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Resource Management Demonstration at Russian Ridge Preserve

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Abstract

Five management options were explored for their effectiveness in maintaining biodiversity and limiting the spread of invasive exotic plant species into Coastal Grassland habitat on Midpeninsula Open Space District lands in San Mateo County, California. Management techniques included time-controlled intensive grazing, fire followed by spot application of herbicide, fire followed by seeding of native species, hand weedeating, tractor mowing, and spot application of herbicides. Costs and effectiveness for each treatment option are presented. Various options reduced yellow star thistle cover; others were effective in reducing the number and cover of exotic species, and some increased the cover and number of native species.

Introduction

Coastal Prairie Grasslands occur along the coastal mountains and on wetter interior ridges of central California (Holland 1995). Coastal Prairie Grasslands that contain California oat grass (*Danthonia californica*) are among the most diverse plant communities of California (Stromberg, Kephart, and Yadon 2000) and among the most threatened plant communities statewide (Noss and LaRoe 1995; Peters and Noss 1995). Russian Ridge is one of the most diverse of the interior ridge grasslands in the Santa Cruz Mountain bioregion and ranks high on a state level as well (Stromberg, Kephart, and Yadon 2000). Remaining examples of this native community are rare and are threatened by development wherever they occur. Old fields in California that revert to the typical California annual grassland (Heady et al. 1988) and old fields that remain weedy are extremely stable if simply left alone, in a reserve, even for many years (Stromberg and Griffin 1996). This demonstration was done in part to alert land managers and regulatory agencies to the significance of this diverse, coastal grassland and to show that active management is required and can be effective to sustain or restore these diverse grasslands.

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Russian Ridge Preserve is located in the Santa Cruz Mountains on an open ridgeline that contains mixed evergreen forest, oak woodlands, steep redwood canyons, and significant areas of open grassland. Open grassland occupies approximately 400 acres of the preserve.

The grasslands of the Russian Ridge Preserve are relicts of Interior Coastal Prairie that extend southward from the Oregon border to the San Luis Obispo County coast and are sub-Arctic in origin (Heady 1992; Holland 1997). Native grasslands are among the most endangered ecosystems in California and in North America (Noss and LaRoe 1995; Peters and Noss 1995). These native grasslands are among the rarest in California and have been fragmented by development and agriculture throughout their range.

The Russian Ridge Preserve grassland is dominated by species such as purple needlegrass (*Nassella pulchra*), June grass (*Koeleria macrantha*), meadow barley (*Hordeum brachyantherum*), squirrel tail (*Elymus elymoides*), and blue wild rye (*Elymus glaucus*). California oat grass (*Danthonia californica*) and Idaho fescue (*Festuca idahoensis*) are present but not abundant. Diverse flowering perennials and herbaceous plants are associated with this grassland. Showy carpets of wildflowers, late-germinating annual forbs, and clovers occupy the bare soil between perennial grass plants. Owl's clover (*Castilleja exserta* var. *exserta*), ruby chalice clarkia (*Clarkia rubicuda*), and California poppies (*Eschscholzia californica*) are a few spring-blooming flowers found throughout Russian Ridge Preserve. Numerous perennial flowers such as blue-eyed grass (*Sisyrinchium bellum*), blue dicks (*Dichelostemma capitatum*), suncups (*Camissonia ovata*), johnny jump-ups (*Viola pedunculata*), checkerbloom (*Sidalcea malaefolia*), and elegant brodiaea (*Brodiaea elegans*) occupy moist soil sites.

Resource Management Demonstration

The resource management demonstration was initiated in 1996 with a survey conducted to map exotic species at Russian Ridge Preserve. Significant areas of yellow star thistle (*Centaurea solstitialis*), Harding grass (*Phalaris aquatica*), and other invasive thistles (*Cirsium* spp.) were mapped (Kan 1996). Exotics were most abundant in disturbed soils, including trails and roadsides, old fields, south-facing slopes with high populations of gophers (*Thomomys bottae*), seasonally wet meadows, and gently sloping benches and plains historically used as feeding or loafing locations by livestock. A restoration and management plan was prepared (Kephart 1997) that targeted (1) reduction and control of annual exotic seed production, (2) depletion of the exotic seed bank in the soil, and (3) the introduction and management of competitive native plants to displace exotic species.

Methods

Throughout the demonstration, five combinations of treatments were

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consistently applied to at least two plots. No control plot was left untreated, but casual observations of untreated areas showed no change from pretreatment conditions. Each year at least two sampling plots received a unique combination of single treatments or combined treatments.

Treated areas were sampled during early spring when species were most easily detected. Sampling occurred within 20 × 50 m plots placed along the topographic contour. Treated areas ranged from 2 to 20 acres. All species found within each 20 × 50 m plot were recorded. Permanent T-bar stakes were installed at each end of a 50 m sampling transect located in the center of the plot. Workers placed 20 × 50 cm steel quadrats at 2.5 m intervals along the transect. The quadrats were painted to facilitate recognition of six cover classes (0-5%, 5–25%, 26–50%, 51–75%, 76–95%, and 96–100%). A cover class for each species present within the quadrat was recorded. A value of 0.01 was assigned to species found only within the larger 20 × 50 m plot. Cover for each species was calculated by averaging midpoints of the cover class assigned to each species for 20 quadrat samples per plot (Daubenmire 1959). A comparison analysis was conducted before and after successive treatments on each plot. Our objective was to determine a trend or shift in the percentage of cover of individual species within each treatment plot.

Six resource management techniques were used at the preserve from 1997–2000: grazing, herbicide applications, prescribed fire, mowing, hand control, and planting native seeds. These applications were conducted individually as well as in combination (e.g., prescribed fire and native plant seeding).

1. Hand Control. Roving exotic-control teams equipped with gasoline-powered weedeaters accomplished hand control of yellow star thistle (YST). Emerging flower heads of YST, as well as bull thistle and Italian thistle, were cut prior to seed maturation. Hand control was conducted each year for a 4-month period beginning in April. Hand-control efforts were conducted on 3 acres in 1997 and 1998.

2. Tractor Mowing. In 1997 and 1998, patches of YST were mowed with a tractor-mounted rotary mower. The treated area varied between years from 0.5 to 3 acres. Each year, YTS was mowed three times to control flowering.

3. Herbicide. Two 5-acre, steep, southwest-facing slopes were treated with Transline™ by hand crews. Individual exotic plants were sprayed. To minimize harm to the abundant native forb species growing actively within the areas chosen for herbicide treatment, application was delayed until YST was in the bolting stage. Typically, Transline™ is applied to YST at the earlier rosette stage (Lanini et al. 1995). Backpack sprayers were used to apply the Transline™ in July to plants that were just at or past the bud stage at a rate of 2 oz per acre. Harding grass was sprayed as above with a 2% solution of Roundup.

4. Grazing. In 1997, vegetation was sampled before grazing. Then, 500 goats were grazed within a 13-acre treatment plot for 12 days starting May 5. An electric fence enclosed the single 13-acre treatment area in 1997. Grazing began when 50% of the YST achieved bud stage. To achieve control of YST (1-inch stubble height), nearly all the vegetative cover was consumed and steep ravines were grazed in most places to mineral soil. Trees, shrubs, and brush were defoliated at the browse line. Although a reduction in YST was achieved the first year, another less intensive and more selective approach was needed.

In 1998, the vegetation was monitored, then the grazing frequency and duration was planned. Along with 40 goats, 17 sheep were used. The animals were contained in smaller (1/4 ac.) cells for short times (2–3 days) until the entire 13-acre area was grazed. This meant grazing continued in 1998 from April 25 for 42 days. The grazing-treatment plots were monitored in 1999 but were not grazed.

5. Burning. Fuel breaks were mowed or grazed to establish a fire line; goat and sheep grazing were used to reduce fuel in steep ravines near forest habitats.

Prescribed fire was used on 80 acres in July 1998, and on 120 acres in August 1999 (including the 80 acres previously burned). About 85% of the ground surface was blackened, and very little white ash was present. Midsummer dates maximized YST control (Hastings and DiTomaso 1996).

6. Planting Native Seeds. To provide site-specific seed for this project, Midpeninsula Open Space staff were trained to identify and collect native plant seed. All seed used on the preserve was grown under guidelines provided by the USDA California Crop Improvement Association (CCIA) Wildland Collected Seed Program. By following the USDA program, the proper identity and purity of native grasses and forbs can be assured; reproductive material and records through all stages of collection and production have been mainained. Twenty native plant species were collected and cleaned for seeding at Russian Ridge Preserve in 1999 and 2000. Russian Ridge sources of purple needlegrass (*Nassella pulchra*), California brome (*Bromus carinatus*), Blue wild rye (*Elymus glaucus*), California fescue (*Festuca californica*), meadow barley (*Hordeum brachyantherum*), and June grass (*Koeleria macrantha*) were registered with the CCIA Certified Seed Program.

Grass seeds were drilled in one direction with a tractor-driven Truax no-till native grass seed drill. The drill was then cleaned and filled with dicot seeds and pulled at 90° to existing drill lines for grass seed. This allowed for mixed seeding but spatially isolated grasses and dicots.

Results

During the implementation of the management techniques, changing management priorities resulted in the following combinations of treatments; (1) hand control (weedeating), (2) herbicide application, (3) grazing, (4) tractor mowing, (5) prescribed fire and planting native seeds, and (6) prescribed fire, application of herbicide on Harding grass, and planting native seeds. Here five responses are discussed; (1) cover of YST, (2) cover of native species, (3) cover of exotic species, (4) number of native species, and (5) number of exotic species.

1. Hand Control. The cost of hand control was $1,140.53 per acre. After the 1998 season, staff determined the cost of hand control prohibitive for large-scale, sustainable resource management. Measured responses to hand control and cost comparisons are shown in Figs. 1–5. Hand control effectively reduced cover of YST, had no effect on cover of native species, was somewhat effective in reducing cover of exotics, and had no effect on the number of native or exotic species.

2. Herbicide Treatment. Within 5 days, the YST was withered and dead. The herbicide control method was the most effective treatment for control of outlying colonies and individual weed plants. Plants that were sprayed died, and unlike hand control, reapplication was not required. Herbicide application cost $298 per acre/year including hand

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labor, materials, and mobilization. Measured responses to herbicides and cost comparisons are given in Figs. 1–5. Herbicide treatment dramatically reduced cover of YST, and had little effect on cover of native species or cover of exotic species in general, or number of exotic and native species.

3. Tractor Mowing. Tractor mowing cost $127.00 per acre, including mobilization cost. Measured responses to tractor mowing and cost comparisons are given in Figs. 1–5. Tractor mowing reduced cover of YST slightly, did not affect cover of native species (in general), reduced cover of exotic species, and resulted in negligible changes in the number of native or exotic species.

4. Grazing. In both years, the sheep and goats preferred YST to other less palatable species. With more abundant rains, more forage was available in 1999, so grazing was initiated prior to the presence of YST flowers. As the dominant annuals cured, YST entered the bud stage and became the only green forage available. To keep the YST vegetative and palatable, the frequency of grazing between cells was increased to daily movements. By controlling the frequency of herd movement, the animals targeted YST and ignored annual grass, dried forbs, and leaf litter.

The cost of grazing was $646.88 per acre including the full-time herder, dogs, and temporary housing. Measured responses to grazing and cost comparisons are given in Figs. 1–5. Grazing significantly reduced the cover of YST, was associated with a negligible increase in cover of native species, increased cover of exotic species, had the greatest effect on increasing the number native species, and a negligible effect on the number of exotic species.

5. Prescribed Fire and Native Plant Seeding. The direct cost of prescribed fire on Russian Ridge was $77.90 per acre. This cost did not

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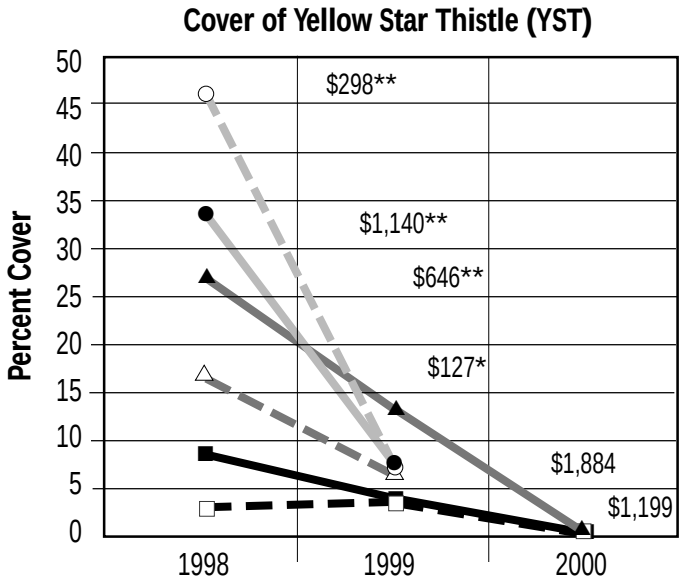

Figure 1. Change of YST cover with various treatments and associated costs at Russian Ridge Preserve.

○ = Herbicide; ● = Hand control; ▲ = Graze;
△ = Tractor mow; ■ = Burn, Harding grass control, Seed;
□ = Burn, seed; $ = Cost per acre; ** = < .001; * = < .05.

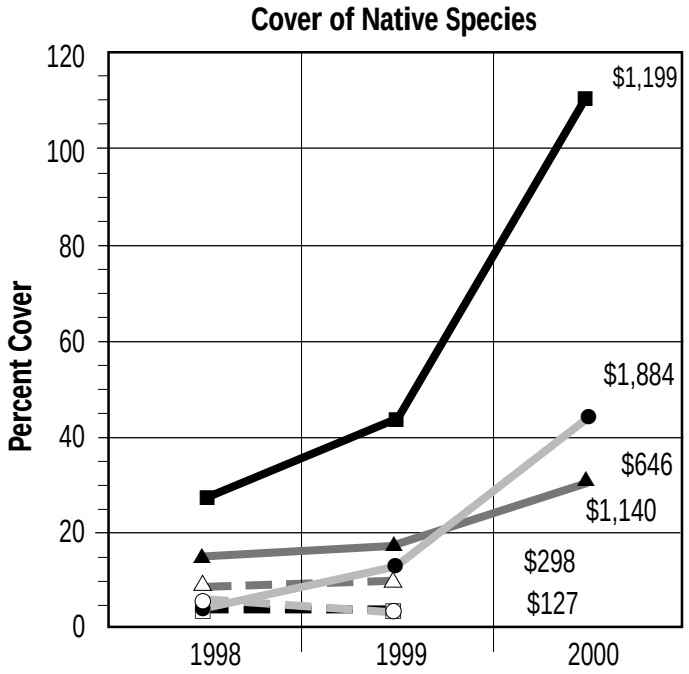

Figure 2. Change in cover of native species with various treatments and associated costs at Russian Ridge Preserve.

■ = Burn, seed; ● = Burn, Harding grass control, Seed;
▲ = Graze; △ = Hand control; □ = Herbicide;
○ = Tractor mow; $ = Cost per acre.

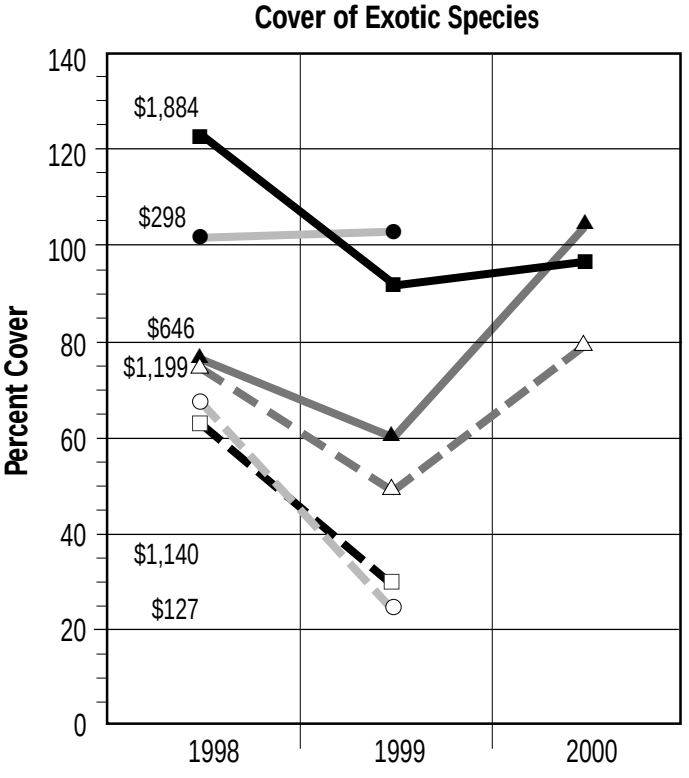

Figure 3. Change in cover of exotic plant species with various treatments and associated costs at Russian Ridge Preserve.

■ = Burn, Harding grass control, Seed; ● = Herbicide;
▲ = Graze; △ = Burn, seed; □ = Hand control;
○ = Tractor mow; $ = Cost per acre.

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include staff time to prepare documents, advertise and implement the fire, and consultant's time. Private contractors that offer plans and implementation charge from $65 to $100 per acre (North Tree Fire 2000).

The dominant forbs that thrived after planting include tidy tips (*Layia platyglossa*), yarrow (*Achillea millefolium*), checkerbloom (*Sidalcea malvaeflora*), sky lupine (*Lupinus nanus*), owl's clover (*Castilleja exserta* var. *exserta*), and California poppy (*Eschscholzia californica*). Blue wild rye (*Elymus glaucus*) was the most successful native grass planted. The cost per acre for prescribed fire and native plant seeding was $1,199.15. Measured responses to burning and planting and cost comparisons are given in Figs. 1–5. Burning and planting native seeds had no effect on YST cover, but did increase the cover and number of native species. Burning and planting only slightly increased the cover of exotic grasses but reduced the number of exotic species.

6. Prescribed Fire, Harding Grass Control, and Native Plant Seeding. In 1998 planting native seeds in areas historically cultivated and planted to Harding grass (*Phalaris aquatica*) began. As a result of the previous cultivation and seeding, native plant cover was limited, diversity was low, and Harding grass dominated the site. To prepare for the control of Harding grass and drill seeding a prescribed fire was conducted. In October, following the fire, the new green leaves of Harding grass were sprayed with a 2% solution of Roundup.

Follow-up spraying of approximately 10% of the Harding grass was required. The cost per acre for prescribed fire, hand control of Harding grass, and native plant seeding was $1,884.12. Measured responses to burning, herbicide control of Harding grass, and planting native seeds, and cost comparisons are given in Figs. 1–5. The combined treatment of burning, spraying Harding grass, and planting native seeds had an insignificant effect on cover of YST, increased cover of native species, slightly reduced cover of exotic species, increased the number of native species, and slightly increased the number of exotic species.

Discussion

The results of the resource management program have a profound effect on visitors who are in awe of the stunning wildflower displays. Many visitors expressed sincere appreciation of Midpeninsula Open Space District administration and staff efforts to manage and maintain the sensitive grassland habitat of Russian Ridge Preserve.

During the course of the work, it became clear which treatment or combination of treatments worked best to reach stated ecological outcomes, and the relative value of the treatments could be assessed by tracking and recording the costs. In addition, the intended ecological outcomes were redefined to include the maintenance of native plant diversity and an increase in cover of native plant species. For example, early efforts were narrowly focused on the control of YST. Seeding native plants became a higher priority in 1999; thus the acreage and diversity of the species planted were increased. Management alone was not sufficient to restore biological diversity in some parts of the preserve. The absence of a native seed bank in the soil, primarily from historic cultivation and land use, affected the species that regenerated after grazing and fire.

Participants learned about the diversity and complexity of native grassland habitats. About 100 species of forbs and 30 species of grasses inhabit Russian Ridge Preserve. The grassland is highly variable. Plant composition and density can change radically from one site to another and between years. Slope, aspect, soil type, and exposure can vary greatly over the topographic relief. Grass, forb, and exotic components all

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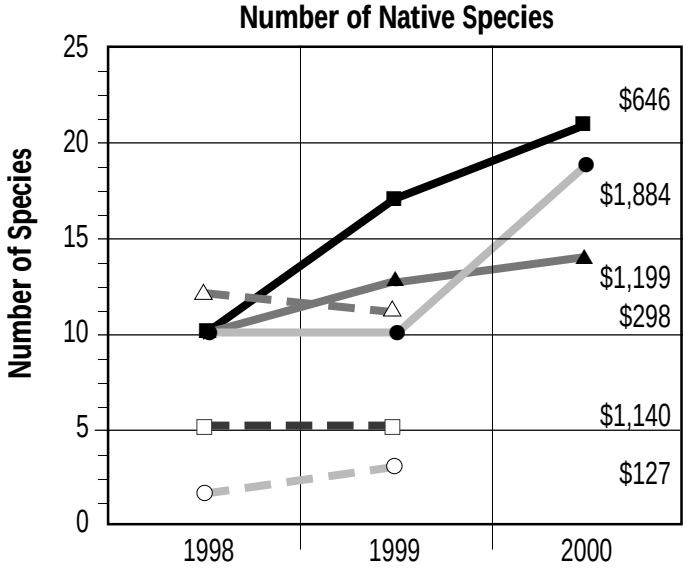

Figure 4. Change in number of native plant species with various treatments and associated costs at Russian Ridge Preserve.

= Graze; = Burn, Harding grass control, seed; = Burn, seed; = Herbicide; = Hand control; = Tractor mow; $ = Cost per acre.

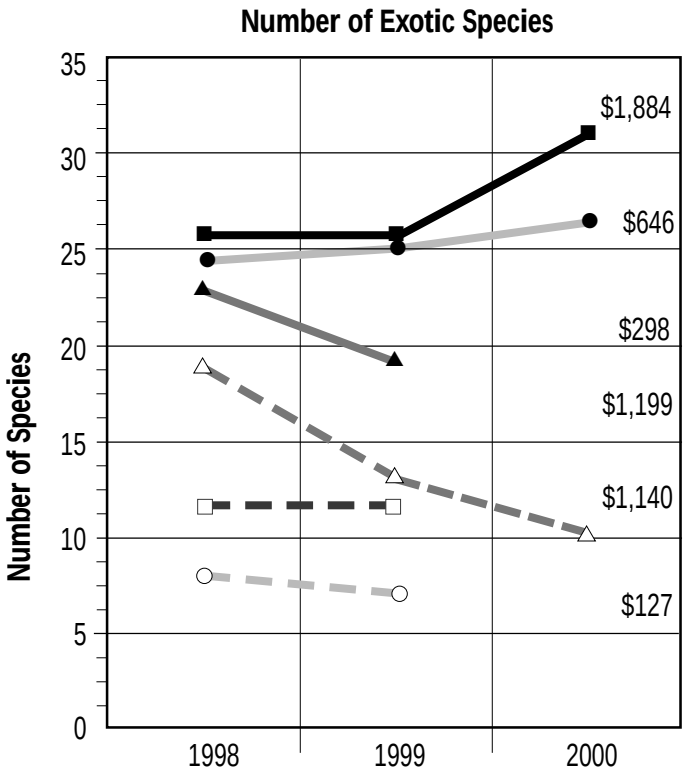

Figure 5. Change in the number of exotic species with various treatments and associated costs at Russian Ridge Preserve.

= Burn, Harding grass control, seed; = Graze; = Herbicide; = Burn, seed; = Hand control; = Tractor mow; $ = Cost per acre.

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respond differently to the various management tools that were applied. Based on resulting data collections, general patterns have emerged.

All treatments except combined prescribed fire and seeding reduced YST cover. Use of the herbicide Transline™ was most effective, fastest acting, and least expensive treatment. Grazing effectively reduced the cover of YST to 1% overall and was an effective alternative to herbicide use. Hand control and tractor mowing reduced cover of YST and are appropriate where prescribed fire and grazing are not options to the District staff. Because of the cost, these treatments should not be prescribed for large-scale operations. The prescribed fire, Harding grass control, and native seeding treatment resulted in total reduction of YST cover.

Increasing and maintaining cover of native species was a primary goal of the resource management program. In areas where the prescribed fire and native seeding treatment was used, native plant cover significantly increased, the increase mostly represented by those species that were seeded. Disturbance-loving native species also increased in cover as a result of grazing. Native *Madia*, clovers, and annual flowers represented species that regenerated after grazing. The seeds of these species were evidently dormant for many years until the thatch layers were removed and the soil surface disturbed. Use of herbicide, mowing, and hand control had little effect on increasing native plant cover.

Mowing and hand control were most effective in reducing the cover of exotic species overall. These treatments decreased exotic forbs such as *Rumex* and *Cirsium*. Exotic species, mostly annual grasses, increased as a result of grazing. The annual grass *Avena fatu* (wild oats) as well as *Erodium cicutarium* (filaree) were the exotic plants that increased in cover as a result of the prescribed fire and native-plant seeding treatment.

Species richness increased most significantly under the grazing treatment. The combined treatment of prescribed fire, Harding grass control, and native seeding also resulted in increased species richness, primarily as a result of seeding. Hand control and tractor mowing had little or no effect on species richness.

On some grazed areas (but not the sampling plots), especially in wet swales, within 5 days after grazing ended YST that was not grazed below secondary basal stems re-sprouted, and nearly all produced flowers by July 15th. In these areas, after goat grazing, all remaining YST flowers were cut again with weedeaters. As late as August 20, new flowers in these wetter grazed areas continued to appear on YST and required additional hand mowing. After each mowing, about 50% of the plants regrew flowers; thus they required mowing at least three times.

A quick study of the affects of fire on YST seed viability was conducted. YST seed was collected within the prescribed fire areas of the preserve. Nonburned seed was compared to seed that was burned. The burned florets collected were from intact erect stems that were only singed by fire. The seed was placed in Petri dishes on September 9, 1998; the dishes contained 25 seeds each from four samples. Nine days later 24% germination in the nonburned seed was observed, and no germination for seeds that were burned.

The prescribed fire and native seeding treatment was most effective in the reduction of exotic species, followed by the herbicide treatment. Prescribed fire was effective on most broadleaf exotics such as *Cirsium* sp. and *Crepis* sp. The herbicide Transline™ targeted YST but also reduced *Trifolium, Crepis,* and *Cirsium* species. Grazing increased the cover of two exotic Mediterranean species, wild oats (*Avena fatua*) and filaree (*Erodium cicutarium*). Species richness also increased where prescribed fire was used. After the second year of prescribed fire and restoration, native plants increased by approximately 18%. Prescribed fire followed by herbicide applications resulted in 27% reduction in Harding grass cover. By spraying the Harding grass in the late fall after fire and regrowth, the amount of herbicide needed to kill the plants was lessened, and accuracy of the spraying was enhanced.

Overall where the District planted wildland-collected seed, cover of native species nearly doubled, especially native grasses and forbs. The seeding of these native plants will in turn contribute to the native seed bank lost as a result of the previous agricultural land use.

The prescribed fire resulted in spectacular flower displays and a 50% reduction in cover of annual weedy plants. By conducting the prescribed fire program, the District demonstrated to the community its ability to manage and maintain a sensitive resource, reduce the risk of wildfire regionally, and coordinate resource management objectives with other resource agencies. The District also learned that prescribed fire could be used the following year after drill seeding and not kill the young native grasses and plants seeded the previous year.

Through the course of the 4-year program, resource management treatments commonly available to the District were demonstrated and analyzed on an operational basis. As a result of this study the District can conduct more informed resource policy and management decisions by understanding the biological effects and economics of those management actions. Based on the results of this study, the District has gained valuable information in regard to future management prescriptions for native grassland restoration and management. This information is important to conservation, restoration, and resource management on a regional scale as well.

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