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Ecological Restoration of Coastal Sage Scrub and Its Potential Role in Habitat Conservation Plans

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ABSTRACT / Extensive acreage loss of coastal sage scrub (CSS), isolation of surviving stands, and the federal listing of several animal species with obligate relationships to this plant community, particularly the threatened California gnatcatcher (*Polioptila californica*), have led to attempts to create CSS to mitigate habitat lost to urban development and other causes. Many of these creations lie within habitat conservation plan (HCP) sites, and they could play a more prominent role by being repositories for plants taken from a single site having site-specific genetics.

Among others, one technique that increases initial resemblance to natural stands uses digitized, to-scale photography, which has been ground-truthed to verify vascular plant associations, which appear as mosaics on a landscape. A combination of placing patches of salvaged, mature canopy plants within larger matrices of imprinted or container plant plots appears to significantly enhance immediate use by CSS obligate bird species, accelerate "spread" or expansion of CSS, and can also introduce many epiphytic taxa that otherwise would be slow or unable to occupy developing CSS creations. Reptile, amphibian, butterfly, and rodent diversity in a salvaged canopy restoration case study at the University of California, Irvine, showed CSS species foraging and inhabiting transplanted canopy patches.

Using restoration techniques to expand existing CSS stands has more promise than creating isolated patches, and the creation of canopies resembling CSS mid-fire cycle stands is now common. Gnatcatchers and other birds use restorations for foraging and occasional nesting, and in some cases created stands along "biological corridors" appear to be useful to bird movement. Patches of transplanted sage scrub shrubs along habitat edges appear to break up linear edge effects. There are no data on which long-term survival, succession, or postfire behavior can be predicted for CSS restoration sites, and postfire community changes are not part of either mitigation or restoration planning at present. Long-term planning including burning is needed so that a fire-adapted habitat will develop. Restoration is important in retaining genetic resources, for ameliorating edge effects, as habitat extenders in buffer zones around HCP sites, and by providing areas into which natural stands can expand.

Coastal sage scrub (CSS) restoration faces regional landscape problems, including the deposition of airborne nitrogen from anthropogenic sources (Allen 1997), foliar damage from air pollution (Westman 1985), lack of species richness (Davis 1999), increasing weediness of natural stands (Westman 1987, Bowler 1990a), large seed banks of exotics, a lack of mycorrhizal fungi at restoration sites, and the inherent difficulty of establishing many species outside natural stands. Lack of understory annuals as compared with near neighbor stands (Bowler 1999b) and a lack of demonstrated fire cycle behavior (Bowler 1999a; see Figs. 1–3) are problems linked with mitigation and restoration.

The term "coastal sage scrub" is a generic one, like "montane forest." Since Westman (1981a, 1981b) defined four major vascular plant associations in coastal sage scrub (Diegan, Riversidian, Venturan, and Diablan) and two in the closely related coastal succulent scrub in northern Baja California, Mexico (Westman 1983; see DeSimone and Burk 1992 for a review of CSS associations), nearly a dozen subassociations have been recognized (Kirkpatrick and Hutchinson 1977, 1980, Jones and Stokes 1992); however, few attempts have been made to restore these finer-grained groupings. The finer-grained aspects of this complex community, including its subassociation and exposure differences, should be recognized in conservation (DeSimone and Burk 1992) and restoration planning (Read 1994). Habitat conservation plan settings provide excellent opportunities for this.

KEY WORDS: Habitat conservation plan; Ecological restoration; Coastal sage scrub; Mitigation; Plant salvage

Coastal Sage Scrub

Coastal sage scrub once covered perhaps 2.5% of the coastal lowlands in California and extended along Pa-

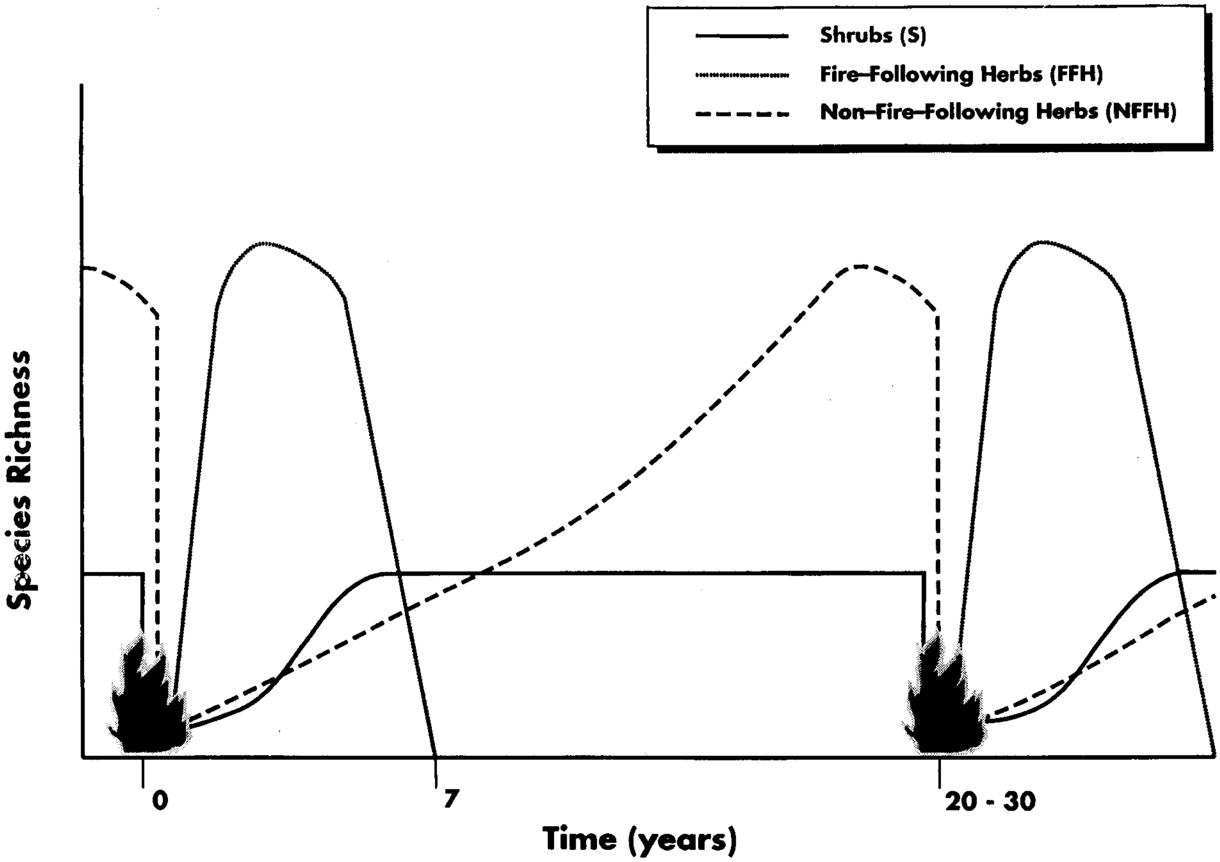

Figure 1. An idealized representation of postfire succession in coastal sage scrub, illustrating interburn cycles of 20+ years. Following fires of this frequency, there is a burst of species richness as fire-following taxa appear immediately after a burn, then decline at around 7 years, with shrubs recovering rapidly and an accretion of non-fire-following annuals present until around 17–20 years. After burning, the cycle begins again.

cific coastal Baja California, but today is highly fragmented in California, with most fragments having a dominance of edge, frequently in direct contact with urban development or roads (see Saunders and others 1991 for a review of the consequences of habitat fragmentation). In a sense this is also a "lack of edge," because natural "edges" abut oak woodland, grassland, or chaparral. Prior to the 1970s CSS was a poorly understood community, in part because some of the dominant canopy plants can invade burned stands of chaparral for a few years, thus it was viewed as successional (see DeSimone and Burk 1992 for an excellent literature review). In the early 1980s Westman (1981a–c, 1883, 1985) published a series of studies demonstrating that CSS is a distinct community, and there has been extensive research on it since then.

Sage scrub exhibits a postfire cycle of species appearance and replacement, beginning with characteristically fire-following taxa, such as *Lupinus*, *Phacelia*, *Escholtzia* and *Amsinkia* spp., and perennials, such as *Leymus condensatus* and *Malacothamnus*. Both annuals and understory perennials persist perhaps 7 years following a fire. Some of the species, particularly fire-followers, are present in the seed bank, whereas others invade from adjacent unburned stands and from the regional seed rain. The shrubs regenerate through root sprouting, and a gradual accretion of nonfire-following herbaceous taxa occurs until about 17–20 years, after which understory species richness declines. At about 40 years after a fire, there are few remaining.

Fire suppression has generated large fuel loads producing vast burns. Prior to this, canopies had many age classes for each species (Fig. 1). This cycle of postfire diversity (Fig. 2) and its emulation has not been incorporated into restoration plans, which instead attempt to mimic mid– or late–fire cycle conditions. Example of CSS restoration strategies that do emulate the fire cycle are presented in Fig. 3.

Most stands today are surrounded by grassland dominated by annual European grasses or the exotic black

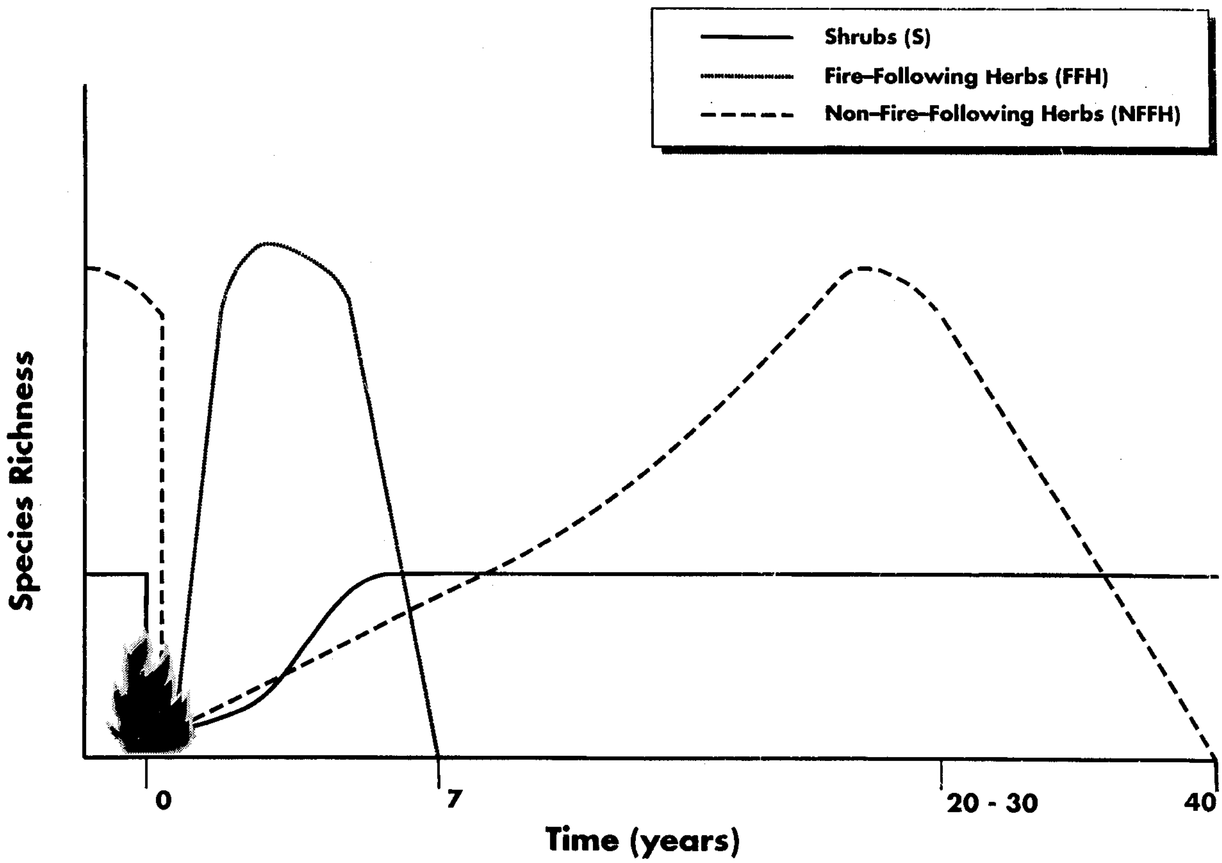

Figure 2. An idealized representation of postfire succession in an unburned condition beyond 40 years. In this situation, after fire a similar postfire succession begins, with understory taxa declining after about 17–20 years, eventually being nearly absent by 40 years after the previous fire.

mustard (*Brassica nigra*). Native grassland is nearly completely extirpated and southern oak woodland is a restricted, endangered habitat. Altered fire cycles, lack of adjacent stands of different age classes, and isolation from "regional seed rain" has led to decline in diversity throughout the postfire cycle. Late successional epiphytic species, such as lichens, have suffered extensive losses with many regional extinctions (Bowler and Riefner 1999). As a result, over 60 vascular plant and over 30 animal taxa in CSS are viewed as rare, threatened, or endangered. In the face of the magnitude of habitat loss and extent of decline of plant and animal species with obligate relationships to CSS, regional preserve systems (the Natural Communities Conservation Plan, or NCCP, for example) have been designed in an attempt to protect surviving large blocks of habitat while resolving political conflicts. The trade-off of preserving some areas and exempting rare, threatened, and endangered species from legal protection was adopted by state and federal agencies, as well as the developers who were largely its promoters and architects. Under these agreements, if additional species qualify for ESA protection, the areas to be developed would remain exempt ("no surprises"; see Smallwood and others 1999). Preserving designated blocks of habitat does not necessarily benefit all the sensitive species within them, as many species have widely ranging, often coastal distributions so that single blocks reflect little of the genetics, remaining populations, or actual distribution of such taxa (Westman 1987). Conservation plans, such as the NCCP and habitat conservation plans (HCPs), have been widely criticized in both the environmental activist (Luoma 1998, for example) and academic communities (Shilling 1997).

Mitigation

Although some papers published as early as 1990 (Bowler 1990b) recommended no further sacrifice of CSS, compensatory mitigation was not required until the California gnatcatcher was federally listed as a threatened species in 1993. Around 1996, mitigation

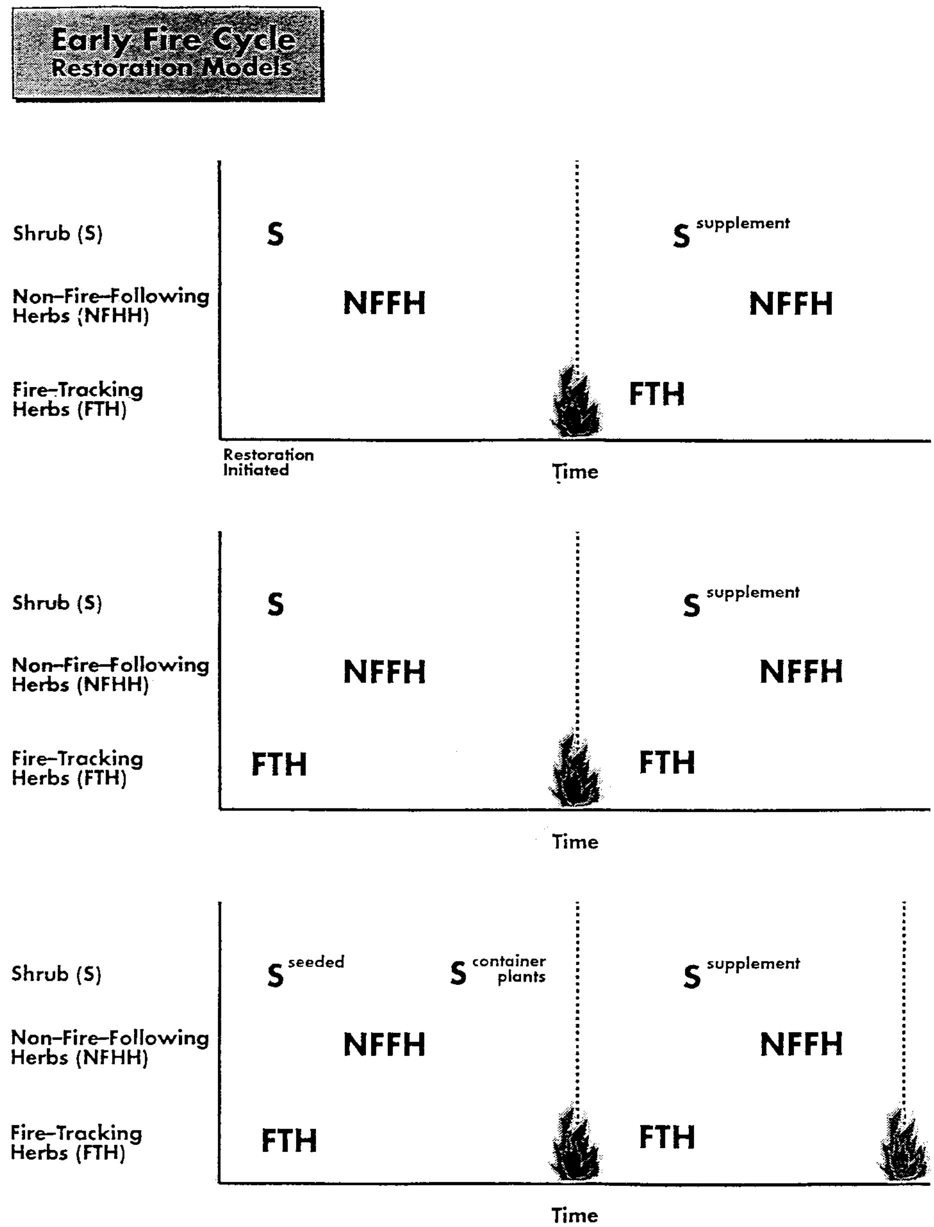

Figure 3. Examples of restoration strategies designed to emulate postfire succession in coastal sage scrub.

became required for taking CSS not currently sustaining gnatcatchers. One of the first gnatcatcher and CSS mitigations was voluntary, when in 1989 the University of California, Irvine, agreed to replace CSS habitat lost to university development and to place a 46-m buffer zone between new development and the university's Ecological Preserve, which supports six to eight pairs of gnatcatchers (Atwood and others 1998). Because compensatory mitigation is usually driven by the Endangered Species Act, habitat creation projects focus on shrubs known to be used by listed animal species. CSS created to mitigate gnatcatcher habitat loss usually includes such shrub species as buckwheat (*Eriogonum fasciculatum*), coastal sagebrush (*Artemisia californica*), black sage (*Salvia mellifera*), and California encelia (*Encelia californica*).

The approach of "replacing" habitat loss using a single formula has led to diminished habitat diversity. The replacement rarely reflects the aspect, exposure, structure or floristic quality, or successional trajectories of the habitat taken. CSS sites created under mitigation requirements make little attempt to restore the whole community; rather, they are simply canopy projects. Though they may emulate a mid– to late–fire cycle habitat, they are species poor in the understory.

For CSS the U.S. Fish and Wildlife Service usually requires a mitigation ratio of 2 acres created: 1 acre lost. Natural habitat is ranked as low, intermediate, or high in value. High value indicates occupation by gnatcatchers or that the site of loss is contiguous with other CSS habitat. Frequently one acre is required to be replaced in kind, but the other might be a "set aside" (preserved) or some other activity such as elimination of exotics like cardoon (*Cynara cardunculus*). The goal is usually to have met specified standards within a 5-year timeframe, with performance completion expected to be 20% the first year, 40% the second, 50% the third, 65% the fourth, and a minimum of 80% by the fifth. Goals usually include cover and diversity (i.e., survival of the plantings), for example, 15 native species have a combined cover of 80% in 5 years. Between 3000 and 5000 acres of CSS loss are being mitigated in this manner in Orange and San Diego Counties (Fred Roberts personal communication).

CSS restoration, as practiced for mitigation, is an assembly rather than a successional process. Techniques commonly used in creating CSS habitat include imprinting (mechanically forcing seeds and mycorrhizal fungi into the ground), hydroseeding, broadcast seeding by hand, and installing container plants grown in nurseries. The translocation of rescued or salvaged plants is also gaining acceptance. Some sites selected for the projects likely could never sustain most of the species in nearby CSS stands because they are located on graded road margins ("biological corridors" because new freeways usually pass through open space areas, thus roadway burrow pits are the only links between urban isolated natural areas), on closed and capped landfills, abandoned agricultural fields, and at other sites disturbed by heavy equipment.

Finally, mitigation responsibilities are usually linked to 5-year performance criteria based on shrub densities, not species richness. Once these criteria are met funding and maintenance are terminated. The result is often an aberrant "community" with a strange mixture of species, such as the dominance of an *Atriplex* species not occurring in natural CSS.

Although not widely discussed, most designs are based on mid– to late–fire cycle vascular plant species (those present at mid–fire cycle times, rather than the entire assemblage present above ground and in the soil seed bank). Mimicking mid–fire cycle above-ground plant assemblages could still allow burning after perhaps a decade, then the introduction of fire-following taxa and other understory taxa as suggested in Fig. 3 (Bowler 1999b). Producing CSS "canopy projects" is now routine, but these created habitats are not followed up with understory supplementation. Regrettably, burning and understory supplementation are not presently part of mitigation or restoration plans, and to my knowledge there has been no scientifically conducted and measured burn of created CSS with recovery and subsequent succession examined. Thus, CSS restoration is still in its infancy.

Canopy projects resemble natural stands in summer when the annual understory is absent, but created CSS adjacent natural stands may eventually support more species. Canopy projects may be all that can be hoped for along freeways and roadsides, which are often "biological corridors" that link isolated CSS stands. Patches of canopy plants also soften edges and expand gnatcatcher territories. HCP sites could serve as genetic repositories for plant patches transplanted from nearby sites destined for destruction. This would both enhance onsite habitat and preserve external genetic resources, which otherwise would be lost.

Some of the pitfalls of a mitigation based approach include:

- Five-year timelines are insufficient for CSS restoration because the inter-fire cycle within this community is decades long.
- Some projects create strange assemblages of species, such as the dominance of Brewer's saltbush (*Atriplex lentiformis* (Torr.) Wats. ssp. *breweri* (Wats.) Hall & Clem.) at Crystal Cove State Park (Orange County, California).
- Overhead sprinkling causes aberrant, spindly, and unbranched growth forms. Plants can have deformed, nonseasonal foliar characteristics, often with dolichoblast and brachyioblast leaves simultaneously in the late summer. Overhead sprinkling enhances nitrogen supplies, encouraging such exotics as annual grasses and black mustard, especially if reclaimed water is used.
- Many shrub and subshrub species have stunted growth forms, particularly on landfills or along graded road margins, due in part to overhead sprinkling and to the density of seeding.
- Some mitigation projects are poorly sited. CSS mitigation sites often suit the convenience and economics of the developer or highway project, rather than the ecological need. Often the aspect, slope, and edaphic factors are not matched to the species planted within created habitats.
- Many mitigation projects are never actually implemented, and within those that are, there is often

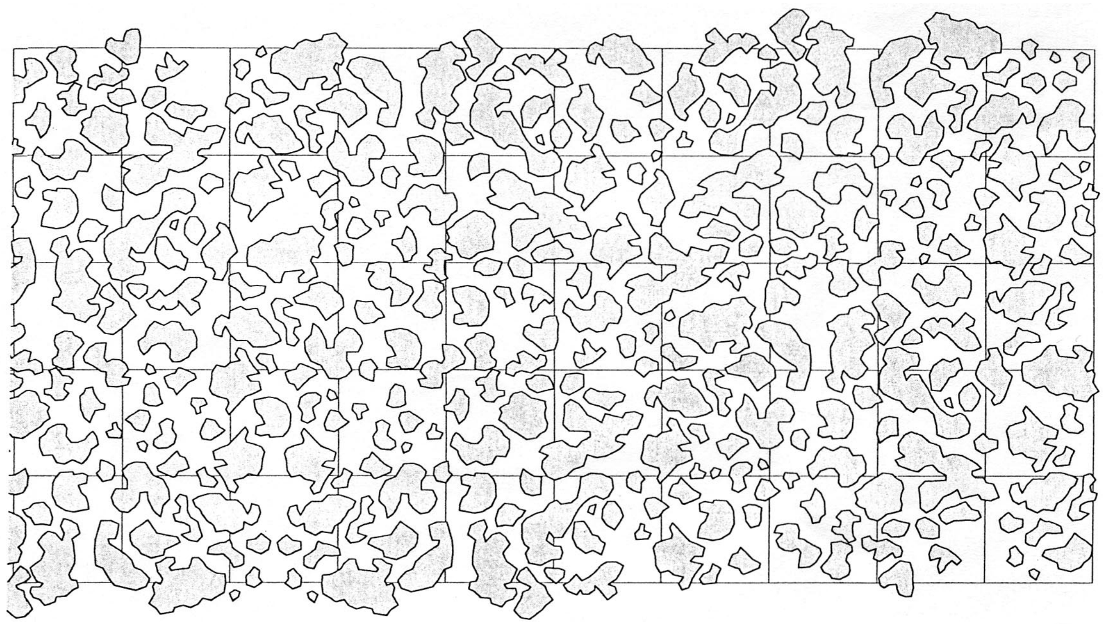

Figure 4. A mosaic representation of coastal sage scrub plant assemblages developed from digitized aerial photographs and transects. This design was incorporated into a repeating sequence used to produce planting designs that directly emulate the model mimicked in a coastal sage scrub restoration at the University of California, Irvine, based on Bowler and Demerjian (1996). In this figure the computer-delineated, wallpaper-like pattern of coastal sage scrub canopy (polygons) are lain on a 100-square-foot grid. (Reproduced with permission from *Restoration and Management Notes*.)

poor follow-up and the protocols for monitoring are inadequate.

Standard and Historical Approaches to Coastal Sage Scrub Restoration

In the early years of CSS mitigation, standard palettes of shrub species with a few understory plants were considered adequate to meet compensatory mitigation goals. Nursery-grown container plants were used in combination with hydraulic ("hydroseeding") or imprinted seeding. Usually 1-gal container plants that have been inoculated with mycorrhizae are planted. Although this is still the most significant way sage scrub restorations are implemented, there is an increasing concern and requirement for near-neighbor or onsite seed sources.

The most widely used landscaping technique is that of hydroseeding, in which native plant seeds are mixed with water, often certain fertilizers in low concentration, and a mulch-like substance, which is then sprayed onto the restoration site. This approach reduces erosion on a short-term basis, but it can initiate germination prior to application, causing rapid mortality; the seeds may fail to contact the soil; or they may produce a random occurrence of plants rather the kinds of associations seen in wild stands, and so forth.

Selection of a Model on Which to Base Restoration Design

To emulate natural habitat for CSS, a model site should be selected with exposure, soil, and slope similar to the restoration site. The natural site can then be characterized using transects, quadrats, and digital photography—and both the model site and the restoration should then be monitored to form an ecological basis for performance standards and to allow for corrections as the site develops. On the University of California, Irvine (UCI), campus in a linear Natural Communities Conservation Plan (NCCP) "biological corridor" adjacent a freeway, an experiment was undertaken using digitized aerial photography of the model site, which was then ground-truthed by transects (Bowler and Demerjian 1996). The mosaic pattern of plant assemblages within the larger model community which emerged was then used as the actual, to-scale design for the restoration (Fig. 4). This was very effective in enhancing the ecological resemblance to the model site. Within a year after planting, gnatcatchers were using the corridor extensively, although primarily as a passage rather than resident site. The use of an actual ecosystem model for design and planting achieves ecological similarity more rapidly than hydroseeding.

Onsite and Near Neighbor Collection of Seeds and Cuttings

Under ideal conditions, a donor habitat, which will be destroyed, can be identified several years in advance of its destruction and can be viewed as a farm. For example, Bowler (1999b) collected seed from 38 native species at Crystal Cove State Park over several years for use in onsite restoration. In a well-executed alluvial scrub restoration, seed from 24 species was collected for the project beginning 2 years before implementation, which allowed purity, germination, and seed content to be analyzed (Blane 1992). At UCI, seeds are collected, plants moved, and soil (if available) is ultimately saved and transported to on-campus restoration areas in advance of development over a period of years. A nearby protected site with similar soil type and depth, slope, and exposure can be dedicated as a host site, with only material from the donor site planted there (much like a genetic voucher site).

If it is not possible to conduct onsite seed and cuttings, a nearby neighbor site should be selected (Bowler 1999a). The importance of retaining local genetics is becoming increasingly recognized among restorationists in California and is now routinely required by regulatory agencies. Using HCPs as designated recipients of site-specific salvage material would both significantly increase the value of mitigation conducted in them as well provide added protection for resources otherwise sacrificed.

One of the problems of early mitigation sites is their extensive introduction of seeds from distant parts of a plant's distribution (Bowler 1999a). Non-native species also tend to follow mitigation projects because of the disturbed habitat and also because of irrigation used to establish plants. As an example, the Argentine ant is able to rapidly expand its distribution following water used for landscaping. This aggressive species immediately displaces native ant species (Fisher and Case personal communication). Ant-eating species, such as the sensitive and rare San Diego horned lizard, are thus affected, not only because their food base is eliminated but also because Argentine ants "swarm" their predators. The community's food chain is exacerbated by the practice of aligning freeways through open-space areas, which otherwise would have strong core areas without the suite of exotics that use roadside habitats as a conduit for colonization.

Salvage of Seed, Plants, and Soil from "Doomed" Sites

It should be emphasized that transplantation should only be employed as a rescue and recovery technique on "doomed" stands and should not be an avenue to strip wild stands in preserves of their recruitment; nor, clearly, should it be viewed as an easy means of simply "moving" a habitat from one site to another so that development can occur in a preferred site.

Values for donor and host CSS transplantation sites include:

- As seed sources—collection can be intensively pursued for years before their elimination: over a 4-year period approximately 450 lbs of seed were collected from a small on-campus site
- Sources for recruitment plants, or seedling collection—transplants are mycorrhizal from natural stand association (site-specific inoculum); over the past 4 years over 1000 seedlings and second-tier plants were collected from on-campus sites
- Sources for mature, canopy forming adults—which bring epiphytes (lichens, algae), invertebrates, and so forth when transplanted
- Genetic integrity—seed, seedlings, and adult plants are from a single locality
- Soil—bringing with it mycorrhizae and the cryptozoic community
- These sites can be farmed; "doomed" stands are possible sites into which seed can introduced, even watered, to generate recruitment plants that are mycorrhizal in the wild

Restoration host sites values:

- Seed sources—exceptional seed production usually occurs when canopy plants are transplanted, which can be harvested or left to further seeding of a restoration site
- Sources of seedlings—extraordinary self-seeding results in large numbers of recruitment plants, which can be harvested because they diminish in number in any event due to competition for water, light, and space
- "Instant habitat" attraction/effect for birds, mammals, and invertebrates that use canopy habitats when transplanted
- Wild-grown canopy plants jump-start restorations

Salvage of CSS was historically viewed as difficult with little likelihood of survival. Developers readily accepted nursery-grown container plants and hydroseeding be-

Table 1 Examples of canopy plant (shrub) survival for plants after 1 year

N	% mortality	Facultatively deciduous	Root type
109	1	*Artemisia californica*	Shallow
125	6	*Artemisia californica*	Shallow
20	35	*Salvia mellifera*	Shallow
?	59	*Eriogonum fasiculatum*	Intermediate; ropy
22	14	*Isocoma menziesii*	Shallow
99	81	*Lotus scoparius*	Deep taproot

cause planting and application could be timed to development and costs could be accurately estimated. Because salvage was not required by agencies, the feasibility of this technique in CSS was only recently studied (Bowler and others 1994, Bowler 1999c). Although an excellent and promising means of recovering plant material of known genetics, salvage is still experimental.

Transplantation of recruitment seedlings from natural stands has a very high success rate (see Table 1), and the plants are mycorrhizal by the time they are a few centimeters in height (Bowler and others 1994). Either direct transplantation can be employed for seedlings, or, if the soil is dry and the weather hot, they can be held in a greenhouse for a few weeks to reduce transplantation shock and increase survival (Bowler and others 1994). In other studies, Bowler (1999c) demonstrated that second-year and large older plants can also be transplanted. Moving plants from sites before development is now an accepted practice implemented by the Nature Conservancy in its management of the Nature Reserve of Orange County (NCCP lands within Orange County), and large canopy plants can be transplanted for less than $4 each, compared with commercially available gallon container material at <$3 (Bowler 1999c). Salvage can be done with hand labor or heavy equipment. Salvage plants of all sizes should be undertaken during winter (November through mid-March) when winter foliage is apparent in seasonally dimorphic taxa. Winter precipitation is usually sufficient to establish plants, so that if transplanted within the winter rain period, irrigation is not required. Facultatively deciduous species transplant most successfully, probably because they can lose their leaves in response to transplantation shock, then recover and regrow leaves. Nondeciduous species have higher mortality rates.

Root Structure

Root structure affects salvage potential. Shrubs with shallow, fluffy roots, such as *Artemisia* and *Salvia*, transplant easily, whereas species with a large taproot, such as *Lotus scoparius*, are most effectively transplanted from the wild as small recruitment plants; mature plants have poor survival. Nondeciduous species, such as lemonadeberry (*Rhus integrifolia*), have poor transplantation success as larger plants. Similarly, toyon (*Heteromeles arbutifolia*) is difficult to transplant as large individuals. *E. californica* is an intermediate species, with roots that can be shallow and fluffy or more rope-like if in a rocky substrate. This species can lose its leaves during transplantation and then recover. Buckwheat, a nondeciduous species with ropy roots, is difficult to relocate. A review of the root structure of chaparral taxa, including many CSS species, is presented by Kummerow and others (1977; see also DeSouza and others 1986).

In mechanically moved large clumps, a number of branches will die, but a few survive and set seed. Retaining dead plants is important in patch dynamics. The dead plants are used extensively by birds, including gnatcatchers, and dead or long-dormant plants are common in many natural stands.

Grafting

My group has made extensive attempts to graft distinct genotypes of around a dozen CSS shrub species onto an individual plant of the same species. This experiment was not successful, in that grafted woody plants are extremely fragile and unsuited to survival in the wild. Also, deer appear to find the grafting sealant extremely palatable. Santa Ana winds consistently damaged grafts. Grafting is not suited to natural-setting restorations in coastal southern California. It had been hypothesized that a broad genetic representation could be expressed within a restoration site by having individual plants host many genotypes and produce genetically diverse seeds. This did not appear feasible in nonprotected settings. Although an interesting concept, grafting does not appear to be a viable technique for woody plants.

Grafting is effective, however, in the Cactaceae (Bowler and others 1999) and can extend the expanse of such species as *Opuntia littoralis* and *O. prolifera*. In both of these species, blades can be grafted to create potential nest sites. This is significant for the coastal cactus wren, which lost 40,000 acres of habitat and around a quarter of the entire known population during the 1993 Laguna Beach fires. Cactus nest habitat can also be expanded by severing large plants at the base, allowing them to callous. The stubs are then planted and reinforced with rebar if needed. Individual plants of *O. prolifera* 180 cm in height were successfully "transplanted" in this manner; they subsequently flowered and set seed 2 years later. Such plantings represent 7 years of growth in terms of cladode production and structure.

Exotics

Because restoration is conducted in disturbed landscapes, invasive weeds challenge most restoration attempts. As an example, CSS and grassland habitats in the University of California, Irvine, Ecological Preserve (Orange County, California) have about 167 vascular plant species, 31% of which are non-native. Westman reported a similar ratio for Riversidian scrub, and Bowler (1990a) found that most San Joaquin Hills CSS sites were about a third exotic in species composition. Because most (78.8%) of the exotics are annuals in the UCI Preserve, the annual/nonannual ratio shifted from 1.13 in the native assemblage to 1.56. The annual/nonannual ratio for the 52 exotics only is 3.7. Exotic annuals dominate the cover of most of the 60-acre preserve. Exotic grasses appear to retard the expansion of native shrub stand expansion (Allen 1997). The heavy seed rain of exotic annuals likely alters population dynamics within the granivorous food chain.

Use of Restoration Sites by Animals

Habitat conversion, including attempting to alter exotic dominated habitats and return them to a native vegetation condition, changes animal use and presence. At a CSS creation site in the San Joaquin Marsh Reserve, which had been closed canopy artichoke, ground squirrels left after a successful restoration was in place. Because of the open ground area between patches or plantings in restoration sites, there are numerous ground-feeding birds present that are excluded by the thatch of dead annual grasses. As restorations are installed in formerly artichoke or exotic grassland habitat, California gnatcatchers use canopy CSS stands within a few days of installation. Bird point counts at the UCI Ecological Preserve indicate that 13 species consistently use the restoration plots, and at adjacent CSS control sites between 3 and 10 species are found.

Similarly, all of the four species of lizards present in the natural stands sage scrub, *Elgaria multicarinatus*, *Eumeces skintonianus*, *Sceloporous occidentalis*, and *Uta stansburiana*, were present in restoration sites at the UCI Ecological Preserve. Three species of snakes, *Lampropeltis getulus*, *Masticophis flagellum*, and *Pituophis melanoleucas*, were also observed in the restoration sites. The only species absent from the restoration plots was the ring-necked snake (found once in the natural stand control sites). The discussion of vertebrate use of the UCI Ecological Preserve is based in part on unpublished data by Fisher and Case (used with permission).

Converting a disturbed habitat from artichoke and mustard can change the mollusk fauna it supports. For example, the exotic snail *Helix aspersa* no longer used such an area after conversion to CSS, and the site was colonized by *Helminthoglypta tudiculata* (a native land snail associated with CSS in adjacent natural stands). At another restoration site, the exotic predatory decollate snail was present when the site was closed canopy artichoke, but is now absent from the site, which is restored CSS. This is suggestive that at least native land snails may track and prefer CSS to the environments created by European grasses, mustard, and artichoke.

Eighteen species of butterflies are known from the UCI Ecological Preserve and the urban dwelling area on its eastern edge. Eleven species have been recorded in CSS over the past 6 years, and five of these species and two others (not previously noted at the site) occur in the CSS restoration (Bowler 1999c).

As Zedler (1998) has shown for salt marshes, even seemingly "simple" communities are difficult to reestablish in ecologically functional ways. At this point mid–fire cycle canopy project creation is well understood, and many of them are used by wildlife such as birds, butterflies, and small mammals.

The highly fragmented UCI Ecological Preserve supported eight focal pairs of gnatcatchers in 1997, six in 1998, and seven in 1999 with birds extensively using two restoration sites (mostly salvaged canopy plants; Atwood and others 1998). Extensive use by butterflies, birds (including cactus wrens and gnatcatchers), and reptiles suggests that tight (10-m diameter), closed canopy and patches of large, transplanted canopy shrubs attract and are used immediately by most of the native fauna.

Biological Corridors

In a review paper (Beier and Loe 1992) and a subsequent study (Beier and Noss 1998), habitat corridors (dispersal corridors and landscape linkages) were characterized by five primary functions: wide-ranging animals can travel, migrate, and meet mates; plants can propagate; genetic interchange can occur; populations can move in response to environmental changes and natural disasters; and individuals can recolonize habitats from which populations have been locally extirpated. Succession, particularly epiphytic succession (lichens, algae, and fungi), should also be able to occur within such corridors. A primary concern is whether restorations and mitigative habitat creations are sinks, drawing animals into habitats that cannot support them for either passage or landscape connecting purposes. At least in terms of gnatcatchers, these corridors may function as ways for a species to get from one core site to another. Banded birds have been recorded as traveling from opposite ends of such linkages. Most links, however, do not provide true connection. Those with major four-lane streets and crosswalks as junctions would exclude animals other than birds. Thus, in these cases entropy rather biology determines successful traverse.

New Roles for Habitat Conservation Plans

HCPs should be complementary to species Recovery Plans under the Endangered Species Act, rather than a substitute. As such they should provide backup refugia within a larger context of recovery-based habitat preserves. HCPs should have buffers around them to protect them from intrusive external damage, such as to watershed problems of pollution and sedimentation, adjacent urban development, or other anthropogenic activities that degrade the HCP over time. It is certain that surprises will happen, ranging from new exotic plants and animals to the decline and endangerment of many species within limited, fragmented habitat, such as sage scrub, to other less predictable occurrences, such as the effects of global warming and climate change. Within this context, species that are sensitive now must have adequate areas of critical habitat and backup refugia. Ideally, HCP sites would be distributed throughout the range or be focused on areas poorly represented by designated critical habitat, as the "large preserve concept" (NCCP) cannot capture the genetic diversity or protect adequate numbers of broadly distributed but rare taxa. HCP settings are an opportunity to be genetic repositories for site-specific salvaged plant material, which would serve to both provide added habitat to a site and retain and preserve genetic resources that otherwise would be lost. HCPs should have management goals, including the ability to manage a site differently if needed as more is learned about habitat and species within them; i.e., adaptive management.

Conclusion

In conclusion, restoration of CSS in southern California lacks adequate consideration of the landscape scale and fire cycle characteristics. Canopy projects with established dominant shrubs are now expected by regulatory agencies overseeing mitigation requirements, but the chances for integrating the diverse understory flora are uncertain, particularly in its postfire cycles. Because the federally listed vertebrate fauna primarily uses the perennial canopy shrubs, it is not likely that mitigation for them will expend the long-term funding needed to assure full community presence in these created habitats. Until whole community values are appreciated and required, it is probable that most of the "restoration" now occurring will yield exotic-filled understories with native plant canopies for the foreseeable future. It is not known how functional such skeletal communities will be, but it can be hoped that at least birds and large predators will be able to use them as at the least as dispersal routes. Canopy projects are, however, well suited to softening edge effects in habitat fragments, provide areas into which adjacent CSS can invade—thus extending habitat—and can serve as genetic preservation of plant material that otherwise is lost. HCP sites can play a strong role in these efforts.

Challenges, among the many, include (also see NCCP Core Group 1997):

- Historic habitat loss, weeds, nitrogen deposition, foliar damage due to air pollution, habitat fragmentation, edge effects, and so forth
- Compensatory mitigation is often confused with restoration, but their scope is very different and allows very incomplete efforts, monitoring, and long-term commitment toward broad ecological goals based on whole community presence and function
- Mitigation (replacement) is driven by such laws as the Endangered Species Act
- Usually "restorations" are targeted toward canopy projects and enhancement of target vertebrates, not whole community concerns
- New approaches should include direct emulation of mosaics of vascular plant species associations within nearest neighbor stands
- Salvage of canopy and understory material provides patches of shrub habitat in large projects
- Restorations of CSS must include burning, then some approach toward introducing fire-following and subsequently appearing taxa
- Site-specific seed sources must be used (nearest neighbor approaches)
- Restorations must use models of emulations based on near neighbor sites in natural condition
- Fidelity to exposure, aspect, and soil type

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