# Climax and "Original Capacity": The Science and Aesthetics of Ecological Restoration in the Southwestern USA

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## ABSTRACT

This paper examines the historical origins of ecological restoration in the arid and semiarid deserts of the southwestern USA. Scientific knowledge and aesthetic valuations both emerged during a period of acute environmental degradation between 1893 and 1905, strongly influencing subsequent debates and practices. In science and aesthetics alike, the historical nature of southwestern landscapes was occluded: Clementsian ecology and range science posited a climax condition and an "original capacity" for livestock, while aesthetic treatments such as those of John Van Dyke saw transcendent and timeless beauty in the dramatic dynamics of actively degrading landscapes. In recent decades, southwestern ecologists have renounced Clementsian ecology and its implied telos of "pristine" presettlement conditions. But aesthetic ideals continue to influence broader debates and practices of ecological restoration in the region, specifically with regard to grasslands, riparian areas, livestock grazing, and fire.


**Keywords:** aesthetics, carrying capacity, climax, desert grasslands, range science, southwestern USA

*The most dangerous and difficult thing to set up about anything in this desert world is the general law or common rule. The exception—the thing that is perhaps uncommon—comes up at every turn to your undoing.*
—John C. Van Dyke,
*The Desert*, 1901 (p. 206)

The southwestern USA has been an important crucible for American ideas and ideologies of nature since the late 19th century. John Van Dyke's seminal treatise on landscape aesthetics, *The Desert,* managed to construct a timeless apprehension of the region's natural beauty from observations made amidst acute ecological degradation during the drought of 1898–1904. Around the same time, the overlapping fields of range science and plant ecology set down roots in the Southwest at institutions such as the Santa Rita Experimental Range and the Carnegie Institution's Desert Laboratory. Over the course of the 20th century, various regional ecological disasters were declared and denounced, often couched in metaphors of the fall, rapine, or invasion. Some were later recognized as false alarms, but in every case the idea of restoring past conditions was implied or propounded. Although the term ecological restoration is relatively new, the goals and practices to which it refers have been ongoing in the Southwest for more than a century, particularly in relation to arid and semiarid perennial grasslands.

As anywhere, ecological restoration in the Southwest begged questions about history: which past conditions were to be restored? The benchmark in this case was circa 1870, just prior to Anglo settlement and the mining, ranching, and railroad booms that drove widespread degradation of grasslands, forests, and watersheds by the end of the 19th century. That presettlement conditions could, and should, be restored was more a matter of faith than of science, however, and in the ensuing century restoration efforts generally failed. Cultivating grasses was attempted experimentally, and heavy equipment and airplanes were later used to remove or kill shrubs and to spread grass seed. But the returns from livestock production could not justify the costs of these practices over such vast areas. Managing rangelands in such a way that they would recover on their own made more sense, but it too proved elusive. In recent decades, ecologists in the Southwest have conceded that grassland restoration may not be possible (or even coherent) and have turned to the more forward-looking term "remediation." Among activists and practitioners, however, restoration not only persists but has also diversified its targets to include fire, riparian areas, and numerous plant and wildlife species.

Continued faith in the restoration ideal in the face of both scientific

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reevaluation and practical failures depends, I will argue, on an aesthetic apprehension of nature similar to the one Van Dyke found in the desert at the end of the 19th century. The dilemmas posed by history to ecological restoration—that any benchmark is arbitrary, that the clock cannot be turned back, and that the lessons of the past are mostly discouraging—must somehow be elided, because they cannot be resolved. Van Dyke achieved this by taking a transcendent perspective that rendered both humans and history insignificant by comparison. Ecologists did it, for most of the 20th century, by appealing to Frederic Clements's theory of plant succession, according to which vegetation communities would return to their "climax" conditions following any disturbance. Although these are not identical strategies, they both rely critically on scale—that is, the observed or postulated relations between larger and smaller units of space and time. Clementsian theory allowed scientists to posit that ecosystem behavior was linear across scales: that patterns discerned at one place and time could be scaled "up" or "down" without difficulty. Ecology distinguished itself from natural history on precisely this basis, early in the 20th century, by invoking universal (and thus ahistorical) "natural laws" such as plant succession. Likewise, an aesthetic apprehension of nature could see the transcendent in a particle of dust—collapsing scales altogether—only by abstracting from history.

Ecologists are now revisiting their Clementsian assumptions about scale, but history and aesthetics continue to bedevil the politics and practices of ecological restoration in the Southwest. The belief that "nature" will restore itself if "protected" from humans or their livestock remains powerful. In the case of riparian areas in the past two decades, for example, restoration through livestock exclusion has yielded results that are aesthetically compelling but historically and ecologically misleading. Efforts to restore fire, on the other hand, ongoing since the 1950s and increasingly prevalent recently, have often been stymied by the unavoidably historical agency of the process itself.

## Degradation and "Natural Appearances"

Scientific and aesthetic treatments of southwestern deserts both emerged at the end of the 19th century. In 1897, Van Dyke, a prominent art historian and critic at Rutgers, relocated from New Jersey to Los Angeles in hopes of curing his asthma. Four years earlier, he had published a series of lectures under the title *Art for Art's Sake*, and he had just completed *Nature for its Own Sake: First Studies in Natural Appearances*. Early in 1898, he set out on a three-year journey across the Mojave Desert into the Sonoran Desert of southern Arizona and the state of Sonora, Mexico. In the Sonoran port city of Guaymas, in 1901, he completed the manuscript of *The Desert: Further Studies in Natural Appearances*. Republished half a dozen times, *The Desert* is easily the most famous of Van Dyke's two dozen books (with the possible exception of *The Autobiography of Andrew Carnegie*, which he edited). It is considered an early exemplar of American nature writing, and Van Dyke is credited with having done for the desert what John Muir did for the Sierra Nevada: elevating it to the sublime among educated Anglo-Americans (Teague and Wild 1997).

Scholars of *The Desert* have focused on its role in American environmental writing and on its disputed authenticity—that is, whether the journey Van Dyke took was a Muir-like epic trek on foot and horseback, as he led people to believe, or a tale concocted from luxury train cabins and hotels (Wild and Carmony 1993). It is clear he was an affluent aesthete, a beneficiary as well as a critic of Gilded Age capitalism. But whether Van Dyke fabricated the trip is in a sense beside the point. After all, *The Desert* is not a story or memoir but an aesthetic-mystical meditation, devoid of plot or narrative; even if Van Dyke lied about the trip, the book cannot do so because it doesn't recount the trip. Instead, it couples aesthetic and philosophical meditations with lengthy descriptions of plants, animals, weather, landforms, and light. These descriptions, a kind of poetical taxonomy, are clearly informed by Van Dyke's conversations and correspondence with scientists at the University of Arizona and elsewhere (Powell 1976). The book's authority rests here, from the vantage of a temporal scale so vast as to render nature eternal (and therefore timeless), such that human activities appear trivial by comparison:

> sooner or later Nature will surely come to her own again. Nothing human is of long duration. Men and their deeds are obliterated, the race itself fades; but Nature goes calmly on with her projects. She works not for man's enjoyment, but for her own satisfaction and her own glory. She made the fat lands of the earth with all their fruits and flowers and foliage; and with no less care she made the desert with its sands and cacti. She intended that each should remain as she made it. (p. 62)

Van Dyke's elevation of nature to the sublime is characteristic of the romantic, preservationist strand of American environmental thinking. What scholars have not pointed out, however, is that Van Dyke wasn't traveling through "pristine" wilderness at all. He made his trip—whether on foot or by train—during the first three years of a severe six-year drought, in which thousands of livestock died of hunger and thirst across southern Arizona and northern Sonora. Less than a decade earlier, during the preceding severe drought, an estimated 50–75 percent of the cattle in southern Arizona had perished after stripping the land of grass, and most of the major floodplains from New Mexico to southern California had been incised with gullies by the force of subsequent floodwaters (Cooke and Reeves 1976, Bahre and Shelton 1996). Van Dyke makes frequent mention of the results: "There is no sod, no moss, to check or retard the flood; and the result is a great rush of water to the low places. In the canyons the swollen streams roll down bowlders [*sic*] that weigh tons, and in the ravines many a huge barranca is formed in a single hour by these rushing waters" (p. 3). "In the summer months it frequently rains on the mesas in torrents. The bare surface of the country drains this water almost like the roof of a house because there are no grasses or bushes of consequence to check the water and allow it to soak into the ground" (p. 208).

From the temporal scale of his aesthetic, however, Van Dyke is unable to connect these observations to recent, historical events. Instead, he writes in what we might term "the ecological present." He implies that the desert is intrinsically characterized by an extreme struggle for survival:

> There is a war of elements and a struggle for existence going on here that for ferocity is unparalleled elsewhere in nature . . . The sunshafts are falling in a burning shower upon rock and dune, the winds blowing with the breath of far-off fires are withering the bushes and the grasses, the sands drifting higher and higher are burying the trees and reaching up as though they would overwhelm the mountains, the cloud-bursts are rushing down the mountain's side and through the torn arroyos as though they would wash the earth into the sea . . . There is no living in concord or brotherhood here. Everything is at war with its neighbor, and the conflict is unceasing. (pp. 26–27)

Nowhere does Van Dyke attribute a historical cause to these conditions. If he recognizes degradation at all—which isn't clear—he blames it on Man in the abstract.

Indeed, the aesthetic power that Van Dyke celebrates was likely made possible by the widespread ecological degradation of the time. What most captivated him was the desert light interacting with vegetation, soil, and climate. "The vegetation of the desert is so slight that practically the whole surface of the sand acts as a reflector" (p. 78). "[T]he dust particles, carried upward by radiation and the winds . . . parry the sunshaft, break and color the light, increase the density of the envelope. Dust is always present in the desert air in some degree, and when it is at its maximum with the heat and winds of July, we see the air as a blue, yellow, or pink haze" (p. 80). Ironically, the dust—which must have been enormously exacerbated, if not outright created, by the combination of drought and overgrazing—figures prominently as a source of the aesthetic sublime. "The dust particle in itself is sufficient to account for the warmth of coloring in the desert air—sufficient in itself to produce the pink, yellow, and lilac hazes" (p. 86). The unique "natural appearances" of the desert are produced by the dust of degradation.

## Range Science and "Original Capacity"

It is hard to believe Van Dyke did not realize that degradation was recent and ongoing, especially because scientists—some of whom he was in communication with—were keenly aware of it and attempting rapidly to understand and reverse it. Congress authorized the first funds for rangeland research in 1895, and the USDA's new Division of Agrostology made the Southwest its top priority. While Van Dyke made his way east from California, early rangeland research was moving west from Texas to New Mexico and Arizona. The goal was recovery to "original capacity," measured in forage for livestock. It took more than 50 years of research before scientists conceded that no fixed "carrying capacity" can be said to exist on these rangelands, and by then two major interventions had already been carried out: chemical and mechanical assaults on mesquite trees, and introduction of grass species imported from Africa. The first was an expensive failure; the second has been deemed an ecological disaster in its own right.

The explicit goal of the early studies was "restoring those ranges that have become nearly valueless through overstocking or other causes" (Lamson-Scribner 1898, 170). Restoration was thus conceived in relation to economic value, understood in terms of carrying capacity: "the number of stock which may be supported upon [any large area] during its poorest years" (Smith 1899). Degradation could be measured as a decline in this number: 40 percent since 1874, according to a survey of livestock producers in 82 Texas counties who were asked to compare their past and current stocking levels.

The "original capacity," it was hoped, could be restored through scientific research and management; in the meantime, what mattered was the "actual capacity." And since carrying capacity was defined in relation to drought years, it could be increased by any means that reduced the exposure of herds to shortages of water and forage: windmills, silage, irrigated pasture, elimination of competitors such as rabbits, prairie dogs, and rodents, etc. From this possibility, a tension developed that would characterize rangeland restoration for decades to come: how to assess natural versus artificial techniques, ecological versus economic returns, "original" versus "actual" carrying capacities. Inducing the range to restore itself would be the cheapest approach, but it would also generate the least revenue (since it appeared to require removing livestock), and no one knew how long it might take. Investments in water systems, fencing, or supplemental feed might expedite increases in carrying capacity, but they also created an immediate economic necessity to generate revenue—meaning more livestock.

Within the Division of Agrostology and its successor agency, the Bureau of Plant Industry, there was lively debate about the merits of native versus non-native grasses, because the USDA's Seed Division was actively collecting and distributing seeds from around the world to boost agricultural productivity at home (Kloppenburg 1988). The debate derived from an implied equation of rangelands with croplands; perhaps carrying capacities could be increased in the same way crop yields had been, through selection of imported germplasm. The equation was a false one, however, because the cost of plowing and seeding such enormous areas was prohibitive relative to the revenues available from extensive livestock production (Sayre 2002). Behind all of this, meanwhile, was a static conception of "original capacity," understood as an inherent attribute of the land itself. That the forage base of 1874 might well have been unusually high due to the recent elimination of large bison herds was ignored, while interannual variability in forage production was deemed epiphenomenal—a matter of "actual" capacity and amenable to human intervention.

With restoration defined in terms of livestock production, and degradation attributed to overgrazing, it seemed logical to view livestock as the key variable in vegetation dynamics. Each experimental technique was evaluated relative to exclosures—fenced, ungrazed plots—understood as "controls" that demonstrated "natural" conditions. In Texas and later in Arizona, researchers concluded that three years of complete rest would restore the range to its "original capacity" (Bentley 1902, Griffiths 1910). They also found, however, that recovery could proceed in the presence of livestock, albeit more slowly, provided that stocking was reduced to "actual capacity," and for obvious reasons this approach was favored. Both approaches relied on the notion that the "natural" tendency of the range was to return to its "original" conditions.

The tension became an outright contradiction as research moved further west. Average precipitation declined from about 76 cm per year in the Texas panhandle to 20–41 cm per year around Tucson (depending on elevation), with a corresponding increase in the coefficient of variation. Not only did this make determining "actual" carrying capacities more and more difficult; it also opened up the possibility that "original" capacities were not stable. Early researchers noted that variables other than livestock numbers—such as fire and the temporal distribution of rainfall—appeared crucial in explaining shifts between perennial grass dominance and annuals or shrubs (Griffiths 1907). But they nonetheless persisted in applying the research model developed further to the east. Hundreds of native and non-native grass species were collected, grown, and studied in greenhouses and "grass gardens," and then transplanted or sown with various methods of cultivation and seedbed preparation. A few trials appeared promising during periods of favorable rainfall, but ultimately all failed, pushing the economics of restoration to their limits: "Where the carrying capacity of the lands is low no methods of eradication of weeds will pay for the labor involved. All that can be done is to get out of the land all that it produces of valuable plants without the abuse of overgrazing and to utilize the weeds if it can be done, if not by cattle then possibly by sheep or goats" (Griffiths 1907, 22). One researcher tried using cactus as emergency forage, but he found that only those protected from grazing by their spines survived (Thornber 1911).

## Climax Theory and Linearity across Scales

With the benefit of hindsight, the errors of applying the early model from Texas to the Southwest are obvious. Despite a steady reduction in stocking rates across the region since about 1920, an estimated 84 percent of perennial grasslands in the Apachean Highlands bioregion has been invaded by shrubs; three-fifths of this area is deemed by The Nature Conservancy to be beyond restoration, either because there is insufficient grass to provide the fine fuels needed to carry a fire (which would be necessary to set back shrubs), or because non-native grasses dominate to such an extent that fire, although possible, would not appreciably help the native grasses (Gori and Enquist 2003). Long-term data from the Santa Rita Experimental Range, south of Tucson, and the Jornada Experimental Range, near Las Cruces, New Mexico, have been invaluable in developing new theories of rangeland ecology in recent decades, because the appropriate temporal scale for understanding vegetation dynamics in arid and semiarid settings turns out to be 20–50 years rather than three to five (Lynam and Stafford Smith 2003, McClaran 2003). Although the relative importance of grazing, drought, fire suppression, and other factors in driving these changes is still debated, there is consensus among ecologists today that removing livestock will not reliably restore perennial grass dominance, and that fire restoration is a necessary, if not sufficient component of any strategy for grassland restoration (McPherson and Weltzin 2000).

It took until 1961 for range ecologists to concede that "sustained grazing capacity does not exist" in southwestern ecosystems (Paulsen and Ares 1961), and the long-term exclosures that were supposed to represent "natural" conditions or scientific "controls" have instead demonstrated that conversion to shrubs can occur in the absence of livestock (and, conversely, that livestock exclusion may not result in restoration of perennial grasses). Curiously, however, little attention has been devoted to explaining how such a fundamentally flawed approach to restoration managed to persist for the

**Fenceline contrast at pasture 8A, Santa Rita Experimental Range, 1920. Livestock exclosure was a necessary step for researchers seeking to understand the impacts of grazing and the rate and direction of recovery following overgrazing.** Photo courtesty of Santa Rita Experimental Range Archives, University of Arizona

better part of a century. The answer, I believe, comes in two parts. The first concerns the hegemonic influence of Clementsian climax theory in range research and policy, institutionalized especially by the U.S. Forest Service between 1925 and 1950. The second, paradoxically, is that the model persisted more in theory and law than it did on the ground.

Clementsian theory was developed in the Great Plains and adapted to range management by researchers working at high elevations in National Forests. In both places, it worked reasonably well as a means of orienting research and management (Young 2000, Young and Clements 2001). Clements himself insisted that plant succession was a "universal" theory that could be applied anywhere (Clements 1916), and in 1920, while employed at the Desert Laboratory in Tucson, he published *Plant Indicators*, a companion volume to *Plant Succession* that focused on range management throughout the West (Clements 1920). Although Clements did not believe in static carrying capacities, his theory had the virtue of systematizing knowledge across scales. It provided a framework within which experimental findings derived from relatively small plots (for example, one meter square) and short time spans (generally less than five years) could be extrapolated to much larger spaces and longer time periods.

By the 1930s, when funding for research increased dramatically, range scientists were documenting an alarming (for them) increase in mesquite dominance throughout southeastern Arizona, and their response was quixotic. On the one hand, they embraced Clementsian theory as the scientific basis of their discipline, describing perennial grassland as the "climax type" for southwestern rangelands. Reports and manuals from the 1930s and 1940s are, in fact, *more* Clementsian in their terms and concepts than had been the case earlier. The report of the U.S. Forest Service's "District 3 Grazing Studies Conference" of December 1921, for example, contains little or no trace of Clements's theories and concepts. Twenty years later, in a Forest Service manual entitled *Southwestern Range Ecology*, three prominent range scientists struggled valiantly to reconcile successional theory with observed vegetation dynamics (McGinnies et al. 1941). They rejected Clements's organic ontology, pointing out that "in a region of diverse topographic and climatic conditions considerable warping and twisting is required to make it fit local conditions." But Gleason's individualistic alternative, "if carried too far results in a complete unsystemization as far as plant communities are concerned, and it does not give sufficient weight to the influence of biotic factors" (p. 107). Something like Clements's theory was prerequisite to any range science: "as recognition of changes in vegetation is of primary importance in range management, we cannot escape the implications of plant succession" (p. 109).

The result was theory for theory's sake, an extension of the Clementsian model despite its incompatibility with empirical observations already made in the region. "In a region of wide variation in climate, particularly precipitation, it is difficult to determine what is climax vegetation and what is not" (p. 112). Plant communities could be identified, but arranging them in a linear succession was sometimes impossible. "Two general types of successional changes are usually recognized, namely: 1) Toward the climax, 2) away from the climax. It is also possible that successional changes may take place which are horizontal or neutral; that is, they are neither toward nor away from the climax" (p. 114). For example, "in Arizona between elevations of 4,000 and 7,000 feet there is a tendency for the development of several types of vegetation; namely, grassland, chaparral, oak woodland, and piñon-juniper woodland" (p. 113). These remarks uncannily anticipate developments in arid and semiarid rangeland ecology 50 years later (Westoby et al. 1989, Illius and O'Connor 1999).

Unable to resolve the problem, the authors of *Southwestern Range Ecology* retreated to the livestock-based metric of their predecessors, concluding that "progressive succession" occurs when productivity increases, whereas "retrogressive succession" is reduced productivity "because of loss of cover, soil depletion, increased run-off or some other reason." Also like their predecessors, they attributed vegetation change to livestock: "Retrogressive succession commonly occurs on overgrazed ranges" (p. 114). Eight pages later, as though recognizing the possible flaws of this argument, they remarked in passing that "there is some evidence to indicate that slow hidden changes take place, so that even where a range appears to be maintained in good condition it is apt to break rapidly during droughts" (p. 122).

On the other hand, from the late 1930s onward, applied research programs in the Southwest moved in an altogether different direction, away from the successional faith that reduced stocking rates would restore grasses and towards aggressive manipulation of plants, animals, and soils (Sayre 2002). In the 1930s, mulching showed some promise in increasing grass germination rates. In the 1920s and 1930s—and again in the 1980s and early 1990s—rodents such as kangaroo rats were fingered for their role in dispersing the seeds of mesquite and other shrubs. A veritable war on mesquites was declared, especially during the severe drought of the 1950s. The search for non-native grasses to revegetate the range was redoubled, yielding several varieties of African lovegrasses (*Eragrostis* spp.) that eventually worked so well that they became ecological threats in their own right. After World War II, the vision of cultivating the range resurfaced in the guise of bulldozers, specially designed tractor implements, airplanes, and even prison labor to remove mesquite trees and seed grasses. Repeatedly, treatments showed signs of success during periods of good rainfall, only to fail during subsequent droughts. This led researchers to blame soil moisture deficiencies, which were in turn blamed on competition from weeds and shrubs—justifying another round of attacks in the 1970s with new chemicals such as paraquat, tebuthiuron, karbutilate, picloram, and glyphosate. A 1979 herbicide application on the Santa Rita Experimental Range increased forage production from 250 to 3,200 kg/ha after 28 months (Cox et al. 1982).

Yet the mesquites remain to be vanquished. In a 1982 review of restoration efforts in the Sonoran and Chihuahuan deserts, a team of prominent range scientists noted numerous chronic problems stretching back 75 years (Cox et al. 1982). Studies lacked on-site weather data, consistency in data collection, replication, and accurate information about seed sources. Many experiments that failed were not published, resulting in needless repetition over time. Selective grazing resulted in overgrazing of introduced plants even at low stocking rates. Above all, though, the problem was spatial and temporal variability: "even when seedbed methods and seeded species are the same, results vary from site to site and year to year" (p. 15). This was essentially a problem of scale: "The situation becomes more confusing when positive results, obtained at atypical sites or in atypical years, were extrapolated and recommended for use over large areas" (p. 16). In recent years, rangeland ecologists have renounced restoration in favor of a more coherent notion of "remediation" that relies on measures of ecosystem processes rather than forage production or species composition (Herrick et al. 1996).

## A Burning Problem

Fire was the blind spot that southwestern range science could not overcome for the better part of the 20th, century. Many scientists recognized its importance, at least in historical and evolutionary terms, and a few tried to examine the issue directly. But the institutions in which they worked—above all the USDA Forest Service—would not allow range research and management to override the national policy of fire suppression. In 1926, Earle Clapp, Chief of Research for the Forest Service, wrote that "the production of timber must be the chief objective in the use of forest lands," and that "all research . . . must have constantly in the background the primary requisites of timber growing and the preservation of the soil conditions which are essential . . . to the growing of the maximum timber crops" (Clapp 1926). He objected to "the general practice of stockmen [in some parts of the country] to burn the range periodically in the belief that it will improve grazing," asserting that "forest fires influence usually for the worse the composition of forage plant associations . . . In protection from fire forage is involved along with timber" (p. 85). Involved, indeed: a preliminary study had found that "fires spread more slowly and ordinarily do less damage where the area has been grazed" (p. 90). Clapp's *A National Program of Forest Research*, published by the American Tree Association for the Society of American Foresters, made the institutional policy clear: overgrazing was preferable to forest fires because timber was more valuable than forage. This would be applied even in southwestern rangelands that produced no commercial timber.

Clapp also endorsed the Clementsian model for rangeland research, even as he admitted that "practically the entire question of association development and succession . . . still awaits investigation" (p. 84). He rested his case on a single example—Arthur Sampson's influential research in Utah's Wasatch Mountains (Sampson 1919)—which showed, he wrote, "that the climax and highly valuable wheat grass type could be retained only under proper range management. Excessive grazing resulted in lower successional stages of much less value" (p. 84).

The legacy of Clapp's premature judgments was evident in the pages of *Ecology* decades later. Utah and Arizona again figured prominently, with different researchers' methods and inclinations strongly shaping their interpretations of empirical evidence. How to evaluate the effects of grazing and fire on Western rangelands was a confounding question since one could not easily control them separately: grazing would suppress fires; not grazing would make fire almost inevitable. Walter Cottam and Frederick Evans (1945) compared two canyons in the Wasatch Mountains and attributed the differences they observed—higher perennial grass cover and lower shrub cover in the ungrazed canyon—entirely to livestock grazing, even though the ungrazed canyon had been regularly burned by the military "to clear the land for target ranges." Without addressing any role that these fires might have played, they inferred that grassland was the "pristine" condition of Great Basin foothills "at the time of the first white settlement," and that livestock alone were responsible for subsequent shrub encroachment.

In southern Arizona, by contrast, researchers found that shrub invasion proceeded with or without cattle, sometimes faster in ungrazed than grazed plots (Glendening 1952). The removal of livestock from the grounds of the Desert Lab had not produced differences in composition compared to adjacent, grazed areas, even after 50 years' time (Blydenstein et al. 1957). Rather than a Clementsian climax, the pre-1870 grassland came to be seen as a "subclimax" maintained by fire (Brown 1950). By the late 1950s, Robert Humphrey had found that fire could reduce mesquite, burroweed, snakeweed, and several cactus species. In *Ecology*, he published the conclusion that the "shrub invasion of southern Arizona semidesert grassland ranges is due primarily to reduction of range fires" (Humphrey and Mehrhoff 1958, 726). In a monograph, he was more sweeping: "the combined evidence appears conclusive to the writer that grassland fires in the desert grassland, as perhaps in grassland areas the world over, have been instrumental in preventing the establishment of woody species" (Humphrey 1958). Humphrey was ahead of his time, however, and after one of his fires escaped control, his research program starved for funds. Studies of fire often occurred by accident, when an experimental site happened to burn and researchers had prefire data to compare. But efforts to restore fire remained negligible.

Growing scientific evidence, reinforced by numerous catastrophic forest fires throughout the West, has by now thoroughly discredited the fire suppression policies that shaped 20th-century federal land management. In many higher-elevation forests there is so much accumulated fuel that fires seem unsafe even under carefully prescribed conditions. Southwestern rangelands have the opposite problem: shrubs have replaced the grasses that once provided fine fuels for fire spread, and where such fuels do exist they are often African lovegrasses, which thrive with burning. But it is clear that fire is a necessary disturbance to the maintenance of desirable conditions in both types of places. Unlike "original capacity," moreover, fire restoration is an ecologically coherent goal because fire is a process rather than a fixed state of productivity or composition. Yet despite persistent efforts by ranchers and the Nature Conservancy, fire restoration has occurred on only a few, discrete locations, due to antiquated policies and norms as well as the threat to rapidly multiplying exurban homes (Sayre 2005).

The more scientists study fire, the more complex and unpredictable it appears to be. Burning in winter has different results than burning in spring or summer; fire effects may depend less on the fire itself than on subsequent rainfall or drought. The "best" conditions for burning are, generally speaking, those that match the evolutionary norm—when a period of drought follows a period of heavier rains—but that is precisely when risks are highest and resources (equipment, firefighters, etc.) are in greatest demand from unplanned fires. Fire is too dangerous and unpredictable, it seems, even compared to the more expensive and failed methods of past restoration efforts.

## Aesthetic Redux: Riparian Areas

If fire restoration is ecologically coherent but practically impossible, riparian restoration is the other way around: ecologically misleading but widespread and relatively easy. Representing less than two percent of southwestern landscapes by area, riparian areas have long attracted a disproportionate amount of human and livestock impacts, and they have experienced dramatic invasions by non-native plants such as tamarisk, Johnsongrass, and Bermudagrass. But their very small extent has made restoration a more manageable challenge than in the surrounding rangelands. Between 1984 and 2006, 588 projects were implemented in the Southwest at a combined cost of nearly $500 million; of the 198 projects in Arizona, 40 were described as "fencing" and 18 as "livestock exclusion" (National River Restoration Science Synthesis 2006). The most celebrated "successes" of livestock exclusion, such as the San Pedro National Riparian Conservation Area (NRCA) in southeastern Arizona, have resulted in conspicuous increases in cottonwood-willow forests in as little as five years (Krueper et al. 2003).

Yet riparian area restoration suffers from both historical and ecological flaws. Restoration proponents and casual observers interpret sites such as the San Pedro NRCA much as early range scientists did their exclosures: as restoration of prelivestock conditions by the inherent regenerative power of "nature." They are correct in one sense: Clementsian successional theory does superficially appear to work in southwestern riparian areas because erosion and deposition deliver moisture and nutrients from the surrounding range. That the resulting climax is historically accurate, however, is simply wrong. Repeat photographs indicate that cottonwood and willow are more than twice as common in the region today as at the time of Anglo-American settlement (Turner et al. 2003), and surveyors' notes of the San Pedro River from the 1860s and 1870s confirm this (Sayre 2004). The ecological conditions that disappeared after settlement were floodplain marshes and sacaton meadows, which cannot be restored by livestock exclusion because arroyo formation has rearranged the hydrology of virtually every major drainage in the region. Meanwhile, the upland vegetation alongside the San Pedro has scarcely changed at all after more than 15 years of livestock exclusion (Krueper et al. 2003).

Excluding livestock neither "restores" past conditions nor repairs the degradation that has occurred in the Southwest since the late 19th century; riparian restoration by livestock exclusion only appears to satisfy the basic criterion of earlier restoration efforts—namely, that conditions circa 1870 can and should be restored. The resulting cottonwood-willow forests provide important habitat for various organisms, but they are quite different from the presettlement plant communities; in any event, riparian areas are a miniscule part of the vast southwestern landscape. Managing for them may yield satisfying results, but the satisfaction is fundamentally aesthetic. It runs the risk, moreover, of resuscitating the very same ahistorical apprehension of nature that helped create and sustain a flawed approach to southwestern landscapes for so long. Ironically, in their efforts to reduce or eliminate livestock grazing, some environmental activists promote ecological theories that southwestern rangeland ecologists struggled for most of a century to overcome. To return to John Van Dyke (1901): "This is a land of illusions and thin air. The vision is so cleared at times that the truth itself is deceptive" (p. 2).

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