2	0
RUAC	Rumex acetocella	7	5	16
RUCR	Rumex crispus	1	0	0
THCH	Thatch	8	10	4
UNFO	Forb species	12	11	7
UNGR	Grass species	10	0	0
VISA	Vicia sativa ssp. sativa	6	7	0
VUOC	Vulpia octoflora var. octoflora	237	317	398
TOTAL PER TREATMENT		990	1000	1000

FLORA BY TREATMENT - FEMA MARGIN		CONTROL	MOWED/MULCHED	MOWED/RAKED
BAGR	Bare Ground	0	14	12
BRCA	Bromus carinatus	6	10	1
BRHO	Bromus hordeaceus	4	2	0
BRMI	Briza minor	2	5	3
COAR	Convolvulus arvensis	37	12	5
DACA	Danthonia californica	2	4	0
DIFU	Dipsacus fullonum	15	12	1
DISP	Distichlis spicata	1	0	0
ELAC	Eleocharus acicularis	0	1	0
ELMA	Eleocharus macrostachya	98	74	55
ERAR	Eryngium aristulatum	46	18	36
ERBO	Erodiom botrys	7	12	9
HOBR	Hordeum brachyantherum	3	3	4
HOMA	Hordeum marinum ssp.gussoneanum	2	0	4
JUOC	Juncus occidentalis	0	1	0
JUPH	Juncus phaeocephalus	108	190	203
LAGL	Lasthenia glaberrima	1	1	2
LIVI	Limnanthes vinculans	1	0	2
LOMU	Lolium multiflorum	378	339	390
MEPU	Mentha pulegium	26	25	62
PLCA	Pleuropogon californicus	129	49	71
POMA	Polypogon maritimus	27	50	33
RAPU	Ranunculus pusillus	2	0	2
RUCR	Rumex crispus	19	14	20
SOAS	Sonchus asper	4	8	3
THCH	Thatch	37	27	44
TRSP	Trifolium species	0	1	1
UNFO	Forb species	17	20	20
UNGR	Grass species	2	0	0
VIS2	Vicia sativa ssp. nigra	3	2	4
VISA	Vicia sativa ssp. sativa	13	46	3
VUOC	Vulpia octoflora var. octoflora	10	40	30
TOTAL PER TREATMENT		1000	980	1020

FLORA BY TREATMENT - FEMA UPLAND

Code	Species	CONTROL	MOWED/MULCHED	MOWED/RAKED
AVBA	Avena barbata	5	6	3
BRCA	Bromus carinatus	52	7	0
BRDI	Bromus diandrus	10	14	7
BRHO	Bromus hordeaceus	23	33	19
BRMI	Briza minor	21	1	9
CASP	Carex species	33	0	10
CHPO	Chlorogalum pomeridianum	16	0	32
COAR	Convolvulus arvensis	0	13	0
COAR	Convolvulus arvensis	28	0	9
DACA	Danthonia californica	3	5	4
DIFU	Dipsacus fullonum	65	3	29
ELMA	Eleocharus macrostachya	3	0	0
ERAR	Eryngium aristulatum	0	0	1
ERBO	Erodiom botrys	2	1	1
HOBR	Hordeum brachyantherum	0	3	1
HOMA	Hordeum marinum ssp.gussoneanum	0	21	2
HOMU	Hordeum murinum	0	4	0
JUOC	Juncus occidentalis	11	0	0
JUPH	Juncus phaeocephalus	4	3	2
LASP	Lactuca species	6	1	0
LOMU	Lolium multiflorum	437	544	452
LUSP	Lupinus species	0	2	8
PAVI	Parentucellia viscosa	2	1	0
PLCA	Pleuropogon californicus	1	0	2
PLLA	Plantago lanceolata	1	0	1
POMA	Polypogon maritimus	3	0	0
RUAC	Rumex acetocella	4	1	7
RUCO	Rumex conglomeratus	0	0	1
RUCR	Rumex crispus	3	0	1
SOAS	Sonchus asper	16	10	19
THCH	Thatch	10	3	3
TRSP	Trifolium species	1	4	1
UNFO	Forb species	11	7	3
UNGR	Grass species	0	0	1
VISA	Vicia sativa ssp. sativa	99	244	247
VUOC	Vulpia octoflora var. octoflora	130	62	125
TOTAL PER TREATMENT		1000	993	1000

FLORA BY TREATMENT - HART MARGIN

		CONTROL	MOWED/MULCHED	MOWED/RAKED
ANAR	Anagallis arvensis	0	0	1
AVBA	Avena barbata	6	12	7
BAGR	Bare Ground	3	3	0
BLBA	Blennosperma bakeri	0	8	3
BRCA	Bromus carinatus	38	8	2
BRDI	Bromus diandrus	1	2	6
BRMI	Briza minor	1	46	6
BRHO	Bromus hordeaceus	29	21	43
CADE	Carex densa	3	44	1
CASP	Carex species	20	0	1
COAR	Convolvulus arvensis	6	8	15
DACA	Danthonia califomica	41	7	10
DICA	Dichelostemma capitatum	0	0	1
DIFU	Dipsacus fullonum	0	0	3
DISP	Distichlis spicata	0	4	4
DOCO	Downingia concolor	1	2	1
ELAC	Eleocharus acicularis	16	3	29
ELMA	Eleocharus macrostachya	22	71	14
ERAR	Eryngium aristulatum	3	39	21
ERBO	Erodiom botrys	2	2	5
ERCI	Erodium cicutarium	0	1	1
HOBR	Hordeum brachyantherum	51	93	104
HOMA	Hordeum marinum ssp.gussoneanum	21	21	20
JUOC	Juncus occidentalis	6	5	4
JUPH	Juncus phaeocephalus	0	28	3
LAGL	Lasthenia glaberrima	5	15	12
LOMU	Lolium multiflorum	523	398	497
PHAQ	Phalaris aquatica	5	9	6
PLCA	Pleuropogon califomicus	20	55	87
PLLA	Plantago lanceolata	0	0	6
RAMU	Ranunculus muricatus	0	5	0
RAPU	Ranunculus pusillus	0	0	3
RUAC	Rumex acetocella	0	0	1
RUCO	Rumex conglomeratus	1	2	0
RUCR	Rumex crispus	11	18	5
THCH	Thatch	72	35	32
TRSP	Trifolium species	0	5	0
UNFO	Forb species	4	1	16
UNGR	Grass species	2	2	2
VUOC	Vulpia octoflora var. octoflora	87	27	28
TOTAL PER TREATMENT		1000	1000	1000

FLORA BY TREATMENT - HART UPLAND

Code	Species	CONTROL	MOWED/MULCHED	MOWED/RAKED
ANAR	Anagallis arvensis	1	1	6
AVBA	Avena barbata	22	67	63
BAGR	Bare Ground	0	5	9
BRDI	Bromus diandrus	18	116	82
BRMI	Briza minor	4	1	3
BRHO	Bromus hordeaceus	56	58	42
CADE	Carex densa	2	0	0
COAR	Convolvulus arvensis	21	18	21
DACA	Danthonia californica	19	47	65
DISP	Distichlis spicata	1	0	0
ELAC	Eleocharus acicularis	1	0	0
ELMA	Eleocharus macrostachya	0	0	1
ERBO	Erodiom botrys	3	2	22
ERCI	Erodium cicutarium	1	9	61
HOBR	Hordeum brachyantherum	9	28	8
HOMA	Hordeum marinum ssp.gussoneanum	3	17	9
JUME	Juncus mexicanus	0	0	2
JUOC	Juncus occidentalis	0	0	2
LOMU	Lolium multiflorum	648	392	387
PAVI	Parentucellia viscosa	0	0	6
PHAQ	Phalaris aquatica	5	0	0
PLLA	Plantago lanceolata	0	3	0
RUAC	Rumex acetocella	1	5	3
RUCR	Rumex crispus	2	0	1
THCH	Thatch	32	8	11
TRSP	Trifolium species	0	4	17
UNFO	Forb species	7	4	1
UNGR	Grass species	1	0	0
VUOC	Vulpia octoflora var. octoflora	143	215	178
TOTAL PER TREATMENT		1000	1000	1000

CRAMER MARGIN - ALL TREATMENTS

		CRAM/M/1/C	CRAM/M/2/C	CRAM/M/3/C	CRAM/M/4/C	CRAM/M/5/C	CRAM/M/1/MM	CRAM/M/2/MM	CRAM/M/3/MM	CRAM/M/4/MM	CRAM/M/5/MM	CRAM/M/1/M	CRAM/M/2/M	CRAM/M/3/M	CRAM/M/4/M	CRAM/M/5/M
ANAR	Anagallis arvensis															
AVBA	Avena barbata															
BAGR	Bare Ground			4					1							
BRCA	Bromus carinatus															
BRDI	Bromus diandrus															
BRMI	Briza minor			2	36	3		1	1	8	5			1	22	1
BRMO	*Bromus hordeaceus*	8				2										
CADE	Carex densa														1	1
CAPR	Carex praegracilis		1													
CASP	Carex species															
CHPO	Chlorogalum pomeridianum															
COAR	Convolvulus arvensis	50					51					28				
DACA	Danthonia californica		6		3			2		2			1		14	
DIFU	Dipsacus fullonum															
DISP	Distichlis spicata			3												
DOCO	*Downingia concolor*															
ELAC	Eleocharus acicularis			1	1				6				2			
ELMA	Eleocharus macrostachya	2	15	16	2	6	7	30	6	4	23	4	20	12	1	11
ERAR	Eryngium aristulatum						4	1	4	2				1		
ERBO	Erodiom botrys	1														
ERCI	Erodium cicutarium															
HOBR	Hordeum brachyantherum	2		2			4		3	7		9		3		
HOMA	Hordeum marinium ssp.gussoneaum			2		1		1						3	1	
HOMU	Hordeum m								1							
JUOC	Juncus occidentalis			1	3				1	1		2			3	
JUPH	Juncus phaeocephalus	1	31	23	13			6	9	2		4	29	12	1	
LAGL	Lasthenia glaberrima				1			3	1				18			2
LASP	Lactuca species	2														
LIVI	Limnanthes vinculans		7	1				3	4				6	2		
LOMU	Lolium multiflorum	106	57	95	107	170	117	78	93	145	162	125	25	127	113	172
LUSP	Lupinus species															
MEPU	Mentha pulegium		10	5	1			1	4	2			18	4	1	
OEOV	Oenothera ovata					1										
PAVI	Parentucellia viscosa															
PHAQ	Phalaris aquatica															
PLCA	Pleuropogon californicus		48	17	5	15		62	36		6		48	21		6
PLLA	Plantago lanceolata															
POMA	Polypogon maritimus		12					1	2				4			
RAPU	Ranunculus pusillus							3					4			
RUAC	Rumex acetocella												4			
RUCO	Rumex conglomeratus															
RUCR	Rumex crispus		1	1		1			2				2	2		5
RUPU	Rumex pulchra	1														
SOAS	Sonchus asper	3														
THCH	Thatch	6	11	23	6		15	6	2			3		6		2
TRSP	Trifolium species							1		1						
TRVA	Trifolium variegatum												23			
TRVE	Tryphysaria versicolor ssp. faucibarbata												2			
UNFO	Forb species	2	1		2			1	1						5	
UNGR	Grass species													6		
VIS2	Vicia sativa ssp. nigra															
VISA	Vicia sativa ssp. sativa	1														
VUOC	Vulpia octoflora var. octoflora	15		4	20	1	2		22	26	4	25			38	

FEMA MARGIN - ALL TREATMENTS

		FEMA/M/	FEMA/M/	FEMA/M/	FEMA/M/	FEMA/M/	FEMA/M/1/M	FEMA/M/2/M	FEMA/M/3/M	FEMA/M/4/M	FEMA/M/5/M	FEMA/M/1/M	FEMA/M/2/M	FEMA/M/3/M	FEMA/M/4/M	FEMA/M/5/M
ANAR	Anagallis arvensis															
AVBA	Avena barbata															
BAGR	Bare Ground						14					11		1		
BRCA	Bromus carinatus	1			5				4	6				1		
BRDI	Bromus diandrus															
BRMI	Briza minor	2							2		3			1		2
BRMO	Bromus hordeaceus	1			1	2		1			1					
CADE	Carex densa															
CAPR	Carex praegracilis															
CASP	Carex species															
CHPO	Chlorogalum pomeridianum															
COAR	Convolvulus arvensis		14	4		19	1		11			2	1	2		
DACA	Danthonia californica				2		1	3								
DIFU	Dipsacus fullonum		12	3					5	5	2			1		
DISP	Distichlis spicata					1										
DOCO	Downingia concolor															
ELAC	Eleocharus acicularis						1									
ELMA	Eleocharus macrostachya	8	9	67	8	6	3	23	47	1			11	29	14	1
ERAR	Eryngium aristulatum	14	11	1		20	5	4	5		4		29	8		1
ERBO	Erodiom botrys	4				3	1		3		8	1		1		7
ERCI	Erodium cicutarium															
HOBR	Hordeum brachyantherum			2		1		3					2		2	
HOMA	Hordeum marinium ssp.gussoneaum	1	1										4			
JUOC	Juncus occidentalis						1									
JUPH	Juncus phaeocephalus	33		25	6	44	10		65	1	114	31		89	1	82
LAGL	Lasthenia glaberrima		1								1					2
LASP	Lactuca species															
LIVI	Limnanthes vinculans		1										2			
LOMU	Lolium multiflorum	52	112	8	151	55	99	122	4	109	5	124	103	5	128	30
LUSP	Lupinus species															
MEPU	Mentha pulegium	9	1	12		4	1		12		12	1	2	42		17
PAVI	Parentucellia viscosa															
PHAQ	Phalaris aquatica															
PLCA	Pleuropogon californicus	66	28	21	7	7	14	26	6	3			30	17	24	
PLLA	Plantago lanceolata															
POMA	Polypogon maritimus	12	1	1		13	3		11	14	22			5	1	27
RAPU	Ranunculus pusillus				2											2
RUAC	Rumex acetocella															
RUCO	Rumex conglomeratus															
RUCR	Rumex crispus	4	6	7		2	1	4	7		2	2	12	4	1	1
SOAS	Sonchus asper	4					4			4		2		1		
THCH	Thatch	4		12	5	16	4		7	1	15	16		4	5	19
TRSP	Trifolium species							1					1			
UNFO	Forb species			17			1		9	1	9	2		11		7
UNGR	Grass species	2														
VIS2	Vicia sativa ssp. nigra		3				2					3	1			
VISA	Vicia sativa ssp. sativa	1			12		4	10	2	30		1	2			
VUOC	Vulpia octoflora var. octoflora	2			1	7	10	3		25	2	4			24	2

HART MARGIN - ALL TREATMENTS

		HART/M/1/C	HART/M/2/C	HART/M/3/C	HART/M/4/C	HART/M/5/C	HART/M/1/MM	HART/M/2/MM	HART/M/3/MM	HART/M/4/MM	HART/M/5/MM	HART/M/1/M	HART/M/2/M	HART/M/3/M	HART/M/4/M	HART/M/5/M
ANAR	Anagallis arvensis														1	
AVBA	Avena barbata		5			1	12					6	1			
BAGR	Bare Ground		3					1	1	1						
BLBA	Blennosperma bakeri										8				3	
BRCA	Bromus carinatus			38					8				1	1		
BRDI	Bromus diandrus			1			2					6				
BRMI	Briza minor					1	44			1	1	4			2	
BRMO	Bromus hordeaceus	1	23	4		1	5		1	14	1	4	24	1	14	
CADE	Carex densa		3					44					1			
CAPR	Carex praegracilis															
CASP	Carex species		20										1			
CHPO	Chlorogalum pomeridianum															
COAR	Convolvulus arvensis	3	2	1				2	2		4	3	2	1	2	7
DACA	Danthonia californica			13	22	6			3	3	1				10	
DICA	Dichelostemma capitatum														1	
DIFU	Dipsacus fullonum												3			
DISP	Distichlis spicata							4							4	
DOCO	Downingia concolor				1						2				1	
ELAC	Eleocharus acicularis		2		14					3					1	28
ELMA	Eleocharus macrostachya		14		8			51		18	2			6	4	4
ERAR	Eryngium aristulatum		1	1	1			1		12	26			1	6	14
ERBO	Erodiom botrys		2					2				1	4			
ERCI	Erodium cicutarium						1					1				
HOBR	Hordeum brachyantherum	23	9	13	5	1	19	16	49	4	5	13	20	67	4	
HOMA	Hordeum marinium ssp.gussoneaum	10	1	6	3	1				5	16		3	2	8	7
JUOC	Juncus occidentalis			5		1			2	3				4		
JUPH	Juncus phaeocephalus							25		2	1		2			1
LAGL	Lasthenia glaberrima				5					15						12
LASP	Lactuca species															
LIVI	Limnanthes vinculans															
LOMU	Lolium multiflorum	117	58	117	85	146	92	11	133	70	92	135	103	80	120	59
LUSP	Lupinus species															
MEPU	Mentha pulegium															
OEOV	Oenothera ovata															
PAVI	Parentucellia viscosa															
PHAQ	Phalaris aquatica	5					9					6				
PLCA	Pleuropogon californicus	11		1	3	5		8		8	39		1	32	7	47
PLLA	Plantago lanceolata											1	1			4
POMA	Polypogon maritimus															
RAMU	Ranunculus muricatus							5								
RAPU	Ranunculus pusillus														3	
RUAC	Rumex acetocella													1		
RUCO	Rumex conglomeratus		1					2								
RUCR	Rumex crispus	4			4	3	1	16	1			1	2	2		
RUPU	Rumex pulchra															
SOAS	Sonchus asper															
THCH	Thatch	18	13		38	3		7		27	1	1	7		8	16
TRSP	Trifolium species									5						
UNFO	Forb species		2		2		1					13	2	1		
UNGR	Grass species	2						1			1			1		1
VIS2	Vicia sativa ssp. nigra															
VISA	Vicia sativa ssp. sativa															
VUOC	Vulpia octoflora var. octoflora	6	41		9	31	14	4		9		5	22		1	

CRAMER UPLAND - ALL TREATMENTS

		CRAM/U/1/C	CRAM/U/2/C	CRAM/U/3/C	CRAM/U/4/C	CRAM/U/	CRAM/U/1/MM	CRAM/U/2/MM	CRAM/U/3/MM	CRAM/U/4/MM	CRAM/U/5/MM	CRAM/U/1/M	CRAM/U/2/M	CRAM/U/3/M	CRAM/U/4/M	CRAM/U/5/M
ANAR	Anagallis arvensis															
AVBA	Avena barbata			3		4	4		13			5		1	3	
BAGR	Bare Ground								3			1				
BRCA	Bromus carinatus															
BRDI	Bromus diandrus	1		5		3			2					28		
BRMI	Briza minor			13	10		2	4	19	9	13		1	1		
BRMO	Bromus hordeaceus	8	3	10	3	15			12	3	9	2	3	3	5	11
CADE	Carex densa															
CAPR	Carex praegracilis															
CASP	Carex species															
CHPO	Chlorogalum pomeridianum															
COAR	Convolvulus arvensis	26					19					19				
DACA	Danthonia californica			2	1			16		24	8		37	20	30	6
DIFU	Dipsacus fullonum															
DISP	Distichlis spicata															
DOCO	Downingia concolor															
ELAC	Eleocharus acicularis															
ELMA	Eleocharus macrostachya				1											
ERAR	Eryngium aristulatum								2							
ERBO	Erodiom botrys	2		2	3		1		12	6		1		7	5	
ERCI	Erodium cicutarium					6		2			12		1			9
HOBR	Hordeum brachyantherum	1	8					1				7	2			
HOMA	Hordeum marinium ssp.gussoneaum	4	1				4				1				1	
JUOC	Juncus occidentalis		5		1					2			1			1
JUPH	Juncus phaeocephalus		1					12			2		7			
LAGL	Lasthenia glaberrima															
LASP	Lactuca species															
LIVI	Limnanthes vinculans														2	
LOMU	Lolium multiflorum	103	86	110	114	153	118	93	69	49	101	129	83	41	56	46
LUSP	Lupinus species			1												
MEPU	Mentha pulegium															
OEOV	Oenothera ovata															
PAVI	Parentucellia viscosa															
PHAQ	Phalaris aquatica															
PLCA	Pleuropogon californicus															
PLLA	Plantago lanceolata						1									
POMA	Polypogon maritimus								2							
RAPU	Ranunculus pusillus															
RUAC	Rumex acetocella		7							5			9	2	5	
RUCO	Rumex conglomeratus															
RUCR	Rumex crispus		1													
RUPU	Rumex pulchra															
SOAS	Sonchus asper															
THCH	Thatch	3	4	1			4				8	4				
TRSP	Trifolium species															
UNFO	Forb species	6	2		1	3	10				1	6		1		
UNGR	Grass species		10													
VIS2	Vicia sativa ssp. nigra															
VISA	Vicia sativa ssp. sativa	6					7									
VUOC	Vulpia octoflora var. octoflora	40	62	53	66	16	30	72	66	102	47	26	56	96	93	127

FEMA UPLAND - ALL TREATMENTS

		FEMA/U/1/C	FEMA/U/2/C	FEMA/U/3/C	FEMA/U/4/C	FEMA/U/5/C	FEMA/U/1/MM	FEMA/U/2/MM	FEMA/U/3/MM	FEMA/U/4/MM	FEMA/U/5/MM	FEMA/U/1/M	FEMA/U/2/M	FEMA/U/3/M	FEMA/U/4/M	FEMA/U/5/M
ANAR	Anagallis arvensis															
AVBA	Avena barbata		5					3	3				1			2
BAGR	Bare Ground															
BRCA	Bromus carinatus	6		46			1		6							
BRDI	Bromus diandrus			1		9	9		4	1				2		5
BRMI	Briza minor		2	13	6						1	1	5			3
BRMO	Bromus hordeaceus	3	2	13		5	2	3	14	4	10	1	6	4	4	4
CADE	Carex densa															
CAPR	Carex praegracilis															
COAR	Convolvulus arvensis						4		9							
CASP	Carex species	32			1									3	7	
CHPO	Chlorogalum pomeridianum		14		2								23			9
COAR	Convolvulus arvensis	8		20								7		2		
DACA	Danthonia californica			3			1		4			1		3		
DIFU	Dipsacus fullonum	21	13		31			3				7			21	1
DISP	Distichlis spicata															
DOCO	Downingia concolor															
ELAC	Eleocharus acicularis															
ELMA	Eleocharus macrostachya				1	2										
ERAR	Eryngium aristulatum													1		
ERBO	Erodiom botrys		2								1					1
ERCI	Erodium cicutarium															
HOBR	Hordeum brachyantherum										3			1		
HOMA	Hordeum marinium ssp.gussoneaum							19	2				1	1		
HOMU	Hordeum m								4							
JUOC	Juncus occidentalis	10		1												
JUPH	Juncus phaeocephalus				4						3	2				
LAGL	Lasthenia glaberrima															
LASP	Lactuca species					6					1					
LIVI	Limnanthes vinculans															
LOMU	Lolium multiflorum	92	81	61	80	123	111	65	78	164	126	113	83	129	69	58
LUSP	Lupinus species							2					8			
MEPU	Mentha pulegium															
OEOV	Oenothera ovata															
PAVI	Parentucellia viscosa				2		1									
PHAQ	Phalaris aquatica															
PLCA	Pleuropogon californicus	1												2		
PLLA	Plantago lanceolata				1											1
POMA	Polypogon maritimus	1			2											
RAPU	Ranunculus pusillus															
RUAC	Rumex acetocella		4						1							7
RUCO	Rumex conglomeratus															1
RUCR	Rumex crispus	1				2								1		
RUPU	Rumex pulchra															
SOAS	Sonchus asper	9			3	4	5		1	4		16		1		2
THCH	Thatch	1			6	3	2		1					2	1	
TRSP	Trifolium species		1								4					1
UNFO	Forb species		4		7		1	6					3			
UNGR	Grass species											1				
VIS2	Vicia sativa ssp. nigra															
VISA	Vicia sativa ssp. sativa	13	33		47	6	58	70	62	11	43	38	47	25	85	52
VUOC	Vulpia octoflora var. octoflora	2	39	42	7	40	5	22	11	16	8	13	23	23	13	53

HART UPLAND - ALL TREATMENTS

		HART/U/1/C	HART/U/2/C	HART/U/3/C	HART/U/4/C	HART/U/5/C	HART/U/1/MM	HART/U/2/MM	HART/U/3/MM	HART/U/4/MM	HART/U/5/MM	HART/U/1/M	HART/U/2/M	HART/U/3/M	HART/U/4/M	HART/U/5/M
ANAR	Anagallis arvensis					1					1			1	4	1
AVBA	Avena barbata	1	4		2	15		37	21	4	5	5	17	17	5	19
BAGR	Bare Ground							1	3	1				1	7	1
BRCA	Bromus carinatus															
BRDI	Bromus diandrus	3	4	2	9			37	43	36			14	47	21	
BRMI	Briza minor					4					1				2	1
BRMO	Bromus hordeaceus	22	18	10	4	2	17	10	10	5	16	9	10	17	1	5
CADE	Carex densa	2														
CAPR	Carex praegracilis															
CASP	Carex species															
CHPO	Chlorogalum pomeridianum															
COAR	Convolvulus arvensis	5	8	4	1	3	3	4	3	5	3	3	9	5	1	3
DACA	Danthonia californica	5	6			8			30	11	6	7	15	34	8	1
DIFU	Dipsacus fullonum															
DISP	Distichlis spicata	1														
DOCO	Downingia concolor															
ELAC	Eleocharus acicularis				1											
ELMA	Eleocharus macrostachya														1	
ERAR	Eryngium aristulatum															
ERBO	Erodiom botrys		2			1					2		2			20
ERCI	Erodium cicutarium				1				3	6				10	51	
HOBR	Hordeum brachyantherum	6	3				27	1				6	2			
HOMA	Hordeum marinium ssp.gussoneaum	1			2		2	1	3		11	7				2
JUME	Juncus mexicanus											2				
JUOC	Juncus occidentalis											2				
JUPH	Juncus phaeocephalus															
LAGL	Lasthenia glaberrima															
LASP	Lactuca species															
LIVI	Limnanthes vinculans															
LOMU	Lolium multiflorum	149	73	179	124	123	118	31	48	80	115	149	40	42	47	109
LUSP	Lupinus species															
MEPU	Mentha pulegium															
PAVI	Parentucellia viscosa													1	5	
PHAQ	Phalaris aquatica	5														
PLCA	Pleuropogon californicus															
PLLA	Plantago lanceolata						1		2							
POMA	Polypogon maritimus															
RAPU	Ranunculus pusillus															
RUAC	Rumex acetocella					1	1	1	3					1		2
RUCO	Rumex conglomeratus															
RUCR	Rumex crispus	1		1												1
SOAS	Sonchus asper															
THCH	Thatch	3	8		15	6		5	1	2			4		5	2
TRSP	Trifolium species						2			1	1		1		13	3
UNFO	Forb species	8				1			3	1			1			
UNGR	Grass species					1										
VIS2	Vicia sativa ssp. nigra															
VISA	Vicia sativa ssp. sativa															
VUOC	Vulpia octoflora var. octoflora	10	54	4	41	34	29	72	27	48	39	10	85	24	29	30

APPENDIX E:

Relative cover data for dominant taxa by plot

Cramer - Margins 2000 - Block data

	C1	**C2**	**C3**	**C4**	**C5**
Lomu	53	28.5	47.5	53.5	85
Coar	25	0	0	0	0
Plca	0	24	8.5	2.5	7.5
Juph	1	15.5	11.5	6.5	0
Elma	1	7.5	8	1	3
Vuoc	7.5	0	2	10	1
Livi	0	3.5	1	0	0
That	3	6.5	11.5	3	0

	C1	C2	C3	C4	C5
Poma	0	6	0	0	0
Difu	0	0	0	0	0
Mepu	0	5	2.5	1	0
Rucr	0	1	1	0	1
Erar	0	0	0	0	0
Doco	0	0	0	0	0
Homa	0	0	1	0	1
Lagl	0	0	0	1	0

	Mm 1	**Mm 2**	**Mm 3**	**Mm 4**	**Mm5**
Lomu	58.5	39	46.5	72.5	81
Coar	25.5	0	0	0	0
Plca	0	31	18	0	3
Juph	0	3	4.5	1	0
Elma	3.5	15	3	2	11.5
Vuoc	1	0	11	13	2
Livi	0	1.5	2	0	0
That	7.5	3	1	0	0

	Mm 1	Mm 2	Mm 3	Mm 4	Mm 5
Poma	0	1	1	0	0
Difu	0	0	0	0	0
Mepu	0	1	2	1	0
Rucr	0	0	1	0	0
Erar	2	1	2	1	0
Doco	0	0	0	0	0
Homa	0	1	0	0	0
Lagl	0	1.5	1	0	0

Cramer Margins 2000 (cont)

	Mr 1	**Mr 2**	**Mr 3**	**Mr 4**	**Mr 5**
Lomu	62.5	12.5	63.5	56.5	86
Coar	14	0	0	0	0
Plca	0	24	10.5	0	3
Juph	2	14.5	6.5	1	0
Elma	2	10	6	1	5.5
Vuoc	12.5	0	0	19	0
Livi	0	3	1	0	0
That	1.5	0	3	0	1

	Mr 1	Mr 2	Mr 3	Mr 4	Mr 5
Poma	0	2	0	0	0
Difu	0	0	0	0	0
Mepu	0	8	2	1	0
Rucr	0	1	1	0	2.5
Erar	0	0	1	0	0
Doco	0	0	0	0	0
Homa	0	0	1.5	0	1
Lagl	0	9	0	0	2

Cramer - Uplands 2000 - Block Data

	C1	**C2**	**C3**	**C4**	**C5**
Lomu	51.5	43	55	57	76.5
Coar	13	0	0	0	0
Brmo	4	1.5	5	1.5	7.5
Brdi	1	0	2.5	0	1.5
Brmi	0	0	6.5	5	0
Avba	0	0	1.5	0	2
Difu	0	0	0	0	0
Visa	3	0	0	0	0
Hobr	1	4	0	0	0
Daca	0	0	1	1	0
Vuoc	20	31	26.5	33	8
Livi	0	0	0	0	0
That	1.5	2	1	0	0

	C1	C2	C3	C4	C5
Poma	0	0	0	0	0
Difu	0	0	0	0	0
Mepu	0	0	0	0	0
Rucr	0	1	0	0	0
Erar	0	0	0	0	0
Chpo	0	0	0	0	0
Homa	2	1	0	0	0
Rapu	0	0	0	0	0

Cramer Uplands 2000 (cont)

	Mm 1	Mm2	Mm3	Mm 4	Mm 5
Lomu	59	46.5	34.5	24.5	50.5
Coar	9.5	0	0	0	0
Brmo	0	0	6	1.5	4.5
Brdi	0	0	1	0	0
Brmi	1	2	9.5	4.5	6.5
Avba	2	0	6.5	0	0
Difu	0	0	0	0	0
Visa	3.5	0	0	0	0
Hobr	0	1	0	0	0
Daca	0	8	0	12	4
Vuoc	15	36	33	51	23.5
Livi	0	0	0	0	0
That	2	0	0	0	3

	Mm 1	Mm2	Mm3	Mm 4	Mm 5
Poma	0	0	1	0	0
Difu	0	0	0	0	0
Mepu	0	0	0	0	0
Rucr	0	0	0	0	0
Erar	0	0	1	0	0
Chpo	0	0	0	0	0
Homa	2	0	0	0	1
Rapu	0	0	0	0	0

	Mr 1	Mr 2	Mr 3	Mr 4	Mr 5
Lomu	64.5	41.5	20.5	28	23
Coar	9.5	0	0	0	0
Brmo	1	1.5	1.5	2.5	5.5
Brdi	0	0	14	0	0
Brmi	0	1	1	0	0
Avba	2.5	0	1	1.5	0
Difu	0	0	0	0	0
Visa	0	0	0	0	0
Hobr	3.5	1	0	0	0
Daca	0	18.5	10	15	3
Vuoc	13	28	48	41.5	63.5
Livi	0	0	0	1	0
That	2	0	0	0	0

Cramer Uplands 2000 (cont)

	Mr 1	Mr 2	Mr 3	Mr 4	Mr 5
Poma	0	0	0	0	0
Difu	0	0	0	0	0
Mepu	0	0	0	0	0
Rucr	0	0	0	0	0
Erar	0	0	0	0	0
Chpo	0	0	0	0	0
Homa	0	0	0	1	0
Rapu	0	0	0	0	0

FEMA - Margins 2000 - Block data

	C1	**C2**	**C3**	**C4**	**C5**
Lomu	26	56	4	75.5	27.5
Coar	0	7	2	0	9.5
Plca	33	14	10.5	3.5	3.5
Juph	16.5	0	12.5	3	22
Elma	4	4.5	33.5	4	3
Vuoc	1	0	0	1	3.5
Livi	0	1	0	0	0
That	2	0	6	2.5	8

	C1	C2	C3	C4	C5
Poma	6	1	1	0	6.5
Difu	0	6.5	1.5	0	0
Mepu	4.5	1	6	0	2
Rucr	2	3	3.5	0	1
Erar	7	5.5	1	0	10
Doco	0	0	0	0	0
Homa	1	1	0	0	0
Lagl	0	1	0	0	0

	Mm 1	**Mm 2**	**Mm 3**	**Mm 4**	**Mm 5**
Lomu	45.5	61	2	54.5	2.5
Coar	1	0	5.5	0	0
Plca	7	13	3	1.5	0
Juph	5	0	32.5	1	57
Elma	1.5	11.5	23.5	1	0
Vuoc	5	1.5	0	12.5	1
Livi	0	0	0	0	0
That	2	0	3.5	1	7.5

	Mm 1	Mm 2	Mm 3	Mm 4	Mm 5
Poma	1.5	0	5.5	7	11
Difu	0	0	2.5	2.5	1
Mepu	1	0	6	0	6
Rucr	1	2	3.5	0	1
Erar	2.5	2	2.5	0	2
Doco	0	0	0	0	0
Homa	0	0	0	0	0
Lagl	0	0	0	0	1

FEMA Margins 2000 (cont)

	Mr 1	**Mr 2**	**Mr 3**	**Mr 4**	**Mr 5**
Lomu	62	51.5	2.5	64	15
Coar	1	1	1	0	0
Plca	0	15	8.5	12	0
Juph	15.5	0	44.5	1	41
Elma	0	5.5	14.5	7	1
Vuoc	2	0	0	12	1
Livi	0	1	0	0	0
That	8	0	2	2.5	9.5

	Mr 1	Mr 2	Mr 3	Mr 4	Mr 5
Poma	0	0	2.5	1	13.5
Difu	0	0	1	0	0
Mepu	1	1	21	0	8.5
Rucr	1	6	2	1	1
Erar	0	14.5	3	0	1
Doco	0	0	0	0	0
Homa	0	2	0	0	0
Lagl	0	0	0	0	1

FEMA - Uplands 2000 - Block Data

	C1	**C2**	**C3**	**C4**	**C5**
Lomu	46	40.5	30.5	40	61.5
Coar	4	0	10	0	0
Brmo	1.5	1	6.5	0	2.5
Brdi	0	0	1	0	0
Brmi	0	1	6.5	3	0
Avba	0	2.5	0	0	0
Difu	10.5	6.5	0	15.5	0
Visa	6.5	16.5	0	23.5	3
Hobr	0	0	0	0	0
Daca	0	0	1.5	0	0
Vuoc	1	19.5	21	3.5	20
Livi	0	0	0	0	0
That	1	0	0	3	1.5

	C1	C2	C3	C4	C5
Poma	1	0	0	1	0
Difu	10.5	6.5	0	15.5	0
Mepu	0	0	0	0	0
Rucr	1	0	0	0	1
Erar	0	0	0	0	0
Chpo	0	7	0	1	0
Homa	0	0	0	0	0
Rapu	0	0	0	0	0

FEMA Uplands 2000 (cont)

	Mm 1	**Mm 2**	**Mm 3**	**Mm 4**	**Mm 5**
Lomu	55.5	32.5	38	82	63
Coar	2	0	4.5	0	0
Brmo	1	1.5	7	2	5
Brdi	4.5	0	2	1	0
Brmi	0	0	0	0	1
Avba	0	1.5	1.5	0	0
Difu	0	1.5	0	0	0
Visa	29	35	31	5.5	21.5
Hobr	0	0	0	0	1.5
Daca	1	0	2	0	0
Vuoc	2.5	11	5.5	8	4
Livi	0	0	0	0	0
That	1	0	1	0	0

	Mm 1	Mm 2	Mm 3	Mm 4	Mm 5
Poma	0	0	0	0	0
Difu	0	1.5	0	0	0
Mepu	0	0	0	0	0
Rucr	0	0	0	0	0
Erar	0	0	0	0	0
Chpo	0	0	0	0	0
Homa	0	9.5	1	0	0
Rapu	0	0	0	0	0

	Mr 1	**Mr 2**	**Mr 3**	**Mr 4**	**Mr 5**
Lomu	56.5	41.5	64.5	34.5	29
Coar	3.5	0	1	0	0
Brmo	1	3	2	2	2
Brdi	0	0	1	0	2.5
Brmi	1	2.5	0	0	1.5
Avba	0	1	0	0	1
Difu	3.5	0	0	10.5	1
Visa	19	23.5	12.5	42.5	26
Hobr	0	0	1	0	0
Daca	1	0	1.5	0	0
Vuoc	6.5	11.5	11.5	6.5	26.5
Livi	0	0	0	0	0
That	0	0	1	1	0

FEMA Uplands 2000 (cont)

	Mr 1	Mr 2	Mr 3	Mr 4	Mr 5
Poma	0	0	0	0	0
Difu	3.5	0	0	10.5	1
Mepu	0	0	0	0	0
Rucr	0	0	1	0	0
Erar	0	0	1	0	0
Chpo	0	11.5	0	0	4.5
Homa	0	1	1	0	0
Rapu	0	0	0	0	0

Haroutunian - Margins 2000 - Block data

	C1	**C2**	**C3**	**C4**	**C5**
Lomu	58.5	28	58.5	42.5	73
Coar	1.5	1	1	0	0
Plca	5.5	0	1	1.5	2.5
Juph	0	0	0	0	0
Elma	0	7	0	4	0
Vuoc	3	20.5	0	4.5	15.5
Livi	0	0	0	0	0
That	9	6.5	0	19	1.5

	C1	C2	C3	C4	C5
Poma	0	0	0	0	0
Difu	0	0	0	0	0
Mepu	0	0	0	0	0
Rucr	2	0	0	2	1.5
Erar	0	1	1	1	0
Doco	0	0	0	1	0
Homa	5	1	3	1.5	1
Lagl	0	0	0	2.5	0

	Mm 1	**Mm 2**	**Mm 3**	**Mm 4**	**Mm 5**
Lomu	46	5.5	66.5	35	46
Coar	0	1	1	0	2
Plca	0	4	0	4	19.5
Juph	0	12.5	0	1	1
Elma	0	25.5	0	9	1
Vuoc	7	2	0	4.5	0
Livi	0	0	0	0	0
That	1	3.5	0	4	8

	Mm 1	Mm 2	Mm 3	Mm 4	Mm 5
Poma	0	0	0	0	0
Difu	0	0	0	0	0
Mepu	0	0	0	0	0
Rucr	1	8	1	0	0
Erar	0	1	0	6	13
Doco	0	0	0	0	1
Homa	0	0	0	2.5	8
Lagl	0	0	0	7.5	0

Haroutunian Margins 2000 (cont)

	Mr 1	**Mr 2**	**Mr 3**	**Mr 4**	**Mr 5**
Lomu	67.5	51.5	40	60	29.5
Coar	1.5	1	1	1	3.5
Plca	0	1	16	3.5	23.5
Juph	0	1	0	0	1
Elma	0	0	3	2	2
Vuoc	2.5	11	0	1	0
Livi	0	0	0	0	0
That	1	3.5	0	4	8

	Mr 1	Mr 2	Mr 3	Mr 4	Mr 5
Poma	0	0	0	0	0
Difu	0	1.5	0	0	0
Mepu	0	0	0	0	0
Rucr	1	1	1	0	0
Erar	0	0	1	3	7
Doco	0	0	0	1	0
Homa	0	1.5	1	4	3.5
Lagl	0	0	0	0	6

Haroutunian - Uplands 2000 - Block Data

	C1	**C2**	**C3**	**C4**	**C5**
Lomu	74.5	36.5	89.5	62	61.5
Coar	2.5	4	2	1	1.5
Brmo	11	9	5	2	1
Brdi	1.5	2	1	4.5	0
Brmi	0	0	0	0	2
Avba	1	2	0	1	7.5
Difu	0	0	0	0	0
Visa	0	0	0	0	0
Hobr	3	1.5	0	0	0
Daca	2.5	3	0	0	4
Vuoc	5	27	2	20.5	17
Livi	0	0	0	0	0
That	1.5	4	0	7.5	3

	C1	C2	C3	C4	C5
Poma	0	0	0	0	0
Difu	0	0	0	0	0
Mepu	0	0	0	0	0
Rucr	1	0	1	0	0
Erar	0	0	0	0	0
Chpo	0	0	0	0	0
Homa	1	0	0	1	0
Rapu	0	0	0	0	0

Haroutunian Uplands 2000 (cont)

	Mm 1	**Mm 2**	**Mm 3**	**Mm 4**	**Mm 5**
Lomu	59	15.5	24	40	57.5
Coar	1.5	2	1.5	2.5	1.5
Brmo	8.5	5	5	2.5	8
Brdi	0	18.5	21.5	18	0
Brmi	0	0	0	0	1
Avba	0	18.5	10.5	2	2.5
Difu	0	0	0	0	0
Visa	0	0	0	0	0
Hobr	13.5	1	0	0	0
Daca	0	0	15	5.5	3
Vuoc	14.5	36	13.5	24	19.5
Livi	0	0	0	0	0
That	0	2.5	1	1	0

	Mm 1	Mm 2	Mm 3	Mm 4	Mm 5
Poma	0	0	0	0	0
Difu	0	0	0	0	0
Mepu	0	0	0	0	0
Rucr	0	0	0	0	0
Erar	0	0	0	0	0
Chpo	0	0	0	0	0
Homa	1	1	1.5	0	5.5
Rapu	0	0	0	0	0

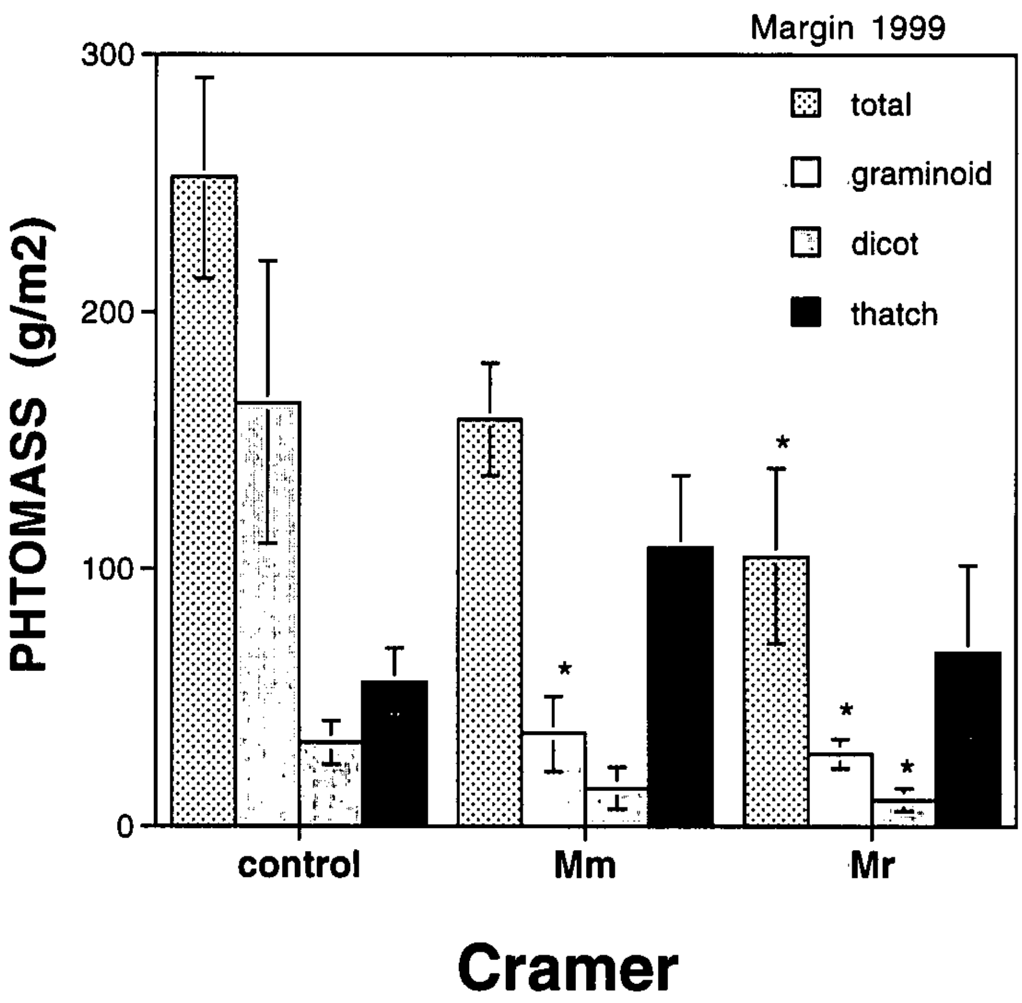
	Mr 1	**Mr 2**	**Mr 3**	**Mr 4**	**Mr 5**
Lomu	74.5	20	21	23.5	54.5
Coar	1.5	4.5	2.5	1	1.5
Brmo	4.5	5	8.5	1	2.5
Brdi	0	7	23.5	10.5	0
Brmi	0	0	0	1	1
Avba	2.5	8.5	8.5	2.5	9.5
Difu	0	0	0	0	0
Visa	0	0	0	0	0
Hobr	3	1	0	0	0
Daca	3.5	7.5	17	4	1
Vuoc	5	42.5	12	14.5	15
Livi	0	0	0	0	0
That	0	2	0	2.5	1

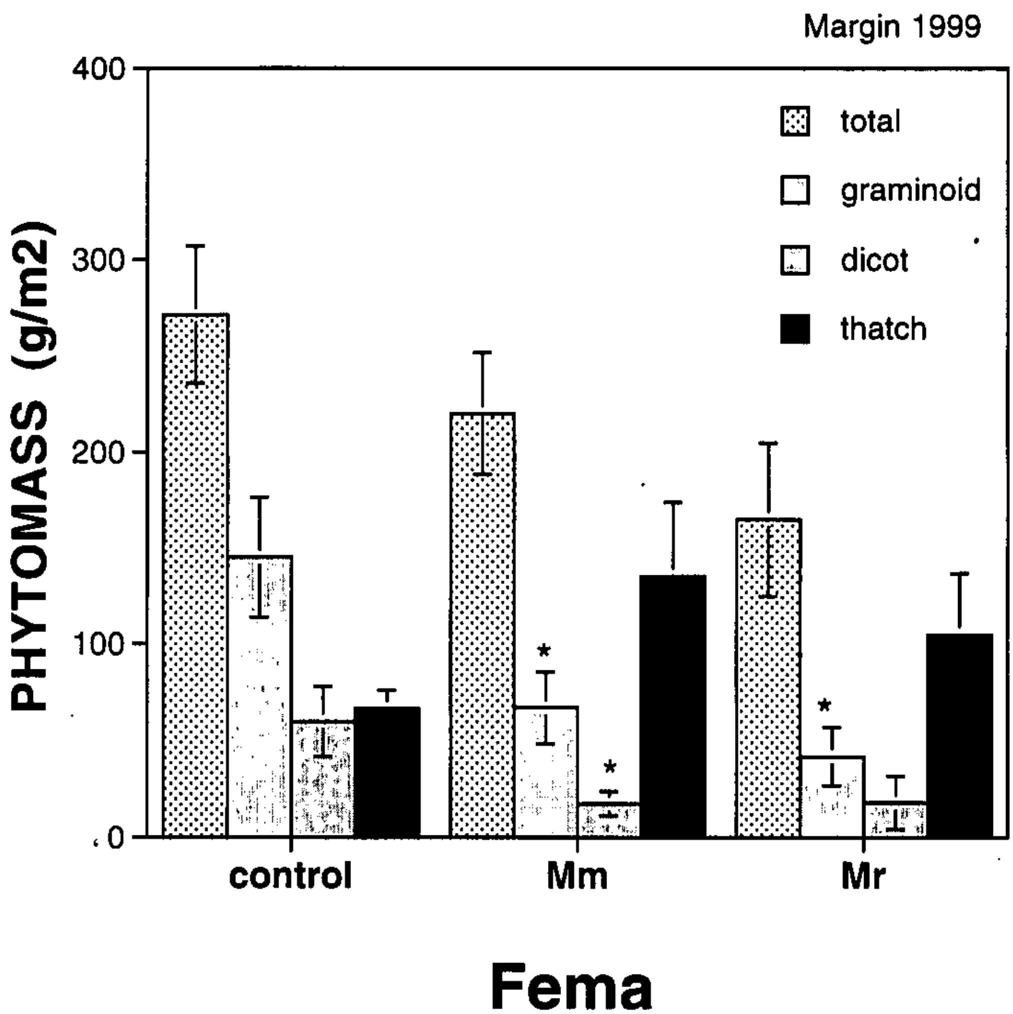
Haroutunian Uplands 2000 (cont)

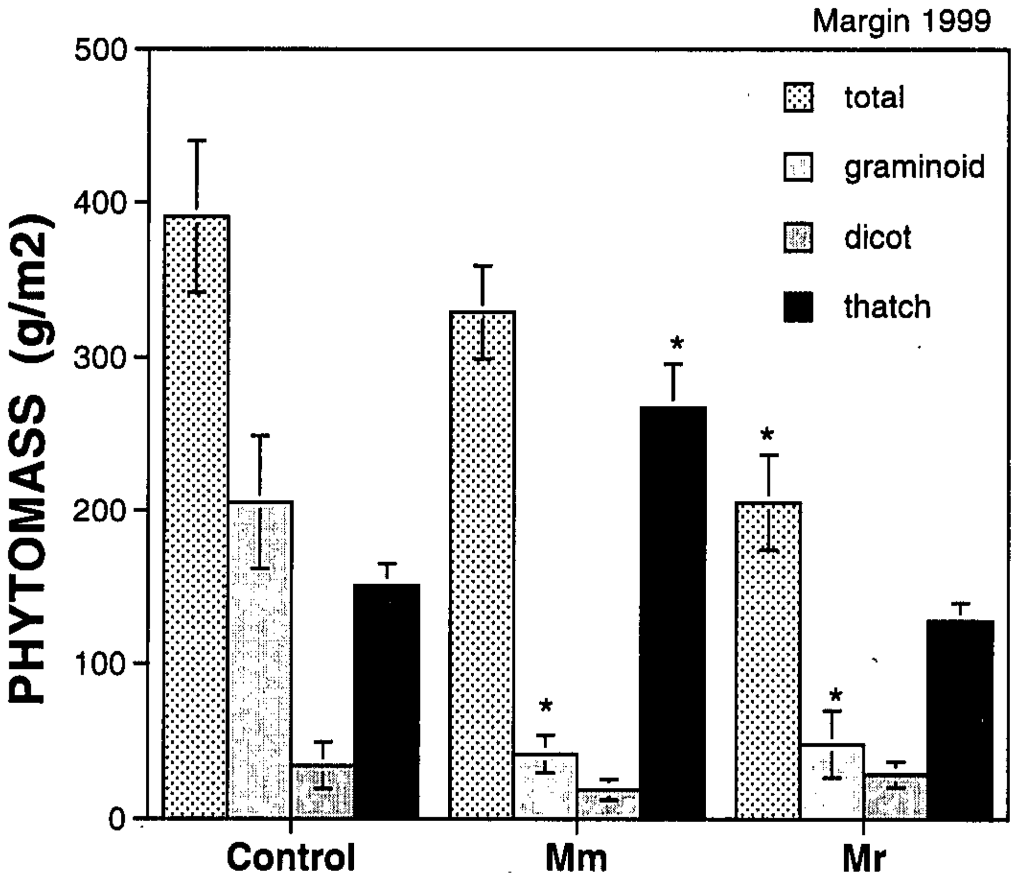
	Mr 1	Mr 2	Mr 3	Mr 4	Mr 5
Poma	0	0	0	0	0
Difu	0	0	0	0	0
Mepu	0	0	0	0	0
Rucr	0	0	0	0	1
Erar	0	0	1	0	0
Chpo	0	0	0	0	0
Homa	3.5	0	0	0	1
Rapu	0	0	0	0	0

APPENDIX F:

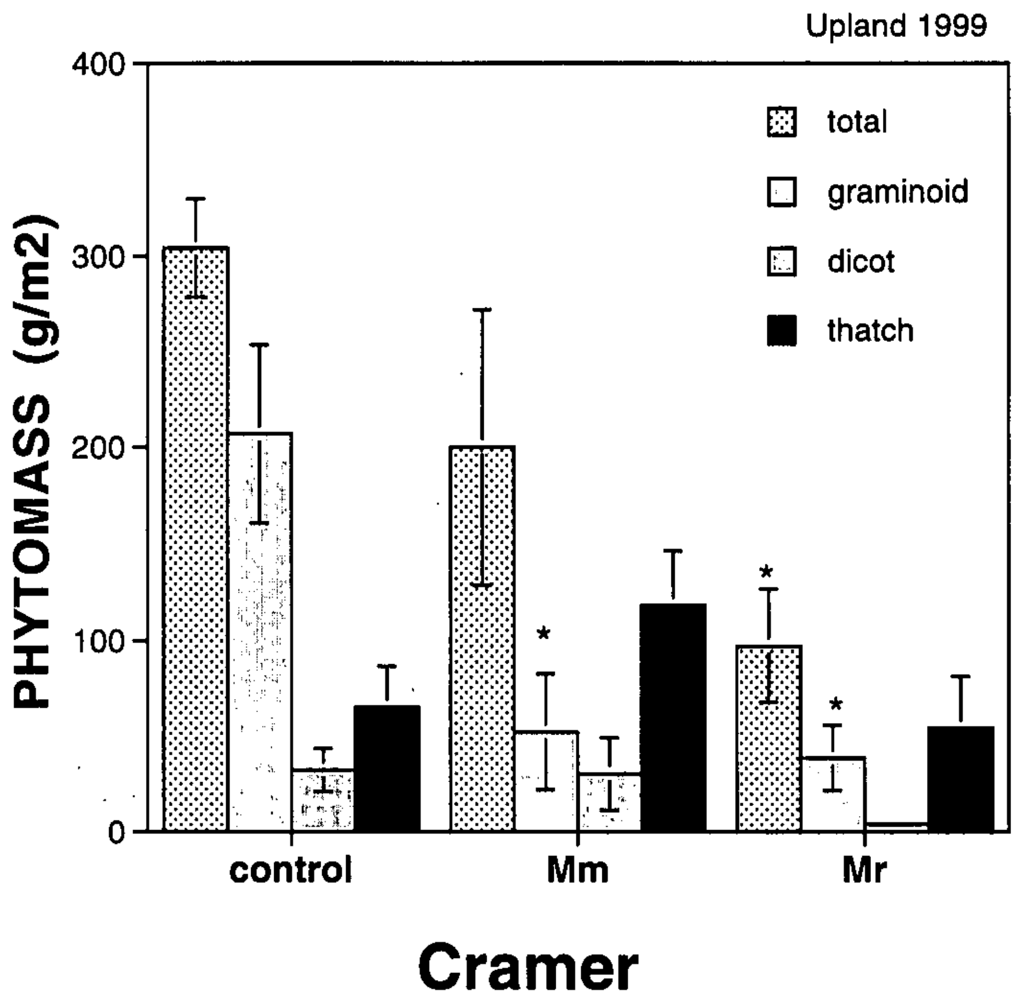
Property-specific phytomass data, Fall 1999

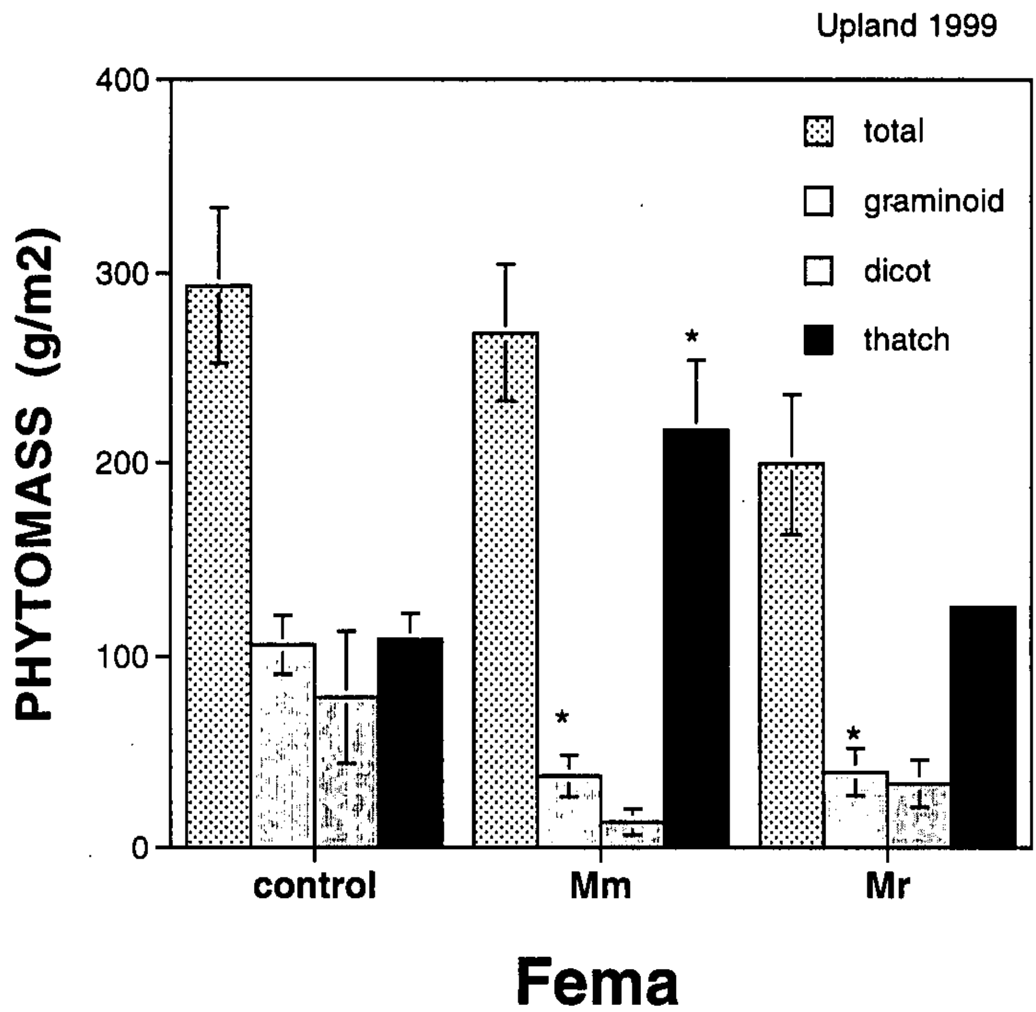

Margin 1999
300
200
100
0
PHTOMASS (g/m2)
total
graminoid
dicot
thatch
*
control
Mm
Mr
Cramer

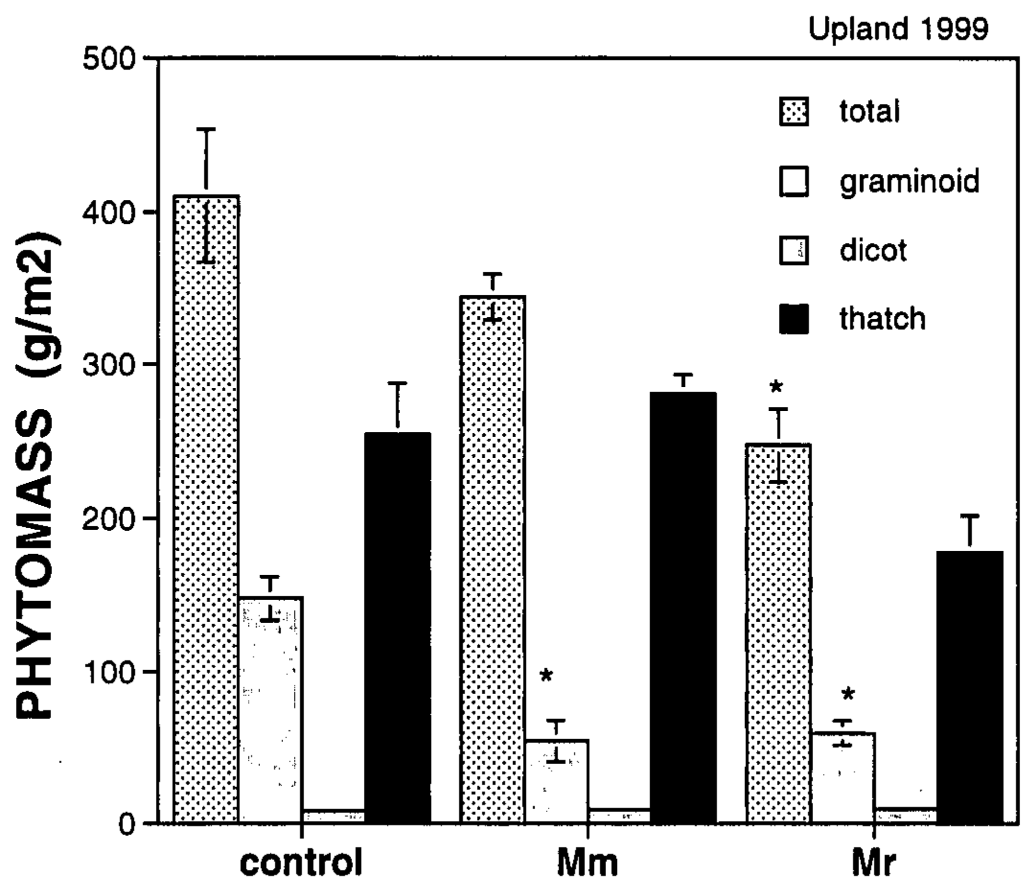

Margin 1999
PHYTOMASS (g/m2)
400
300
200
100
0
total
graminoid
dicot
thatch
*
*
*
control
Mm
Mr
Fema



Haroutunian


Upland 1999
PHYTOMASS (g/m2)
400
300
200
100
0
total
graminoid
dicot
thatch
*
*
*
control
Mm
Mr
Cramer

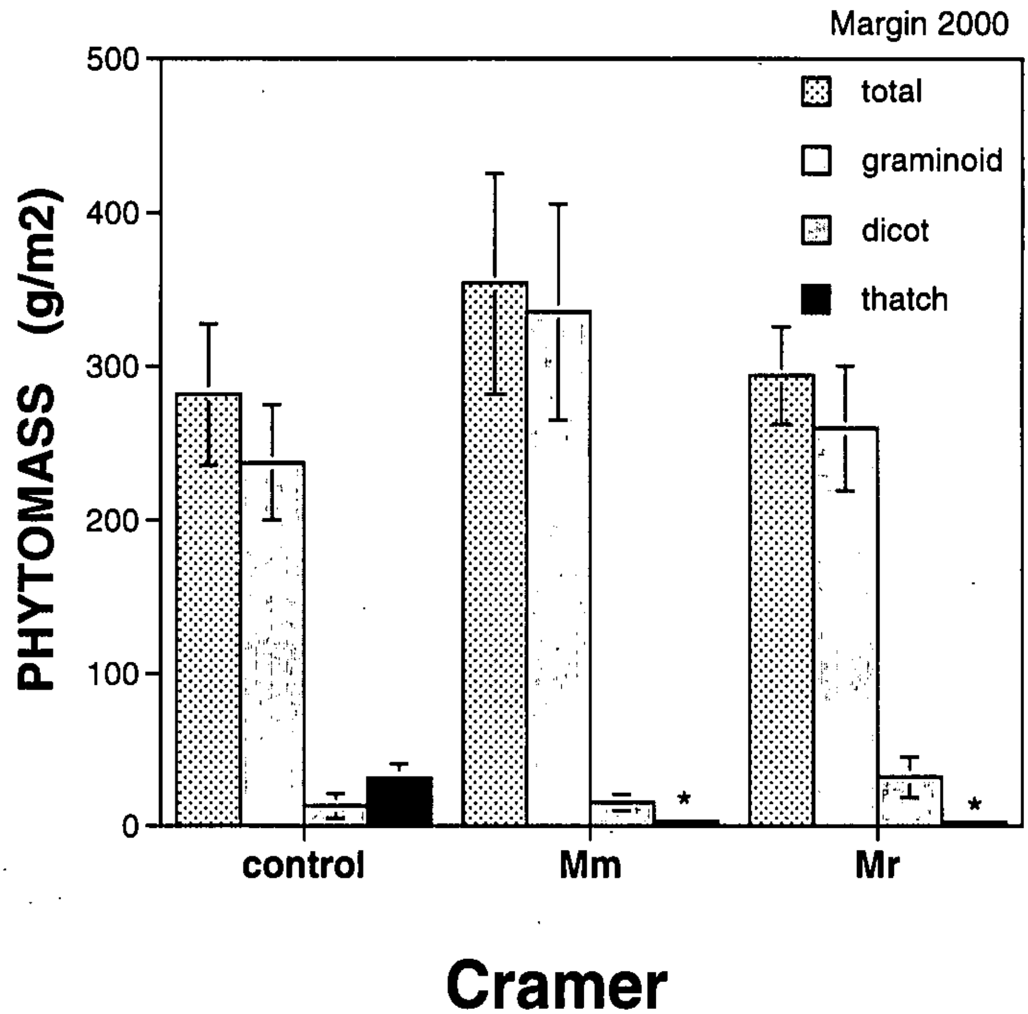

Upland 1999
PHYTOMASS (g/m2)
400
300
200
100
0
total
graminoid
dicot
thatch
*
*
*
control
Mm
Mr
Fema

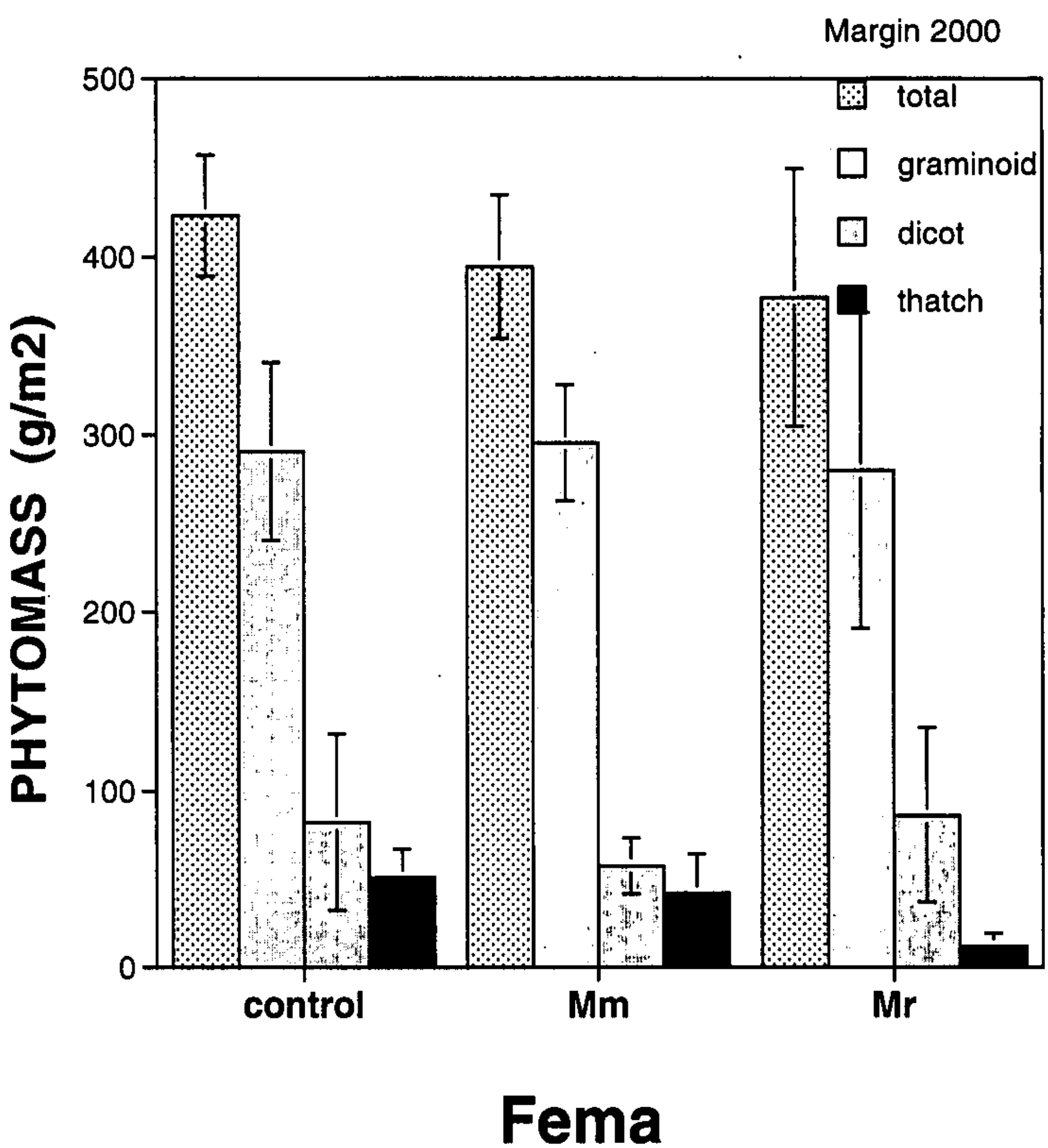


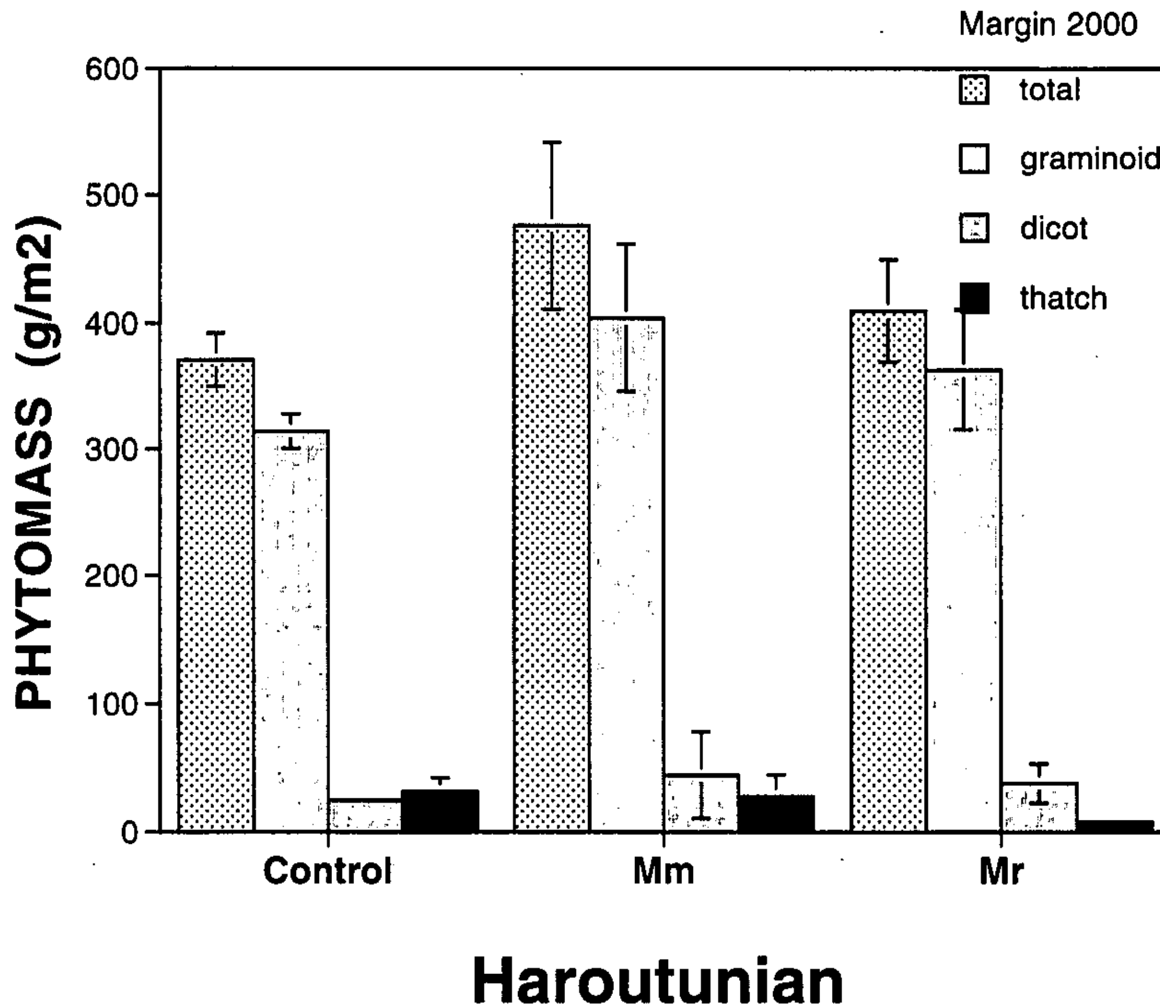
Haroutunian

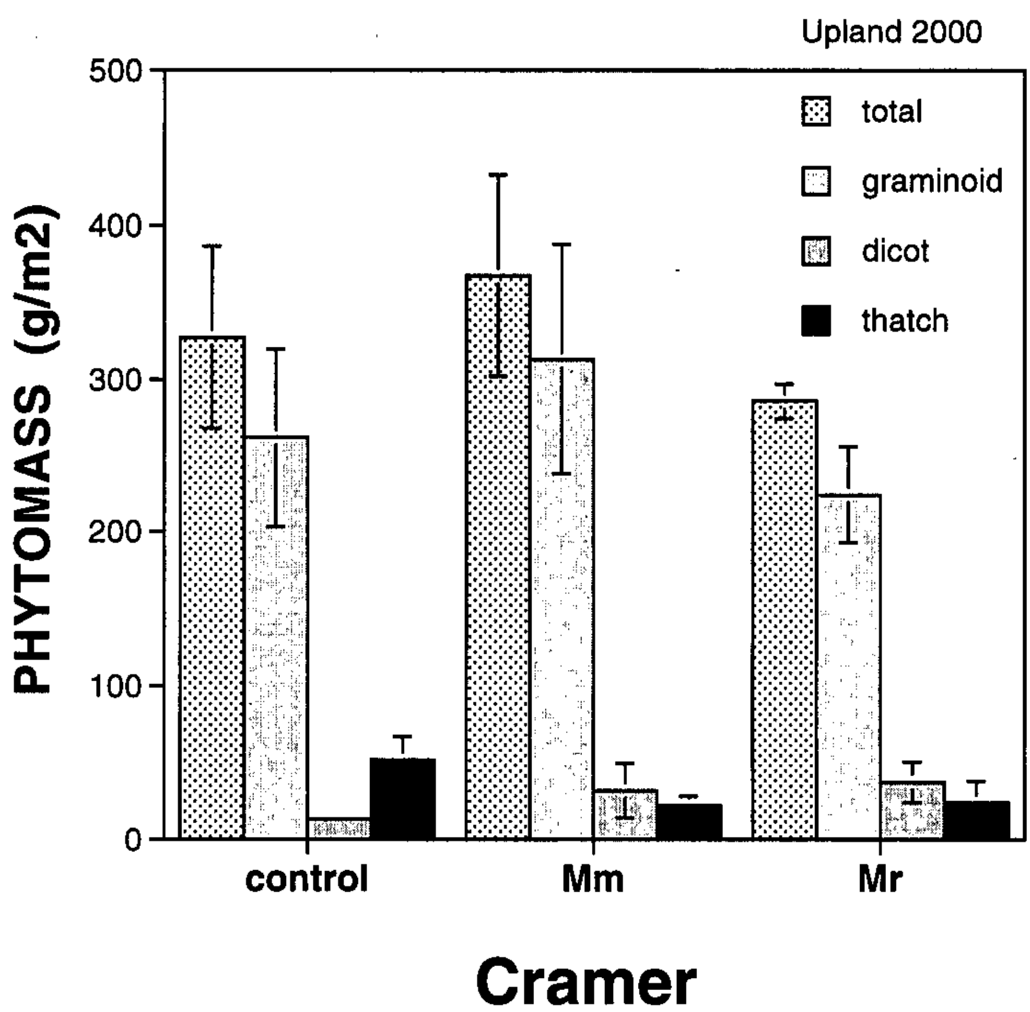
APPENDIX G:

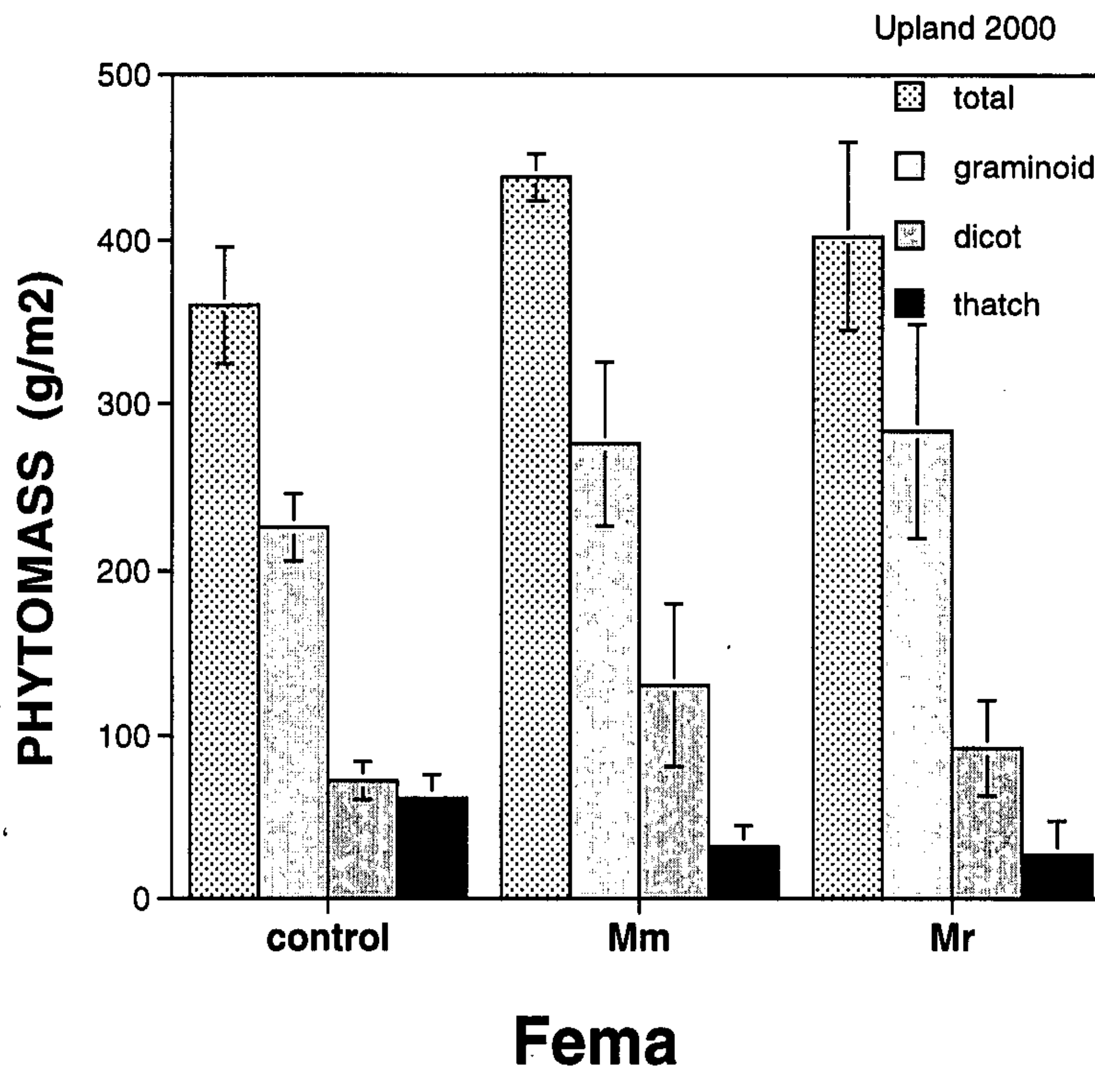
Property-specific phytomass data, Spring 2000

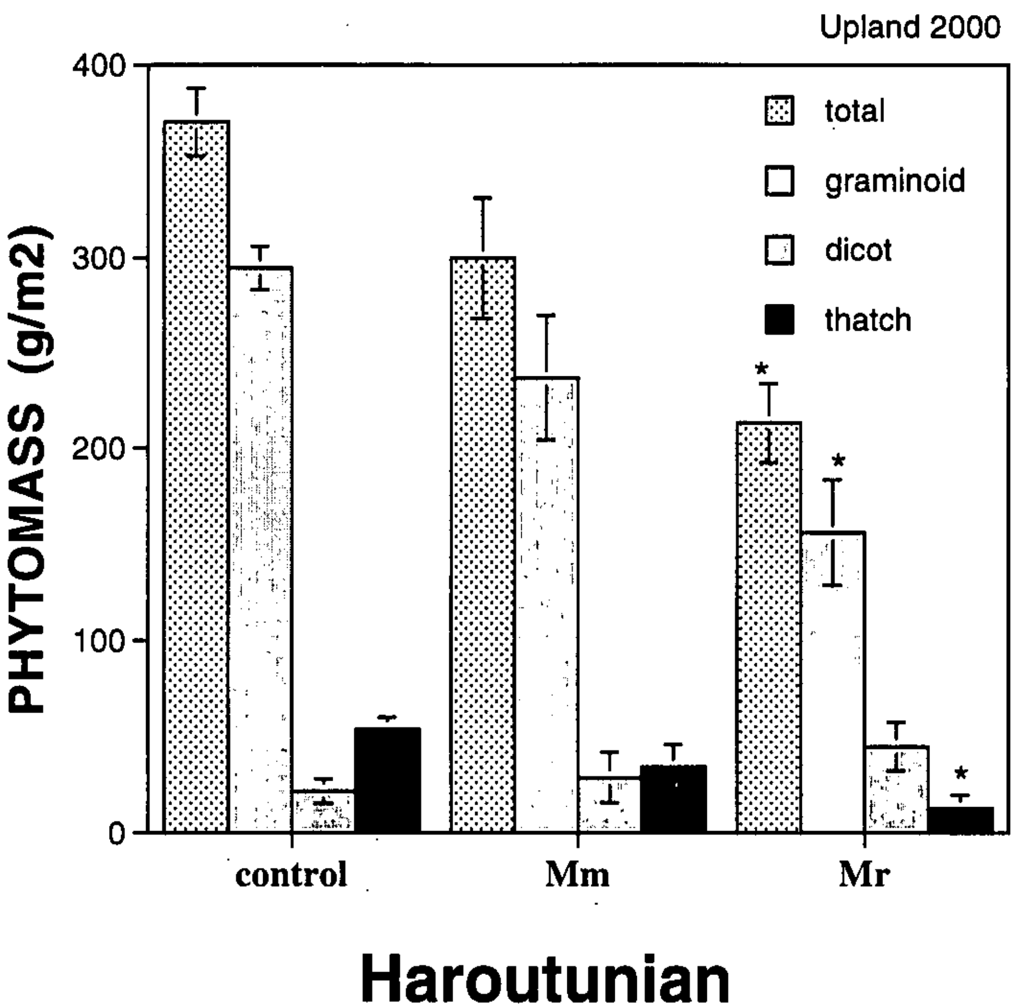

Margin 2000
total
graminoid
dicot
thatch
PHYTOMASS (g/m2)
500
400
300
200
100
0
*
*
control
Mm
Mr
Cramer


Margin 2000
total
graminoid
dicot
thatch
PHYTOMASS (g/m2)
0
100
200
300
400
500
control
Mm
Mr
Fema


Margin 2000
total
graminoid
dicot
thatch
PHYTOMASS (g/m2)
600
500
400
300
200
100
0
Control
Mm
Mr
Haroutunian


Upland 2000
total
graminoid
dicot
thatch
PHYTOMASS (g/m2)
500
400
300
200
100
0
control
Mm
Mr
Cramer


Upland 2000
total
graminoid
dicot
thatch
PHYTOMASS (g/m2)
0
100
200
300
400
500
control
Mm
Mr
Fema



Upland 2000
PHYTOMASS (g/m2)
400
300
200
100
0
total
graminoid
dicot
thatch
*
*
*
control
Mm
Mr
Haroutunian

APPENDIX H:

Soil chemistry data by plot, Fall 1999

Cramer
Soils 99

Sample #	Inventory	OM %	C-Org %	TKN %	NH4-N ppm	NO3-N ppm
Margin	**Control**					
1	C1M1	4.34	2.52	0.243	6.4	9.1
7	C2M1	3.30	1.91	0.146	8.2	2.0
13	C3M1	5.34	3.10	0.307	15.7	35.9
19	C4M1	3.19	1.85	0.146	17.3	12.1
25	C5M1	9.98	5.79	0.408	26.6	26.7
Margin	**Mm**					
2	C1M2	5.64	3.27	0.256	6.4	6.9
8	C2M2	5.08	2.95	0.230	11.4	9.3
14	C3M2	4.18	2.43	0.252	8.9	10.2
20	C4M2	4.91	2.85	0.230	14.4	9.2
26	C5M2	4.63	2.68	0.224	25.1	4.6
Margin	**Mr**					
3	C1M3	5.55	3.22	0.294	17.0	20.6
9	C2M3	4.67	2.71	0.219	12.5	11.4
15	C3M3	4.71	2.73	0.136	16.7	7.3
21	C4M3	4.03	2.34	0.194	11.0	7.3
27	C5M3	9.35	5.42	0.367	50.4	32.0
Upland	**Control**					
4	C1U1	6.17	3.58	0.342	7.5	10.7
10	C2U1	2.82	1.64	0.122	5.9	14.6
16	C3U1	2.79	1.62	0.125	6.9	7.9
22	C4U1	3.75	2.18	0.198	9.8	5.4
28	C5U1	4.46	2.59	0.243	9.0	4.6
Upland	**Mm**					
5	C1U2	5.17	3.00	0.273	6.9	6.9
11	C2U2	4.30	2.50	0.211	9.1	2.5
17	C3U2	3.53	2.05	0.137	11.8	6.7
23	C4U2	2.93	1.70	0.114	10.3	3.4
29	C5U2	2.82	1.64	0.142	6.8	1.9
Upland	**Mr**					
6	C1U3	4.42	2.57	0.231	7.0	3.3
12	C2U3	3.15	1.83	0.148	8.0	2.3
18	C3U3	3.23	1.87	0.125	6.3	1.7
24	C4U3	2.12	1.23	0.103	9.8	3.3
30	C5U3	3.83	2.22	0.145	7.8	2.8

FEMA
Soils 99

Sample #	Inventory	OM %	C-Org %	TKN %	NH4-N ppm	NO3-N ppm
Margin	**Control**					
1	F1M1	3.91	2.27	0.208	7.6	1.9
7	F2M1	3.12	1.81	0.144	12.1	1.4
13	F3M1	3.91	2.27	0.185	15.3	5.8
19	F4M1	4.68	2.71	0.209	6.5	8.3
25	F5M1	2.72	1.58	0.106	9.7	0.7
Margin	**Mm**					
2	F1M2	3.23	1.88	0.181	7.4	2.0
8	F2M2	3.12	1.81	0.146	7.6	0.9
14	F3M2	2.27	1.31	0.158	11.4	1.2
20	F4M2	4.82	2.80	0.185	7.4	6.3
26	F5M2	4.04	2.34	0.174	13.3	6.7
Margin	**Mr**					
3	F1M3	3.14	1.82	0.169	7.4	4.5
9	F2M3	2.27	1.31	0.158	11.4	1.2
15	F3M3	4.40	2.55	0.197	12.7	6.3
21	F4M3	2.68	1.55	0.212	13.7	8.3
27	F5M3	2.94	1.71	0.112	9.6	2.1
Upland	**Control**					
4	F1U1	4.57	2.65	0.267	5.2	1.3
10	F2U1	4.35	2.52	0.199	9.0	2.1
16	F3U1	2.77	1.60	0.095	4.9	1.8
22	F4U1	3.71	2.15	0.162	9.7	2.2
28	F5U1	3.23	1.88	0.144	10.7	1.6
Upland	**Mm**					
5	F1U2	3.56	2.07	0.144	6.4	2.4
11	F2U2	2.92	1.69	0.132	7.4	0.7
17	F3U2	3.96	2.30	0.168	7.0	3.7
23	F4U2	4.76	2.76	0.216	9.0	1.7
29	F5U2	3.19	1.85	0.198	9.6	1.9
Upland	**Mr**					
6	F1U3	4.68	2.71	0.218	5.7	5.9
12	F2U3	3.28	1.90	0.175	8.9	1.3
18	F3U3	3.96	2.30	0.204	13.4	2.5
24	F4U3	4.91	2.85	0.136	12.1	1.9
30	F5U3	3.30	1.92	0.167	9.0	1.6

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Sample #	Inventory	OM %	C-Org %	TKN %	NH4-N ppm	NO3-N ppm
Margin	**Control**					
1	H1M1	4.38	2.54	0.213	19.8	24.0
7	H2M1	5.08	2.95	0.294	22.8	9.6
13	H3M1	4.65	2.70	0.167	21.5	1.8
19	H4M1	2.66	1.54	0.117	14.3	3.2
25	H5M1	2.90	1.68	0.165	18.1	1.7
Margin	**Mm**					
2	H1M2	5.11	2.97	0.288	44.6	13.5
8	H2M2	4.99	2.90	0.408	24.1	8.2
14	H3M2	3.98	2.31	0.189	19.3	1.1
20	H4M2	5.60	3.25	0.293	21.5	5.6
26	H5M2	3.21	1.86	0.160	14.5	1.2
Margin	**Mr**					
3	H1M3	5.08	2.95	0.293	22.4	48.2
9	H2M3	5.20	3.02	0.340	22.5	24.4
15	H3M3	5.32	3.09	0.314	28.1	31.4
21	H4M3	3.66	2.12	0.189	17.8	1.8
27	H5M3	4.57	2.65	0.242	18.2	2.1
Upland	**Control**					
4	H1U1	4.24	2.46	0.217	17.7	2.9
10	H2U1	3.05	1.77	0.134	35.1	6.3
16	H3U1	3.98	2.31	0.180	12.4	4.2
22	H4U1	3.93	2.28	0.152	15.0	1.7
28	H5U1	4.51	2.62	0.187	12.8	1.5
Upland	**Mm**					
5	H1U2	3.49	2.03	0.187	12.0	3.3
11	H2U2	2.66	1.54	0.099	18.4	14.1
17	H3U2	4.01	2.33	0.167	13.0	3.7
23	H4U2	1.50	0.87	0.069	8.3	0.6
29	H5U2	2.79	1.62	0.108	10.6	1.5
Upland	**Mr**					
6	H1U3	3.76	2.18	0.184	14.3	4.7
12	H2U3	3.17	1.84	0.121	19.3	5.5
18	H3U3	2.96	1.72	0.104	14.9	4.4
24	H4U3	2.90	1.68	0.110	13.2	2.7
30	H5U3	2.92	1.69	0.115	9.7	2.0

APPENDIX I:

Caretaking the Santa Rosa Vernal Reserve System:

Who will meet the challenge of long-term management?

CARETAKING THE SANTA ROSA VERNAL RESERVE SYSTEM: CHALLENGES OF LONG-TERM MANAGEMENT

The science of long-term management of environmentally-significant lands is relatively new. Consequently, many organizations are continuously examining their management practices to determine which elements are most effective at meeting the goals of biodiversity preservation and ecological restoration. Our ability to do biological resource management depends heavily on economic foundations, institutional requirements, and scientific expertise. It can be influenced by the form of land ownership and the restrictions that come along with that ownership. Finally, we must learn from established organizations that are already grappling with funding, human resource, technical and human resource limitations. Therefore, the success of the Santa Rosa Vernal Reserve System (SRVRS) at preserving unique species and natural communities will be determined by how we provide sound management services into the indefinite future. This report provides a basis for evaluating and ultimately selecting a partner for providing long-term management services for SRVRS properties.

Economic, Institutional and Scientific Considerations

Perhaps one of the most challenging aspects of long-term management programs is the financial burden. Organizations involved with long-term management must have a financial base to support land acquisition, project staffing, scientific study, including long-term monitoring programs, physical infrastructure development and maintenance, daily operational expenses, administrative costs, and public relations campaigns. Depending on the size and stature of an organization, developing and maintaining this financial base can be achieved in a number of different ways. A large portion of every organization's operating budget is derived from private individual and/or corporate donations. Additionally, money can be raised from institutional grants, through the assemblage of capital partners and contractual management agreements, or from sale of land donated to or purchased at a discounted rate by the organization. For larger organizations, such as The Nature Conservancy (TNC), there is an option of creating credit card programs from which a portion of each purchase is donated directly to the organization.

Once money is raised, it is imperative that funds are invested to provide a continuous flow of capital. To this end, many of the larger land management organizations count economic advisers among their permanent staff. One of the key roles these staff members play is in the development of endowments for the organization. In the best case scenario, the amount of money brought into the project in the beginning is large enough to create a viable endowment that will support the long-term management program. However, since this is not often the case, most organizations find themselves in a situation where they are only able to fund a project a few years at a time. According to Mike Eaton, Director of the Cosumnes River Project (TNC) this continuing challenge to raise enough money to support programs in perpetuity is one of the reasons that TNC has begun to move away from being the primary partner in long-term management projects. One can imagine that if TNC, possibly the most economically sound conservation organization in the world, is deciding that the economic challenge of perpetual management is too great, financial burden may in fact be the single greatest challenge to conserving of our vast natural resources.

The second challenge for long-term conservation management is the institutional requirement. Often projects require large numbers of people to develop viable management plans, to carry out specific tasks and complete scientific studies, and to maintain monitoring programs for many years. As this field of land management grows, more educational institutions are offering major programs that prepare students for careers in this area. However, because of the great financial challenges faced by land management organizations and the nature of the non-profit sector, it is often difficult, especially for the smaller groups, to offer salaries that can compete with other industries. As a result of this, many organizations depend heavily on volunteer services. Because the social trend is beginning to swing towards awareness of the fragility and finite size of our natural resources, many more people are getting involved with management programs on a volunteer basis. Yet it is almost impossible to replace the value of a trained scientist, no matter the size of the volunteer base.

Finally, the scientific expertise required for long-term biological resource management is largely unavailable. Each species or ecosystem depends on a great variety of complex natural processes and relationships, so our knowledge is rudimentary and our tools are few. As a result, much of the scientific work done on management properties is experimental and narrowly applied. While this is not necessarily a drawback, it does require continuous inquiry, monitoring and adaptive management to expand the expertise. Sometimes, the other two challenges, economic and institutional structure, can restrict an organization's ability to do sufficient science or to overhaul a management program when necessary. Yet another challenge faced in this realm is the fact that reserves do not exist in a bubble, so that in addition to adapting to natural processes, managers also must adapt to changes in anthropogenic impacts.

Forms of Land Ownership

There are four common ownership situations that land management organizations can participate in for the environmentally-sensitive lands they steward. Each way has its advantages and drawbacks from the standpoint of providing essential long-term managment.

The first form of ownership is called "Fee Simple" or "Fee". When an organization owns a piece of land in Fee, either through purchase or donation, there are no limitations (other than zoning, building, and health codes) to what the managers can do on the land. Of course, this is the least complicated situation in terms of management, as the organization has complete discretion to conduct whatever projects it determines to be necessary. The main drawback to owning land in Fee, however, is that the entire financial burden of on-going stewardship is taken on by the organization. As with the Pixley Vernal Pool Preserve, owned in fee by the Center for Natural Lands Management (CNLM), it is usually most advantageous for an organization if the lands owned in fee are small and relatively easy to manage.

Probably the most popular form of ownership/management is partnership. Often, these alliances are formed between private management groups and public agencies. In this case, as the name implies, there is a collective of owners who share the financial responsibilities. This type of ownership often results in the development of cooperative management groups, as in the case of the CNLM's Cosumnes River Preserve and the Sonoma Land Trust's Sonoma Baylands project. The main drawback to this type of ownership is that all partners are involved in management planning and so developing the original management plan may take longer and requires more negotiations. However, once that overall plan is completed, each of the organizations can contribute not only money, but human resources as well.

The third possible ownership situation involves the control of conservation easements. A management organization can control a conservation easement in two ways. Either a private landowner will donate or sell an easement on land to which the owner retains title, or a management group can acquire an entire parcel and then resell it with a conservation easement attached. Conservation Easements (CE's) are legal agreements, written in the form of a deed, in which the development rights to the property are controlled by the management organization. The landowner still has the right to sell, lease, and mortgage land protected by a CE. However, this offers private landowners an opportunity to have portions of their land protected, in perpetuity, from extensive development while allowing a management group to restore and maintain sensitive ecological lands. The main benefit of this situation lies in the ability of the management organization to restore degraded lands, protect fragile ecosystems, and increase land stewardship. Perhaps the biggest drawback to this situation is that the financial burden falls to the management group. This can be alleviated if the landowner donates money along with the land, but this does not always happen.

The final form of ownership is when an organization agrees to manage a property on a contractual basis. In this case, the landowner, public or private, retains title and discretionary rights to the entire property. Although this situation does not transfer final decision-making power to the management group, because the landowner has hired the group to develop a plan and strategies to achieve the land conservation goal, there is not usually a problem. An added benefit in this case is that the contract fee usually includes all money necessary for completing a project.

Successful Land Management

Based on the challenges of successful long-term conservation land management, there are a number of characteristics that make some organizations more successful than others. To contend with the economic challenges, an organization needs to have strong public relations and be well known in its community, have an experienced grant writing staff as well as staff with money management expertise, and have a well-developed process for cost determination. For challenges associated with institutional structure, a successful organization has permanent staff members who are responsible for overall organization management and administrative duties, staff who can coordinate and oversee student intern and volunteer programs, and a strong network of unaffiliated experts who can participate when necessary. Finally, land management organizations must have a strong scientific program. This includes well-trained staff scientists and/or good connections with outside experts, experience with development and maintenance of restoration and monitoring programs, well-developed project evaluation programs, and sufficient flexibility within the scientific team to be able to create adaptive management programs when necessary.

With these characteristics in mind, we review four land management organizations that could be potential stewards of the SRVRS. Interviews with key personel (Attachment 1) were conducted using a standarized questionaire (Attachment 2). We examine funding mechanisms, methods for determining the costs of long-term management, the kinds of management techniques the organization has actually employed, human resources, methods of management evaluation, and the features of one or more recent management projects (see Table A-1).

The Sonoma Land TRUST

The Sonoma Land Trust (SLT) has been in existence since 1976 and has been participating in active land management since its inception. The organization has mainly been involved in three land-management processes. In a number of cases, the SLT manages lands that the organization owns in fee. In this situation, the SLT can manage the land in perpetuity, sell the land, and thus the long-term maintenance costs, to a public (i.e. state or federal) agency, or sell the land, with a conservation easement, to a private owner. In other situations, the SLT manages conservation easements that are part of privately owned land. Conservation easements are binding agreements, which prevent future development and perpetually restrict the uses of land to activities which do not degrade its resources. In these situations, the SLT must work with the landowners to design a management program that will uphold the intent of the conservation easement. This may include training the landowner to become the steward of the easement. Finally, the SLT may act as an intermediary between private landowners and public agencies to facilitate the development of conservation easements or the outright acquisition of specifically targeted lands.

Funding

Funding for all aspects of the SLT, including land acquisition, restoration, and long-term stewardship and management, comes from a number of different sources. The majority of funding is raised through monetary donations, either from individuals or from local businesses. In 1998, more than 30% of the annual budget for the organization was provided by private contributions. This type of support is given either as general donations to the organization or as gifts for specific projects. The second largest source of revenue is ìproject incomeî, any income generated as a result of work on a specific project. This money is earned either through reimbursement by public partners for specific expenses or, in some cases, a private landowner sells the SLT a piece of land for a discounted rate and then the Trust can resell it to a public agency as a park. Other sources of funding for the SLT include private grant money, public tax money, and additional support from both public and private project partners.

In addition to monetary support, the SLT increases its value through land donations. Because the Trust is a non-profit organization, any donation entitles the donor to tax credits for charitable donations. Additionally, when a landowner donates a conservation easement, in which the landowner retains title to the land but agrees to protect its natural resources with management plans developed by the Land Trust, he or she can receive income and estate tax benefits.

David Katz, Executive Director of the Land Trust, says that funding sources do not really impact the type of long-term management done on a given property. Although in some cases, such as the restoration of tidal wetlands in the Sonoma Baylands, all of the project partners participate in devising the overall management plan. This allows each of the partners to include the objective of his or her organization in the long-term management of a project.

Management Cost Determination

One of the main concerns for any project is cost. According to Mr. Katz, this is one of the biggest challenges facing any land management organization, simply because the cost can vary so greatly for any project. Costs include three broad categories: acquisition (i.e. land or easement purchase, initial studies, survey and title fees), determination of restoration goals and objectives, and stewardship costs. For the SLT, stewardship costs vary greatly depending on how long the Trust holds the land. For instance, if the SLT plans to maintain ownership in perpetuity, costs of annual stewardship, insurance, and legal protection must be included in the overall project price.

Because potential costs are so variable, each project is evaluated independently. The final determination is made by the Board of Directors, SLT staff, and, if necessary, outside agencies. Although the SLT does not employ anyone specifically to handle the economics, there is a strong background of experience among those associated with the organization. Along with other equally qualified individuals active in this process, Mr. Katz specialized in natural resource valuation as a graduate student at Yale.

Human Resources

The organization has five (5) full time employees, approximately sixty (60) regularly active volunteers, and a number of other occasional volunteers. Volunteers act as stewards and are active in on-going monitoring programs. SLT provides an annual training program for its volunteers, complete with formal training materials that are always available, especially for new volunteers. This extensive volunteer group reflects the excellent rapport the SLT has with local landowners and communities. In fact, one of the advantages for local landowners working with the SLT, says Katz, is the strength of the community ties.

In addition to the experience and expertise of those people within the organization, when necessary, the SLT will contract with outside agencies for specific expertise. ìWe believe very strongly in the benefits of partnershipsî, says Katz. Partnerships have included municipal, state, and federal agencies, private organizations, and private landowners. Involvement by the partners can range from financial support to land stewardship to direct involvement in the scientific processes, as is the case with Circuit Rider Productions. This is another local non-profit organization that has partnered with the SLT to complete initial surveys and biological mapping, to collect and propagate native vegetation, and to provide volunteers trained to work on various restoration projects.

Management Techniques

Because the SLT has been actively managing lands in Sonoma County for so long, the organization has had the opportunity to practice a large variety of management techniques. Such experience includes the use of fencing and grazing to protect sensitive grassland areas, occasional use of herbicides for spot treatment of invading exotics (with agreement of all partners), and consideration of physical design of an area to increase protection and restoration capabilities. Furthermore, volunteers are often used to do manual eradication of exotics and have even been used to control feral animals that threaten a landscape or native animal population.

Project Evaluation

How and when evaluations are done depends entirely on the project. ìWe simply do not have a large enough volume of projects to have developed a specific protocolî, says Katz. Funding is also an important factor in deciding the frequency and type of evaluation. For example, the Army Corps of Engineers agreed to fund 5 years of monitoring for the Sonoma Baylands project on the San Pablo Bay. The SLT used this funding to hire an independent monitor who has been required to produce annual monitoring reports. The criteria for what is monitored were agreed upon by all partners and included as part of the overall management plan.

In another example, the SLT has been working on a project to restore 45 acres of tidal wetlands on the Petaluma River. The Department of Fish and Game (DFG) supplied the money for monitoring, which the SLT used to hire independent monitors. In this case, the SLT is a very active partner in the project and directly supervises the monitoring. As part of this supervision, the SLT is responsible for oversight of the production and distribution of the monitoring reports.

The latest monitoring report from this project was produced in May 1998. This report includes the explanation of results from monitoring programs undertaken in the marsh restoration area, as well as suggested monitoring strategies. In addition, the report discusses overall project performance, based on the goals and objectives defined in the original management plan for this project.

Finally, Mr. Katz noted that the goal for some projects is to design a very low-maintenance management plan. In such a situation, the land is monitored infrequently, often only when a specific problem arises and must be addressed.

Project Summary: Petaluma River Marsh Restoration

The Petaluma River Marsh restoration project is a coordinated effort between the Sonoma Land Trust (SLT) and the California Department of Fish and Game (CDFG). The project came about after the SLT purchased, with state bond funds, a parcel of land on the east bank of the Petaluma River immediately north of the Highway 37 bridge. During the original tidal work, the SLT discovered that there was approximately 45 acres (18 hectares) of the property that were actually state lands which had been diked to provide more farmland. Upon making this discovery, the SLT raised the funds and developed the partnerships necessary to create a tidal marsh restoration project for this 45-acre area.

The goal of the project was to reopen the area to tidal action in order to recreate the tidal wetlands that had flourished in this area prior to the installation of the riverfront levee. The comprehensive restoration project included raising the elevation of the inboard levee to protect adjacent low-lying farmland, construction of a central access levee to the Pacific Gas & Electric (PG&E) tower in the middle of the site, excavation of on-site soils to use as fill material for the inboard and central levees, excavation of small pilot channels, lowering the riverfront levee to high intertidal marsh elevations, and breaching the outboard levee in two locations. The SLT partnered with the U.S. Army Corps of Engineers to design and complete the physical reconstruction portion of the project.

The land affected by this project was once part of a series of wetlands that surrounded the entire San Francisco Bay. As such, this restoration project has been watched closely by a number of organizations that are attempting to restore other portions of these wetlands that had also been diked for farmland. In an effort to enable these other organizations to learn from their experience, the SLT included partners from many different disciplines to produce comprehensive, long-term monitoring reports. Agencies and individuals involved in the monitoring program included the U.S. Fish and Wildlife Service (USFWS); CDFG; Stuart Siegel, UC Berkeley; Jules Evens, Avocet Research Associates; Vir McCoy; students in the UC Berkeley Field Geography course taught by Dr. Eric Edlund; and the environmental education program of the Save San Francisco Bay Association. Funding for this monitoring has been supplied by the CDFG.

Center for Natural Lands Management

The Center for Natural Lands Management (CNLM or the Center) was founded in 1990 and now has offices in Fallbrook, Arcata, Chico, Sacramento, Santa Cruz, Kern, Riverside, and Thousand Palms. Since it began, the CNLM has worked to protect biological resources through the long-term stewardship of mitigation and conservation lands. Developed with a primary goal of preserving or assisting ìin the preservation of natural habitat, native species and functioning ecosystemsî, the CNLM has worked with a broad range of organizations, including land trusts, conservation organizations, public agencies, developers, and other land managers. All management projects undertaken by the Center are governed by a belief that management will only be successful if it is focused on landscapes and natural communities rather than on specific species.

The organization manages lands in three different ways: managing lands whose fee title has been purchased by or donated to the organization, managing conservation easements on private properties, and managing on a contract basis. As of October 1999, the CNLM managed a total of 42,378 acres in California (7,313 acres owned in Fee, 1,981 acres of Conservation Easements, 33,084 acres managed contractually). In addition, the CNLM works with public agencies and other project proponents to develop and implement Habitat Conservation Programs (HCPs) and conservation banking programs for wetlands and endangered species.

Funding

As with any other land management organization, funding is a key issue for determining which projects the CNLM is willing and able to manage. Funding sources for CNLM include private individual and corporate donations as well as a substantial amount of private grant money. Private donations can be made in the form of cash, securities, real estate, or endowments. In addition, any projects that are undertaken with partners are done so with each of the partners sharing a portion of the financial burden.

If the project is being done on a contractual basis, the derived cost is presented to the client, and then the client has an opportunity to decide if they are willing to cover the necessary costs. As CNLM is a non-profit organization, any donations entitle the donor to individual and estate tax benefits.

Management Cost Determination

Perhaps the most distinctive facet of the CNLM has been its efforts to develop a cost-determination program for long-term land management projects. Based on previous experience and an extensive study of the both the projected and the actual management costs of habitat areas within California, the CNLM has developed a software program called the Property Assessment Record (PAR, Attachment 3). By analyzing the characteristics and management needs of a property, this program allows land managers to consider all of the potential management tasks for a specific project. Once these have been determined, the PAR helps the manager to estimate the costs of those tasks, as well as administrative costs associated with each task. Based on this analysis, the PAR generates a report which shows the necessary initial capital outlay, the estimated cost of annual stewardship, and the amount needed as an endowment or annual income to support the project in perpetuity. According to Cameron Barrows, the Southern California Regional Director for CNLM, the program allows a land-management planner to consider hundreds of potential costs when determining the feasibility of a project. Because the PAR allows one to consider any combination of management actions, a manager can easily determine the cost of each objective for a given project. This can aid a planner in deciding which tasks will be undertaken based on the budget for an entire program.

Because the CNLM is based on the idea that land preservation includes not only staving off potential development, but also identification and continuous conservation of critical processes and elements, the organization believes that a critical component of management is the effective planning of long-term funding. Using grants provided by the National Fish and Wildlife Foundation, the Packard Foundation, Dean Witter Foundation, and ARCO Foundation, the CNLM conducts seminars to inform conservation planners of the purpose, process, and benefits of the PAR program.

Human Resources

The CNLM has 10 full time staff members with a wide range of expertise. 80% of the permanent staff have received Bachelorís and/or Masterís/Ph.D. degrees in different areas of biology and land management and all have had extensive field research experience. As part of each management project, staff are expected to present results of their experimentation at scientific meetings and to publish findings in peer reviewed scientific journals. In addition, the CNLM has one full-time staff member who is responsible for managing the economic portions of projects. She holds a Masterís degree in Regional Economics and is a specialist in real estate, land economics, and finance. A balance of other staff members, including biologists, preserve managers, and support personnel, is maintained and utilized by the CNLM as project needs dictate.

In addition, the CNLM works with a number of academic institutions at all levels of project management, as well as large groups of volunteers. Student interns are generally included as part of the management planning teams, so that the planners may gain insights the students may have and to allow the students the opportunity to learn exactly what it takes to successfully manage conservation lands. Furthermore, the Center offers numerous opportunities for students to complete research for graduate theses. According to Mr. Barrows, the CNLM is considering development of a Preserve Management program in universities in Southern California. Finally, volunteers generally act as docents at the various CNLM sights. Because the volunteers are members of the local communities, the interactions between them and the CNLM helps foster positive public relations for the Center.

Management Techniques

The size of projects managed by the CNLM ranges from 20,000+ acres (Coachella Valley Preserve) to approximately 40 acres (Pixley Vernal Pool Preserve). In addition, the wide variety of managed habitats (e.g. desert dunes, vernal pools) gives the CNLM extensive experience with many kinds of management techniques.

At the 12,000 acre Lake Mathews Multi-Species Reserve in Riverside County, the management program has included species monitoring and enhancement using fencing to control human and other animal trespassing, control of invasive exotics through manual extraction, herbicide application, and native species transplanting.

In the March Air Force Stephenís Kangaroo Rat Preserve, a multi-year prescribed burn program has been implemented to evaluate the impact of fall vs. spring burns. The managers hope to use this knowledge to develop a management strategy that will favor native forbs and Stephenís Kangaroo Rat populations. Prescribed burn programs have also been undertaken at the Pixley Vernal Pools and Lokern Preserves, and the Manila Beach and Dune Preserves.

At the Pace Preserve wetland bank project, the CNLM is using various techniques to address issues of water management, levee maintenance, water structure maintenance, and revegetation issues.

In addition to management techniques aimed at restoring or maintaining physical features of preserves, the CNLM is very active in developing environmental education programs, public access plans, and interagency and research coordination.

Project Evaluation

Project evaluation follows the same general guidelines for each site managed by the CNLM. As part of the initial project planning, a management plan that contains measurable objectives is developed. According to Mr. Barrows, regardless of the partners involved, the CNLM is adamant that long-term objectives and short-term goals are clear and easily measured. The philosophy of the Center is that conservation goals should primarily attempt to cover community dynamics and ecosystem functions, rather than focusing on species level functions. This allows multi-disciplinary planning teams to formulate comprehensive conceptual models that identify system attributes and stresses. With such a model in hand, management staff is able to develop hypotheses regarding appropriate conservation goals.

Once this initial management plan is developed, preserve staff are required to maintain on-going monitoring programs to determine project performance. The schedule of the monitoring programs is included as part of the original management plan. Monitoring programs are designed to test specific hypotheses about the functional aspects of the original conceptual model. They are designed to focus on both habitat characteristics, derived from remote-sensing data, and on population and community diversity, determined by statistically valid, on-the-ground sampling. By determining community response to the management model, continuous testing of the tenets of the original model is possible. As results are compiled, management approaches can be modified, if necessary.

Project Summary: Coachella Valley Preserve

In April, 1984, The Nature Conservancy (TNC), in partnership with the Bureau of Land Management, the U.S. Fish and Wildlife Service (USFWS), and the California Department of Fish and Game (CDFG), purchased 1,920 acres of the Coachella Valley as a part of TNCís National Wetlands Program. This acreage became the Coachella Valley Preserve (CVP). In January 1997, the CNLM signed a Memorandum of Understanding with TNC to transition management and fee title of several TNC properties to the Center. One of the properties included in this arrangement was the CVP. The CVP is managed jointly by the CNLM and USFWS.

The CVP includes three separate preserve units that total 20,000+ acres. Originally developed to protect the Coachella Valley fringe-toed lizard, Uma inornata, an endemic, threatened animal, the focus of the preserve system has grown to include the protection of the desert sand dunes, palm oasis woodlands, and blown-sand fields of the Coachella Valley.

There are two main facets of management that take place in the CVP. First is the development of viable use plans for the area. Because the Thousand Palms Oasis draws many human visitors, it has been imperative to define the extent to which people will be allowed access. Based on the management model developed by the CNLM, it was determined that the most fragile areas, the desert dunes, would not be threatened by un-guided access to the Oasis. To this end, Cameron Barrows, Preserve Manager of the CVP, has developed a volunteer docent program that leads tours of the dunes and other fragile areas.

The second management challenge of the CVP is the necessity for increased understanding of the habitats and communities of the area. In response to this need, the CNLM has developed a series of on going research projects in the Preserve. These projects include: Dietary Patterns and Reproductive Success in the Fringe-toed Lizard, Patterns of Sand Dune Species Richness, How to Restore Desert Dunes, and What is the Effect of the Introduced Saharan Mustard and can it be Controlled. As part of its active involvement with academic institutions, the Center has actively recruited interns and graduate students to work on these research projects. Completion of these projects will allow the CNLM to revisit the hypotheses developed in the original management plan and determine if the direction of the plan is correct or if it must be adapted.

Project Summary: Pixley Vernal Pool Preserve

Another project that was transferred to the CNLM from TNC in 1997 was the Pixley Vernal Pool Preserve (PVP). It is now owned in fee and managed by the CNLM.

In 1986, the U.S. Department of Interior designated the PVP as a National Natural Landmark because of its unique botanical value.

The PVP is located in the southeastern San Joaquin Valley, 19 miles west of the Sierra Nevada foothills. It covers approximately 40 acres and is entirely surrounded by a wide area of cultivated fields. Depending on precipitation levels, 25 to 75 vernal pools are formed each year. The main vegetation type is the Northern Hardpan Vernal Pool with non-native annual grassland.

The predominance of non-native grasses presents the biggest management challenge on this preserve. High densities of these grasses inhibit growth of native grasses and other annuals, can restrict movement by wildlife, and can increase the potential for wildfires. In response to this problem, the Nature Conservancy's preserve manager developed a prescribed burn program aimed at controlling the non-native grasses and promoting the biodiversity of the area. Permanent vegetation transects and photopoints were established and pre-activity surveys were conducted prior to commencement of the burn program. A series of burns were carried out during May and June of 1997, in partnership with TNC, BLM, and the Kern County Fire Department, and the CNLM is planning another round for June, 2000. Surveys were conducted shortly after the burns to determine changes in vegetation structure and impacts on animal species. The burns are also aimed at reducing some of the thick ìmulchî layer that builds up year after year and affects germination capabilities of native species. Further monitoring will be done to determine the effectiveness of this management technique. Additionally, management of this preserve includes monthly visits to keep trash and trespassing under control.

The Nature Conservancy
(As Managing Partner of the Cosumnes River Preserve)

The Nature Conservancy (TNC) was founded in 1951 to preserve plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive. It is now the largest private, international conservation group in the world, having protected approximately 71 million acres worldwide. Historically, TNC raised money from private and corporate donors and then used that money to purchase ecologically significant lands. Based on management plans developed with help from its own staff of scientists and managers, TNC maintained ownership and management rights in perpetuity. More recently, however, TNC has made an effort to include a larger group of partners in the long-term management of its lands. The Cosumnes River Preserve (CRP or the Preserve) is an excellent example of this change in strategy.

In 1987, TNC became one of the managing partners in the CRP. Partnering with the Bureau of Land Management (BLM), CDFG, California Department of Water Resources (CDWR), Ducks Unlimited, Inc., Sacramento County Department of Regional Parks, Open Space, and Recreation, and the Wildlife Conservation Board (WCB), TNC developed the CRP. The original goal of preserving 500 acres of Valley Oak woodland, undertaken with BLM and DU, was realized quickly. Today, the Preserve encompasses approximately 37,000 acres of land that includes parcels owned in fee by TNC or other partners, as well as conservation easements on private lands.

Funding

TNC has a number of different funding sources which vary depending on the project. The majority of funds are donated by private or corporate donors. These donations are made as monetary gifts, donations of securities, real estate (land for conservation or land TNC can sell and then retain the profit from), gifts in kind, and endowments. Another large portion of funds comes from partners involved in specific projects. In the case of CRP, most partners have undertaken some portion of the financial responsibilities. Yet another source of financial support for TNC is their Adopt-an-Acre program. In this program, the adopterís annual contribution is earmarked for a specific project. TNC also has a credit card program. TNC receives $1 for each new account and then continues to receive 0.5% of all purchases made on the card. While this is a phenomenal idea and generates a large amount of income for TNC, it is unlikely that any organization that is not as large as TNC would face some difficulty in developing such a program. Other funding sources include grants for specific aspects of projects, money earned through sale of land to private or public landowners, and farm income associated with many TNC lands. As TNC is a non-profit organization, all gifts entitle the donor to income and estate tax deductions.

Funding sources are one of a trio of factors that significantly impact the types of management programs undertaken by TNC. According to Becky Waegell, the Grasslands Coordinator for the Cosumnes River Preserve, these factors are whether a project is considered to be important, if it is determined to be necessary, and if it is feasible. Money is a great indicator of whether or not people think it is important, necessary, and is likely to be feasible.

Management Cost Determination

According to Mike Eaton, Cosumnes River Project Director, TNC (specifically at the CRP) does not have a systematic method for determining project cost. Because each project presents such a vast array of potential costs, the considerations are different in every case. Generally, when TNC contracts to purchase a piece of land, a general survey of the infrastructure is completed in order to assess the clean up, repair, and replacement needs. This "start-up stewardship" is included in the original acquisition budget. Based on the long history of TNC's experience, these estimations are quite accurate. If it is clear that a project is going to require major restoration work, TNC will attempt to bring partners together so that all can share the responsibilities of planning, designing, and funding the project.

Human Resources

The CRP has a six (6) full-time staff members, including two whom also work on the Sacramento River Delta Program. According to Mr. Eaton, TNC has begun to change its understanding of who is qualified to successfully manage preserves. Historically, all project managers were required to have a degree in some area of science and to practice of that study as their primary occupation. However, as TNC has changed its focus from preserving land by excluding human presence to community based conservation, a managerís responsibilities now include developing the preserve, incorporating human impacts, and building local stewardship. Because of this, Eaton says, TNC has realized that preserve managers and their staff must have a fair amount of experience dealing with public relations issues. He believes that one of the main reasons TNC has been so successful at CRP is because of the tremendously positive relations the preserve managers and staff have developed and maintained with the local landowners.

In addition to the permanent staff, CRP employs approximately six interns each year for work on different projects. Interns work directly under a CRP staff member who is responsible for the training and safety of the intern. These students work on various projects, including bird inventories, grassland restoration projects, and the Valley Oak riparian community restoration project.

The CRP also has a broad base of volunteer support. One group of volunteers, mostly from the Bay Area, is called the Hard Core volunteers. This group of 15-20 individuals has been actively involved in the CRP projects for a number of years and works with the staff on a regular basis. This group acts as docents and works in the

Visitorsí Center at the preserve, as well as directing groups of other volunteers on project work days. The second group of volunteers is those who occasionally participate on work days. These volunteers often participate in trail maintenance or planting programs. Both groups are directed and supervised by CRP staff.

Management Techniques

Management techniques used at the CRP have varied greatly. All projects done at the Preserve are based on the original management plan, developed in 1990-1991. Once the project objectives were made by the cooperative management group of partners, TNC corporate scientists and CRP staff scientists decided on specific management techniques to achieve those goals. Two of the focus areas at the CRP are restoration of Valley Oak riparian ecosystems and restoration of native grasslands.

The Valley Oak riparian ecosystem restoration has presented an exceptional opportunity to watch nature regenerate itself with only minimal human help. In 1995, an experimental levee breach was made that allowed the Cosumnes River to flow along a course almost identical to the original course before the levees were built. Juvenile salmon and native Delta fish were observed in the newly created waterway and the Sacramento splittail, a federal candidate for endangered species, spawned in the shallow waters. In addition, when the waters receded in the spring, a cottonwood-willow forest began to grow almost immediately. Based on the success of this experiment, TNC partnered with the U.S. Army Corps of Engineers in 1997 to dismantle approximately six (6) miles of levees and to floodproof the existing CRP infrastructure in order to give more area back to the Cosumnes River.

With respect to native grassland restoration, a number of other techniques have been utilized. An intensive reseeding program has been developed, using native stock propagated at a local nursery. In this project, a no-till drill was used in order to limit the amount of disturbed habitat so that exotics would not have an advantage in disturbed habitat. Experiments with prescribed burns, grazing, and fencing have also been undertaken.

Project Evaluation

In 1990-1991, a master plan was developed to guide work on the entire Cosumnes River Preserve. This plan was divided into five main parts, the Lower and Upper Flood Plains, Blue Oaks, Vernal Pools, and Upper Foothill Oaks. Based on the overall plan, a more detailed plan was developed for each of these subdivisions. Included in the smaller plans was a determination of objectives along with a compendium of strategies for achieving those goals. Over time, minor revisions and additions have been made to the original plan, but the overall objectives remain the same. All current project evaluations are based on these original plans.

According to Mr. Eaton, TNC believes very strongly in continuous testing of hypotheses upon which the management plans are based. Because of this, CRP staff members do continuous project monitoring which results in the production of progress reports. Examples of these monitoring reports include inventories of bird diversity and nesting habits, as well as grassland response to reseeding and fire. Reports are mostly funded by project grants and are distributed to all members of the cooperative management team. While the response or opinion of each member of that team theoretically carries the same weight, there are often a few of the team members who are just as happy to leave the management monitoring and decision making to the other team members.

Project Summary: The Consumnes River Preserve

The Cosumnes River Preserve is a project that is jointly managed by the Nature Conservancy and six other partners. The project originated in 1987 when TNC teamed up with the Bureau of Land Management (BLM) and Ducks Unlimited, Inc. (DU) in an effort to protect 500 acres of Valley Oak riparian ecosystem. Since that time, the project has incorporated four more partners, the California Department of Fish and Game (CDFG), the California Department of Water Resources, Sacramento County Department of Regional Parks, Open Space, and Recreation, and the Wildlife Conservation Board, and has grown to approximately 37,000 acres.

An overall land management plan was developed in 1990-1991, with the participation of all partners. This management plan created a cooperative management team that includes representatives from each of the partner groups. The team is meant to meet four times each year to discuss current issues and to determine if changes should be made to the management plan. Since it was initially authored, the plan has undergone some minor adjustments, but the three main objectives of the plan still remain. These objectives are: restoration and safeguarding of ìthe finest remaining example of California valley oak riparian ecosystem and its surrounding habitatsî; restoration and creation of freshwater wetlands in an attempt to increase the populations of migratory waterfowl in the Pacific Flyway; and demonstration of the compatibility of human uses, including education, recreation, and agriculture, with the natural environment.

According to Ms. Waegell, the Preserve has been in an intense growth phase until very recently. Although TNC and its partners are often interested in enfolding more land and habitat types into this project, the focus seems to be shifting towards more intense management of the current lands of the preserve. In fact, TNC is trying to sell the Howard Ranch, a 12,000-acre parcel acquired by TNC and incorporated into the CRP just last year. With this shift in concentration, the staff at CRP are currently involved in projects focused on maintaining restored riparian areas, restoring plant and animal biodiversity through creation of specific habitat requirements, and a continuing monitoring program to determine overall project performance.

With respect to the third objective, demonstrating the compatibility of human uses and the natural environment, CRP has been a model project. Attributed to the work of the preserve manager and staff, this project has phenomenally positive relations with surrounding landowners and communities. Not only have the adjacent landowners come to understand the benefits they receive directly from this project, but they have also praised the project so much to others that TNC has been able to acquire new lands and conservation easements with very little resistance. Because the surrounding lands are mostly agricultural, a community that has historically been at odds with environmental organizations, it is particularly impressive that TNC has been able to foster such good relations. According to Mike Eaton, CRP Director, these interactions have been the primary reason that this preserve has been able to grow so rapidly.

LandPaths

A relatively new organization, LandPaths (Land Partners through Stewardship) was created in 1996 by a group of community members, local private landowners, and public agency representatives. Originally a project of the Tides Foundation, an organization that facilitates donor-advised grants for non-profits working for social change, LandPaths has recently begun the process to become an independent non-profit. The focus of this organization is to form partnerships between landowners and experts in land management and restoration. Once the alliance has been made, LandPaths works with the partners to implement practices that maximize resource conservation while allowing managed public access. To date, the organization has been active in developing and monitoring management plans for three different projects.

Funding

Funding for LandPath projects has come from three main sources. A large portion of the operating budget for each of the projects has come in the form of gifts from the landowners themselves. The McCormick Sanctuary project included a $350,000.00 gift and the McCrea Family Property included a $50,000.00 gift. An additional funding source is private, individual donations and grant monies. Finally, the organization increases the value of its portfolio by limiting the capital necessary for land acquisition. By creating partnerships with private landowners, such as the McCrea Family, and public agencies, including the California State Parks Department (CSPD) and the Sonoma County Agricultural Preservation and Open Space District (SCAPOSD), LandPaths is able to acquire management and access rights to lands without the financial burden of land purchase. In the case of the McCormick Sanctuary, the SCAPOSD purchased the land in two phases in 1995 and 1996 for $2.3 million. As it became clear that the additional burden of creating public access was too great for the Open Space District, the land was transferred to the CSPD. Because one of the main focuses of LandPaths is to create public access to natural lands, the organization was the perfect choice of partners for development of a management plan that included public access.

Management Cost Determination

There are three main factors LandPaths considers when determining the cost of projects. The first, and most important, is the type and amount of resource protection needed on the land. This is determined through initial surveys, such as the Natural Resource Analysis and Enhancement Plan completed by Circuit Rider Productions for the McCormick Sanctuary. The second consideration is the type of public access that the landowner wants to allow. Depending on the extent of public access, cost of a project can increase substantially as more trails need to be built and maintained. Finally, since a large part of the operating budget is based on financial gifts, certain choices concerning management projects and access development are made in consideration of the size of those gifts.

Human Resources

LandPaths has 3 permanent employees, the Executive Director, the Education Director, and an executive assistant. Perhaps one of the most significant characteristics of LandPaths is the amount of volunteer involvement the organization generates. To begin with, every one of the seven member Executive Board is a volunteer. In addition, each project has used a management committee to make decisions and plan specific operations. All members of these committees are volunteers. Finally, the organization has a core group of five regular volunteers as well as revolving groups of approximately 15 additional volunteers. Volunteers fill a large number of roles in the organization, including acting as docents, participating in design and maintenance of trails, replanting stream corridors and oak woodlands, and assisting agency ecologists in land protection and enhancement. These people play a vital part in the organization, as one of the groupís key intentions is to facilitate guided public access to the exquisite lands in Sonoma County.

In an effort to ensure that all of the volunteers are well informed and can be used to best benefit the organization, LandPaths trains its volunteers to conduct ecological monitoring surveys, and has even developed training on U.S. EPA stream biological assessment methods.

In addition to the staff and volunteers who work specifically for LandPaths, the organization has numerous partners in other community groups. Some of the partners include: Sonoma County Trails Council, Sonoma County Regional Parks District, Sonoma County Water Agency, Sonoma State University, the Bay Area Ridge Trail Council, Circuit Rider Productions, and the Wine Growers Association.

Management Techniques

Because it is a relative newcomer to the management field, LandPathsí experience with specific management techniques has been focused on a small group of important techniques. On all three projects, LandPaths has worked on restoring degraded riparian ecosystems. In this area, the organization has experience working with manual extraction of invasives, replanting native trees to enlarge the area of riparian vegetation along creeks, clearing streambeds, and redesigning trails to have less impact on the waterways. As part of the management projects, LandPaths has developed low-impact stream crossings and has worked on road restructuring to lessen the impact on surrounding habitats.

In addition, LandPaths has been working with the McCrea family, the Sonoma Developmental Center, and the California State Parks Department to develop a ridge trail on the eastern side of Sonoma Mountain. In this capacity, the organization has been responsible for designing and implementing the development of many miles of trails. This has allowed LandPaths an opportunity to develop those trail designs that allow the greatest amount of access while creating the least amount of impact on the surrounding habitats.

Project Evaluation

Project evaluation is done on a continuous basis on LandPath projects. Based on the original management plan, objectives are derived and progress towards those goals is monitored. As the organization relies so heavily on volunteer support, those volunteers who work with the organization on a regular basis are trained to conduct monitoring projects and relay the information to the permanent staff. This information is included in annual reports produced for the management committees of each project. In the case of large projects, such as alteration of stream channels or road reconfiguration on the McCormick Ranch site, LandPaths has subcontracted the evaluation responsibilities and has solicited the aid of the Department of Fish and Game to insure proper and rigorous evaluation.

Project Summary: McCormick Ranch

The McCormick Ranch Sanctuary is a 1200-acre parcel located between Sugarloaf Ridge and Hood Mountain state parks. The parcel encompasses a large portion of upland area which forms the headwaters of the Santa Rosa Creek. Originally purchased by the Sonoma County Agricultural Preservation and Open Space District in two phases in 1995 and 1996 for $2.3 million, the land title was then transferred to the State Parks Department. As a brand new organization, LandPaths took over management of this land in an effort to facilitate restoration of riparian ecosystems and to create an opportunity for free and open public access for passive recreation (hiking, biking, and horseback riding) on this exquisite piece of land.

LandPaths partnered with Circuit Rider Productions to determine where restoration and protections were needed and where it was safe to plan for public access. Using the $350,000 gift donated by the landowner and the Natural Resource Analysis and Enhancement Plan produced by Circuit Riders, LandPaths established a long-term management plan for the McCormick Sanctuary. The management committee was made up of LandPaths staff, the LandPaths Executive Board, and the Superintendent of the Silverado District of the State Parks Department. This plan included specific programs aimed at restoration of degraded riparian communities, road and trail improvements to lessen erosion into the waterways, which provide spawning grounds for Steelehead salmon, and trail expansion to improve public access to the land.

Purely by chance, LandPaths is actually opening the McCormick Ranch for unguided passive recreation today. The space will be open for use until the fire season begins and then will reopen in the Fall. As this is the first time the public will have unguided access to the land, opportunities for monitoring and possible adjustment to the management plan will be many.

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	Sonoma Land Trust	Center for Nat. Lands Mgmt	The Nature Conservancy	LandPaths
Funding				
Private donations	+	+	+	+
Grants	+	+	+	+
Land sales	+	+	+	
Farm Land Income			+	
Financial Partners	+	+	+	+
Human Resources				
Permanent employees	5	10	6	3
Interns	occasionally	Varies	6-8	0
Volunteers	60	many	20+	20+
Habitats				
Acreage	1-3,000	40-20,000	10-40,000	300-1,200
Riparian - streams	+	+	+	+
Riparian – rivers	+	+	+	
Grasslands	+	+	+	+
Wetlands/Vernal pools	+	+	+	
Oak woodlands	+	+	+	+
Low elev. Forests	+	+	+	
High elev. Forests		+	+	
Coastal	+	+	+	
Mgmt Techniques				
Manual Extraction	+	+	+	+
Native planting	+	+	+	+
Exotic control	+	+	+	+
Prescribed burns	+	+	+	
Fencing	+	+	+	+
Grazing	+	+	+	
Public education	+	+	+	+

Attachment 1 (Appendix I):

Management organization contacts

SONOMA LAND TRUST

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CIRCUIT RIDER PRODUCTIONS, Inc.

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(707) 838-6641
http://www.crpinc.org/

Attachment 2 (Appendix I):
Interview questionaire

1. Company/Organization name:
2. Number years in conservation property management business:
3. Main funding sources for the organization:
4. Do funding sources impact type of management projects undertaken? Examples:
5. Cost is determined
   a. Per management technique
   b. Per hour
   c. Other
6. Is cost determination process consistent with all projects?
7. Human Resources
   a. Number of staff (FT, PT):
   b. Number of paid staff on each project
   c. Is your staff trained on a continuous basis?
   d. Does your organization use outside experts?
   e. Number of interns, volunteers:
   f. Interns, volunteers perform what kinds of duties
   g. Interns, volunteers are trained by _______, supervised by________
8. Management Techniques
   a. Which management techniques have been used on your projects? Examples:
   b. Whose choice is it to use one technique instead of another?
   c. What habitats have you worked on?
   d. What is the largest? Smallest? What is the most acreage you could realistically manage/yr?
   e. How do you decide whether to manage or reconstruct?
   f. How do you interact with landowners?
   g. Is landowner education ever part of the management plan?
   e. Do you ever set up a management plan and then hand it over to the landowner to extend into the future? If so, do you ever monitor these programs?
9. Project Evaluation
   a. Goals and objectives are determined by whom?
   b. How often and by whom are projects evaluated?

c. Have you finished any projects that have received final evaluations?

d. By whom are final project evaluations done?

What has been your most successful project? Why? Least successful? Why?

Attachment 3 (Appendix I):

Paying for long-term management:

The Property Analysis Record

HOME

Preserves

Property Analysis Record

Statement of Qualifications

Membership

Perpetuity

Board of Directors

Job Opportunities

Grants Available

Management Issues

Center For Natural Lands Management

The Property Analysis Record: Paying for Perpetuity

Every parcel preserved for the benefit of biological resources requires management involving some level of expense. If not planned in advance, management in perpetuity can escalate into a tremendous capital requirement. The ideal, of course, is to establish a funding source that provides enough income to cover annual stewardship costs and includes a buffer to offset inflation.

How Much Money Is Enough?

The basic yardstick for deciding how much is needed is the average annual cost of management over the very long term. Unfortunately, there is no easy way to determine this, and managers around the country are struggling to develop formulas for calculating these costs. The costs vary widely with the nature of the land, the type of protection (owned or under easement), the purpose of conservation (endangered species, visitor services, education), and further varies year by year.

The Property Analysis Record

The Center for Natural Lands Management has developed a new tool, the Property Analysis Record (PAR). The PAR is a computerized database methodology that is extremely effective in helping land managers calculate the costs of land management for a specific project. The PAR helps analyze the characteristics and needs of the property from which management requirements are derived. It helps pinpoint management tasks and estimates their costs as well as the necessary administrative costs to provide the full cost of managing any property. The PAR generates a concise report which serves as a well-substantiated basis for long-term funding including endowments, special district fees, and other sources.

PAR Seminars

The Center presents the Property Analysis Record (PAR) methodology to land trusts, governmental agencies, environmental consultants, project proponents, and other interested parties throughout the U.S. through the seminar, "Planning Sustainable Conservation Projects." PAR software and a user's manual are provided to participants, and software is upgraded as new versions are introduced.

The PAR Seminar enables participants to:

- Understand the need for long term stewardship;
- Readily determine and justify the long-term activities and financial requirements of a conservation project;
- Develop biologically and economically sustainable projects;
- Identify a complete array of management responsibilities;
- Provide an understanding of the financial components and financing mechanisms for stewardship;
- Provide an accurate tool to standardize management and costing methodologies;

- Increase communication and partnerships to produce cost-effective conservation projects.
- Use a project PAR for ongoing biological and financial management.

PAR Concepts
As a part of the PAR seminar, participants are taught short-term and long-term planning concepts; management techniques; methods of estimating tasks and budgets; methods of establishing financing, including endowments; and utilizing fees and special districts to fund the stewardship necessary to preserve the habitat in perpetuity.

The Future
The PAR is being used by many organizations nation-wide. Seminars have been held by the Land Trust Alliance, the U.S. Fish and Wildlife Service, the Society for Ecological Restoration (SER), the Trust for Public Land in California and the First National Mitigation Bank Conference in Washington D.C. Previous seminars have been jointly funded by the National Fish and Wildlife Foundation, the Dean Witter Foundation, ARCO Foundation, and the David and Lucile Packard Foundation.

Although the Center's primary focus has been on protecting California's species, habitats across the country will benefit from what we've been able to apply here in California. Each state faces their own challenges with conservation efforts. And because the PAR is a flexible tool, managers from other states will now learn the methodology and be able to apply that knowledge to their individual circumstances. A certain goal is to create datasets for the PAR appropriate for conditions in every part of the country.

The PAR software has been modified over the last several months to become even more useful to ongoing conservation management. In these new versions, the long-term budgets of the PAR can be modified using the basic techniques of the PAR to provide short-term budgets, work-schedules by individual, and the fund budgets needed by investment managers. Over the long-term, other management techniques such as GIS will be integrated into the PAR making the system more universally adaptable.

Synopsis
There are many reasons for using the PAR. The initial reason is to anticipate and prepare for the costs of long-term management of the habitat. The ultimate reason is to create better, more sustainable conservation projects. The PAR embodies the recognition that to be sustainable ecologically, a conservation project must also be sustainable financially. Without planning in perpetuity, many of our conservation projects may only be temporary. The PAR helps overcome the difficulties of planning in perpetuity in a straight-forward and user-friendly manner.

If you are interested in attending a PAR seminar and receiving the seminar, please drop a line to: CNLM, 425 E. Alvarado St. Su. H, Fallbrook, CA 92028 or CNLM 464 NE Irving Ave., Bend, OR or e-mail bpace@cnlm.org.

The cost of the seminar and software is $200 for nonprofits, $400 for governments, $600 for forprofit organizations, and $1,200 for a user license.

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