

Restoration of Coastal Ecology on Landfill

by David Kaplow

DESIGN ASSOCIATES WORKING WITH NATURE (DAWN) is a non-profit land-restoration organization based in Berkeley, California. Its goals include: (1) collection, propagation, and research of native plants; (2) land restoration and management; (3) research in restoration techniques; and (4) public education.

HISTORY OF THE PARK

The Berkeley North Waterfront Park is an 85-acre expanse of landfill extending into San Francisco Bay due east of the Golden Gate Bridge. This site, the old Berkeley Dump, was covered with subsoil from construction sites in such a manner that the terrain became a rolling one with hills as high as sixty feet. The soil is generally very high in clay and very low in organic matter. Compaction is widespread.

Before DAWN's involvement, an eight-acre section of the park had been landscaped by the city—an operation intended as the first stage in development. In the 2.7-acre "natural area," native trees and shrubs, mostly Monterey Cypress *Cupressus macrocarpa* and *Ceanothus* species, had been emphasized. Spaced evenly throughout the site, they were all irrigated by a drip system with emitters placed ten feet on center. A groundcover of wildflowers, *Gazania*, and *Atriplex semibaccata* had been hydromulched.

After one year, the wildflower-*Atriplex* cover had given way to weedy grassland species, largely Wild Oats *Avena fatua*, Ripgut Brome *Bromus diandrus*, Annual Rye *Lolium multiflorum*, Bur Clover *Medicago hispida*, Bristly Ox-tongue *Picris echioides*, and Kikuyu Grass *Pennisetum clandestinum*. The shrubs and trees showed signs of decline due principally to moisture stress, wind burn, and salt burn.

We were faced with the challenge of creating a natural landscape in an area that had never before supported natural vegetation. Nevertheless, our

goal was to create a native-plant ecosystem there that could sustain itself. Needless to say, there were problems. Of these the chief were:

- Determination of conditions at various locations within the site
- Identification of native plants and plant communities suitable to each of the locations
- Replacement of annual weeds with a stable, perennial groundcover

SITE CONDITIONS

The waterfront park is visited by summer fog, salt wind, sea breezes, and winter-storm winds—in short, typical maritime influences. During the warmer part of the year, it is probably the coolest and windiest spot in the East Bay, but even so, it is not so cool and foggy as along the ocean.

The heavy clay soil of this landfill is the single greatest deterrent; for, by restricting root growth, water movement, and air movement, it threatens waterlogging in the winter and then, the opposite, an insufficiency of soil moisture in the summer. Shrubs and trees, unable to survive in the worst of the clayey situations without irrigation, are restricted to those sections where the soil is less compacted and more structured.

Having decided the best way to improve the structure and increase the fertility of the soil was to add organic matter, we tilled mulch into it. The long-term improvement, however, will come from the addition of organic matter by the fibrous root systems of the grasses. We are using the mature mollisol as the model for the eventual soil of the park. Typified by its dark, organically rich surface horizon, this soil order, often created by prairie vegetation, is common in the Bay Area.

Knowing little about the soil other than that much of it was almost hopelessly clayey and compacted, we sought indicators. They proved to be, reasonably enough, the shrubs and weeds already there. In some areas, the original shrubs had grown well and the weeds grown tall. These places we subsequently planted with shrubs, native grasses, and trees. In other areas, the original shrubs had died and the weeds grew shorter and more sparsely. Here, we introduced native grasses and herbaceous perennials, but no woody plants.

PLANT MATERIALS

Over 120 species of plants were field-tested at the park—all, except *Vulpia myuros* and *Festuca ovina*, native Californians. Some are southern Califor-

nia endemics, but by far the greater part of the seed and cutting stock was collected by DAWN members from along the central California coast. Container plants were raised at the DAWN nursery, located at the Waterfront Park. Virtually all plants, then, were coastal genotypes raised in the very coastal environment in which they would be planted. To lessen the strain of adjustment even more, we gave the potting mix a high mineral content, thus making it more like the soil of the plants' destination.

Containers ranging in size from two inches to two gallons were tried, among them styroblocks and leach tubes, in the use of which for large-scale production of grasses DAWN has been an innovator. We found that although we could plant the grasses in two-inch containers fastest—50 to 100 per hour—they generally competed poorly against weeds and were often trampled. Although those in four-inch containers did better, we could plant them at a rate of only 20 to 50 per hour. Plants from gallon containers had the highest rate of survival, but allowed only the slowest rate of planting: 10 to 20 per hour.

In all cases, this was evident: the grass seedlings that were successful were the young and vigorous ones; rootbound or old seedlings seldom recovered their vigor after being planted out.

Most plants were introduced as container stock, but we had enough of the grasses *Festuca rubra*, *Deschampsia caespitosa*, *Hordeum brachyantherum*, *H. californicum*, *Bromus carinatus*, *B. maritimus* and *Elymus glaucus* to do seeding plots as well. We had successful establishment and growth of all but *Elymus glaucus*.

We have been able to identify native plants appropriate to each of the various conditions at Waterfront Park. The most widely usable group of plants has been the grasses. Of them, the species we found most successful are:

<i>Agrostis hallii</i>	<i>Elymus condensatus</i>	<i>Hordeum</i>
<i>Bromus carinatus*</i>	<i>Elymus glaucus*</i>	<i>brachyantherum*</i>
<i>Bromus maritimus*</i>	<i>E. triticoides</i>	<i>H. californicum*</i>
<i>Calamagrostis</i>	<i>E. mollis</i>	<i>Koeleria macrantha</i>
<i>nutkaensis</i>	<i>Festuca californica</i>	<i>Stipa lepida</i>
<i>Danthonia californica</i>	<i>F. ovina*</i> (exotic)	<i>S. pulchra</i>
<i>Deschampsia</i>	<i>F. rubra</i>	<i>Vulpia myuros*</i> (exotic)
<i>caespitosa*</i>		

*Introduced by seed.

Rushes, too—*Juncus* spp.—are successful, particularly in clay soil.

Also widely usable have been many herbaceous perennials. Of these, the biggest success has been Gum Plant *Grindelia stricta*, and the next-biggest, as a group, the sagebrushes *Artemisia* spp. A list follows:

<i>Achillea borealis</i>	<i>Diplacus aurantiacus</i>	<i>Horkelia californica</i>
<i>Anaphalis margaritacea</i>	<i>Erigeron glaucus</i>	<i>Iris douglasiana</i>
<i>Artemisia californica</i>	<i>Erysimum concinnum</i>	<i>Phacelia californica</i>
<i>A. douglasiana</i>	<i>E. franciscanum</i>	<i>Polygonum paronychia</i>
<i>A. pycnocephala</i>	<i>Eschscholzia californica</i>	<i>Scrophularia californica</i>
<i>A. suksdorfii</i>	<i>Fragaria chiloensis</i>	<i>Sisyrinchium bellum</i>
<i>Astragalus nuttallii</i>	<i>Franseria chamissonis</i>	<i>S. californicum</i>
<i>Cardionema ramosissimum</i>	<i>Grindelia hirsutula</i>	<i>Solidago spathulata</i>
	<i>G. latifolia</i>	<i>Tanacetum camphoratum</i>
<i>Castilleja</i> spp.	<i>G. stricta</i>	<i>Wyethia angustifolia</i>
<i>Chrysopsis villosa</i>	<i>Heracleum lanatum</i>	<i>Zauschneria californica</i>
<i>Coreopsis gigantea</i>		

Most shrubs have worked reliably only on the less-compacted soils—in the main, only those with some structure and organic matter. Among the more versatile shrubs, *Atriplex* spp., *Eriogonum* spp., and *Salvia* spp. stand out. The shrubs we've used include:

<i>Atriplex canescens</i>	<i>E. staechadifolium</i>	<i>L. propinquus</i>
<i>A. lentiformis</i>	<i>Galvezia speciosa</i>	<i>L. variicolor</i>
<i>Ceanothus gloriosus</i>	<i>Garrya elliptica</i>	<i>Rhamnus californica</i>
<i>C. griseus</i>	<i>Haplopappus ericoides</i>	<i>Rhus integrifolia</i>
<i>C. maritimus</i>	<i>H. venetus</i>	<i>R. ovata</i>
<i>Eriogonum arborescens</i>	<i>Isomeris arborea</i>	<i>Ribes glutinosum</i>
<i>E. giganteum</i>	<i>Lavatera assurgentiflora</i>	<i>Rosa californica</i>
<i>E. latifolium</i>	<i>Lupinus albifrons</i>	<i>Salvia leucophylla</i>
<i>Eriophyllum confertiflorum</i>	<i>L. arboreus</i>	<i>S. mellifera</i>
<i>E. lanatum</i>	<i>L. littoralis</i>	<i>Sambucus mexicana</i>

One special group was of plants that required dune conditions. Even though difficult or impossible to establish in most of the park, they grew extremely well in the dunes we created. Some of these plants are:

<i>Artemisia pycnocephala</i>	<i>Coreopsis gigantea</i>	<i>Haplopappus ericoides</i>
<i>Astragalus nuttallii</i>	<i>Eriogonum latifolium</i>	<i>Polygonum paronychia</i>
<i>Cardionema ramosissimum</i>	<i>Eschscholzia californica</i>	<i>Tanacetum camphoratum</i>
	<i>Franseria chamissonis</i>	

Two of the species grew so vigorously that they are worthy of special attention. They are *Franseria chamissonis* and *Tanacetum camphoratum*.

Trees are restricted to richer, uncompacted soils—preferably those with some wind protection. We have had good results with:

<i>Abies grandis</i>	<i>Heteromeles arbutifolia</i>	<i>Pinus contorta</i>
<i>Aesculus californica</i>	<i>Lyonothamnus floribundus</i>	<i>P. radiata</i>
<i>Alnus oregona</i>		<i>P. torreyana</i>
<i>Cupressus guadalupensis</i>	<i>Myrica californica</i>	<i>Prunus ilicifolia</i>
<i>C. macrocarpa</i>	<i>Picea sitchensis</i>	<i>Quercus agrifolia</i>

Plants were arranged in the landscape by community. Distinct areas of prairie, scrub, and woodland were created, according to the soil and exposure at each. Trees were planted in the richest soil and, where possible, with northern exposure and wind protection. Prairie was seeded in those areas where the original landscape shrubs had died because of exposure and poor soil. Shrubs were planted in those areas that could not support trees but where the original shrubs had survived. Throughout landscape development, we used the local plant communities as models for the eventual species combinations. Although we used a diversity of species on a unique landfill site, the final landscape was very similar to the local one. We successfully established many species of coastal plants from throughout the state, but those that consistently did well were the local natives. For instance, the best combination of planted shrubs is *Baccharis pilularis con-sanguinea*, *Artemisia californica*, *Eriophyllum staechadifolium*, and *Diplacus aurantiacus*—almost identical to that of the Berkeley Hills and the Marin coast. The most successful hillside grasses—*Festuca rubra*, *Stipa pulchra*, *Danthonia californica*, *Bromus carinatus*, *Agrostis hallii*, *Hordeum brachyantherum*, *Koeleria macrantha*—are also the most widespread locally.

LANDSCAPE ESTABLISHMENT

We have found that the first goal in creating a landscape on a severely disturbed site, such as landfill, is the establishment of a groundcover consisting largely of perennial grasses. The native prairie creates a stable weed-resistant base on which shrubs and trees can be established later.

But in this particular project, because we were testing a wide variety of species in a short time, we established the trees and grasses concurrently. Shrubs were planted in islands to duplicate a natural pattern and to facilitate mowing the grass. We found that the shrubs survived and grew well but that

weed control in the shrub areas would have been much easier had a perennial cover been there in the first place.

The first step, then, in type conversion was the suppression of weeds. Although they were allowed to germinate in the fall, the entire site was covered by two inches of composted mulch in late December, before they had a chance to grow large. About a month later, we tilled the mulch into the soil, killing them. Those that we removed we piled into windrows, which we later covered with four to six inches of sand, creating dunes, which we subsequently planted.

We planted and seeded the prepared site in late January and early February 1983: in time to take full advantage of the spring growing season. (We have found fall seeding, too, to be very successful at the waterfront site because, by the time the spring sea breezes and the summer drought arrive, the plants have grown to a larger, hence safer, size.)

Soon after the planting and seeding, the natives germinated and the weeds began to reappear. At first, we pulled them out by hand, concentrating on Bristly Ox-tongue and Bur Clover. But later in the spring, we switched to mowing. The native grasses showed an almost immediate positive response.

We have found that regular watering and mowing are a very good way to establish a native grassland. Later on, after the plants have put on some size, the watering and mowing can be phased out. For long-term maintenance, mowing two or three times a year is more than sufficient to keep the prairie in optimal condition. Watering is optional; it needs to be done only for appearance.

CONCLUSION

Today, landscaping in California relies heavily on exotic plants, irrigation, and intensive management. Although there is a great deal of interest in water-conserving and low-maintenance native landscapes, native plants are viewed individually and not as part of natural landscaping systems. In this project, we were concerned with plant communities, not just individual plants. We see self-maintaining plant communities as the key. In conventional landscapes, plants tend to be separated enough to allow growth of specimens, but in wild stands and restored stands, plants are closer together. They interlock. The competition among them creates a fabric that binds the landscape together and resists weeds.

Communities tend to be of uniform height and appearance and hence can be used as recognizable design elements in a landscape. Each community, moreover, tends to be relatively uniform as to requirements for establish-

ment and management and hence can be dealt with as a management unit. In short, management is simplified.

We were interested in the grassland community as a first stage in an open-space landscape not only because it has the most flexibility and is the cheapest to establish over large acreage, but also because, most importantly, it creates a stable, weed-resistant base that can later be built upon.

We have found that the best indicator of what will grow on a site, even a landfill site, is the local vegetation. It shows the successful and stable plants possible on the site. Many people are interested in using new plants, both exotics and natives from other regions in the state. These plants have great landscape value as embellishments to a local plant community, but not as the basis of the landscape.

In planning a landscape, a prime concern should be the type of maintenance required, for the cost of maintenance can quickly become greater than the cost of installation and can, moreover, go on for many years. It is important to use a management system appropriate to the size and type of landscape. For small areas, the management is generally hand labor. In very large areas, on the other hand, intensive care is not feasible. Here, it is necessary to use such methods as grazing, prescribed burning, and mowing. But a medium-sized landscape, such as that of the Waterfront Park, is too small for economical grazing and too large for hand control alone. In this case, timed mowing and irrigation are the main methods of maintenance.

Our experience has shown us that native plants work well as landscape subjects. Some plants present difficulties, but the vast majority can be established reliably with excellent results—if the landscaping and maintenance are planned correctly. It is easy and inexpensive to maintain them when they are used as part of natural landscaping systems.

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