9 Stewardship of Rangelands in the 21st Century

Managing Complexity from the Margins

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The term *range* has an Old World etymology, but its meaning cannot be separated from European expansion, conquest, and settlement. According to the *Oxford English Dictionary*, *range* as a noun derives from the Old French verb *renger,* which denoted the movement of herders and livestock across extensive open areas of land. It dates from the late fifteenth century, just prior to Columbus's voyages to the Americas. Many of the lands into which Europeans would subsequently expand, notably North America and Australia, lacked domesticated livestock, so, strictly speaking, they also had no rangelands – until Europeans arrived with their cattle, goats, sheep, horses, and pigs, that is. And as Alfred Crosby has shown, domesticated livestock were among the Europeans' most powerful weapons of ecological imperialism, not simply for the work they could do or the food they could provide, but above all because indigenous peoples lacked immunity to the many Old World diseases – smallpox, measles, mumps, and influenza, for example – that had evolved from the prolonged proximity of people and livestock at high densities. "It was their germs," Crosby writes, "not these imperialists themselves, for all their brutality and callousness, that were chiefly responsible for sweeping aside the indigenes and opening the Neo-Europes to demographic takeover."[1] Richard White puts the matter bluntly: "Without domesticated animals, Europeans would have neither survived nor conquered" in the New World.[2] In more ways than one, then, range livestock production was "the principal means whereby Europeans colonized and exploited the natural resources of sub-Saharan Africa, Australia, North and South America."[3]

The definition of range – and rangeland, which is the preferred term nowadays – has changed over time, but its frontier underbelly persists. In current usage, rangelands are a type of land, or rather a collection of types of land: grasslands, prairies, savannas, shrublands, steppes, tundra, and deserts. Each of these can plausibly be understood as a kind of biome or ecosystem, but the same cannot be said for the encompassing category, rangelands, since the constituent elements do not share any biologically or ecologically relevant attribute. All they have in common is that they are *not* any of the other major types employed to classify Earth's land

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cover. Rangeland is thus a residual category, a catch-all for any landscape that is neither forested, cultivated, buried in ice, built up, nor paved over. From an evolutionary perspective, livestock enabled Old World peoples to secure reliable livelihoods from non-arable landscapes by converting natural vegetation into edible calories and protein; from a modern perspective, rangelands are places not (yet) put to some other, more intensive use, and therefore (still) available for livestock grazing, expressly or as a kind of default or placeholder land use.

Little wonder, then, that rangelands are shrinking as humanity gradually converts them to other purposes. The Millennium Ecosystem Assessment estimates that 35–50 percent of wetter, more fertile rangelands (e.g., temperate grasslands) have been converted to crop production, for example. They remain the most extensive type of land, however, encompassing some 40 percent of the ice-free terrain on the planet, roughly 1.5 times as much as the world's forests and 2.5 times as much as croplands.[4] Indeed, from an economist's perspective, rangelands suffer from excess supply: they are the least valuable territory, in money price per unit area, in nearly every society where they are found. There are many reasons for this, to be sure: steep terrain, rocky or infertile soils, low and erratic rainfall, extreme temperatures, and inaccessibility characterize many rangelands. But their biophysical marginality is alloyed with political and economic elements as well. Rangelands are perennial targets for development schemes of all sorts – factories, subdivisions, waste facilities, military installations, solar arrays, power plants, mines, you name it – if only because they proffer cheaper ground than other places. To paraphrase Marx, rangelands constitute a reserve acreage of under-employed lands at the ever-expanding fringes of the world's economic geography.

That rangelands appear "worthless" and "empty" is a powerful illusion, at once demonstrably false and perversely self-fulfilling. They support an estimated one billion people and supply animal protein, water, or other resources for twice that many. Their value for conservation is enormous, precisely because they are not plowed, paved over, or otherwise simplified by intensive human use. They hold approximately 30 percent of the world's soil carbon, and only tropical rainforests harbor greater biological diversity.[5] They may appear inhospitable, bewildering, or threatening from the vantage point of the "civilized" world of sedentary states and city-dwellers, but from the perspective of a nomadic pastoralist, rangelands are none of these things.[6] Yet like Marx's reserve army of the unemployed, they are rendered exploitable by the same forces that subsequently exploit them. The greatest threat to rangelands worldwide is land use change and fragmentation,[7] "made possible by two enabling conditions – the growing power of centralized, bureaucratic states and the spread of capitalism… the power of this combination is now felt even in remote, relatively unpopulated and economically marginal rangeland areas."[8] In the words of historian and geographer Diana Davis:

> The assumption that the world's drylands are worthless, deforested, and overgrazed landscapes has led, since the colonial period, to programs and policies that have often systematically damaged dryland environments and marginalized large numbers of indigenous peoples, many of whom had been using the land sustainably.[9]

To think about rangelands thus requires holding seemingly contradictory ideas side by side: at once diminished and vast, worthless and invaluable, marginal and pivotal. The narrative and conceptual space delineated by these polarities is thick with histories, both human and evolutionary, and also with parables, legends, stories, and speculations. The designation "Great American Desert," for example, which geographer Edwin James slapped onto the North American High Plains in his map for the Long Expedition in 1823, helped retard Euro-American settlement there for a half-century, not because it was true but because people took it to be true. Rangelands are enigmatic, liminal, beguiling spaces, and it can be difficult to distinguish fact from fiction, the actual from the imagined. Australian rangeland scientist Mark Stafford Smith has written that "In caricature, the relationship between centres of power and drylands falls into one of three categories – rape and pillage, well-intentioned but poorly understood intervention, or benign neglect."[10] The knowledge claims underlying Stafford Smith's second category have generally circulated under the sign of science, but rangelands have repeatedly induced a mix of wishful thinking, erasure, and hyperbole. Three ideas will serve to illustrate, two from the past and one that is making the rounds now.

Desertification

> Because deserts are perceived as the most "worthless" lands on the planet, the history of desertification and dryland development policies lay bare the political and economic foundations of our most common and influential desert imaginaries and our deeply capitalist relations with nature more generally.[11]
>
> Diana Davis

In late 1975, the Royal Swedish Academy of Sciences used its journal *Ambio* to publish an article entitled "Desertification: A World Problem," written by Erik Eckholm, a Senior Researcher at the Worldwatch Institute in Washington, DC. "Deserts are creeping outward in Africa, Asia, and Latin America," Eckholm began. This was not due to climate or drought, he argued, but to over-population and associated human impacts. "Populations are, in effect, outgrowing the biological systems that sustain their way of life… dessicated [sic], barren, desert-like lands are being *created,* a process that has become known as desertification." Overgrazing, fire, and imprudent cropping in "fragile" arid and semi-arid rangelands

were altering the climate and reducing local rainfall in a vicious cycle. "It is a malignancy undermining the food-producing capacity of Africa, Asia, and Latin America," and it could only be stopped by urgent outside interventions to reduce livestock numbers, plant trees to slow erosion, and modernize production systems. "Human cultural patterns in the desert must be reshaped."[12]

Eckholm's piece was just one of many breathless declarations of a global desertification emergency in the early 1970s, a discourse enflamed by searing images of emaciated children and eviscerated livestock in the Sahelian region of West Africa. The hyperbolic tone suggested a novel, unprecedented threat, and indeed many people and countless livestock perished. But the narrative was more than a century old. Seemingly unbeknownst to the likes of Eckholm, desertification had its roots in nineteenth-century French colonial Morocco and Algeria, where scientific foresters diagnosed regional "desiccation" as the result of native herders' livestock and land management practices. As Diana Davis has shown, "The idea of desertification itself is in fact a colonial construction, a concept with little basis in empirical evidence initiated and propagated by those with a poor understanding of arid-land ecosystems."[13] Colonial administrators and professional scientists such as François Trottier, A.D. Combe, Paul Boudy and Charles Flahault, many of them trained at prestigious French universities, gave desertification the imprimatur of objective science. Whatever their individual motives may have been, their ideas "served three primary purposes: the appropriation of land and resources; social control (including the provision of labor); and the transformation of subsistence production into commodity production."[14] Similarly, the late-twentieth-century revival of the desertification narrative served powerful post-colonial interests in developing countries as well as the ascendant international development apparatus, giving rise in rapid order to a report from the U.S. Agency for International Development (1972), a UN General Assembly resolution (1974), an international conference and UN Plan of Action to Combat Desertification (1977), and eventually a permanent instrument, the UN Convention to Combat Desertification (1994).[15]

Several of the claims that gained the most traction in desertification discourse were quickly shown to be false (e.g., that the Sahara Desert was expanding southward at thirty miles per year); many others rested on incommensurable, spurious or non-existent data, dressed up in authoritative-sounding declarative prose (e.g., "at least 35 per cent of the earth's land surface is now threatened by desertification").[16] But banal factual refutations could not keep up with a narrative that, as in the colonial Maghreb, "was so useful to so many in positions of power who used it to justify their actions."[17] In the 1990s, arid lands expert Chuck Hutchinson pointed out that the strongest empirical case of desertification was the southwestern United States, but that went nowhere – demonstrating that the concept was really meant for use in poor countries.[18] Every decade or

so, another compendium of scholarship documents the conceptual incoherence and empirical lacunae of desertification.[19] The latest of these calls Sahelian desertification "something that never occurred but was widely believed to have existed" and observes that the concept "has become a political tool of global importance even as the scientific basis for its use grows weaker."[20] Satellite remote sensing demonstrates unequivocally that the Sahel region has "re-greened" with better rainfall since the 1980s, and climate models now suggest that the severe drought of 1967–72 may actually have been driven by industrial aerosol emissions from Europe![21] But the desertification discourse marches on, as we will see, and the policy measures mobilized through the narrative – such as sedentarization of nomads, privatized land tenure, fencing, destocking to fixed carrying capacities, improved breeding, and agricultural intensification – continue to be advanced in many developing countries, despite repeated and well-documented failures.[22]

Succession

Frederic Clements is universally regarded as a major figure in the history of ecology, and his theory of plant succession is by all accounts the foundation on which the field of range science was built. Curiously, no authoritative biography of Clements has been written, and the existing literature about him rarely touches on the broader social and political contexts in which he lived and worked.[23] Born in Lincoln, Nebraska, in 1874, Clements grew up in the midst of one of the most dramatic episodes of landscape transformation in history: the breakneck conversion of the Great Plains from bison-dominated prairie to intensive grain agriculture in the span of a single generation. As a student of Charles Bessey and Roscoe Pound at the University of Nebraska, Clements fell under the spell of the prairie and its grasses, earning his doctorate at the age of 24 and immediately joining the faculty of botany. An ambitious scientist and obsessive worker, he was further motivated by the fact that the prairies around him were rapidly disappearing under the settlers' plows.

Nebraska provided Clements with an exceptional natural laboratory: a highly diverse but spatially continuous plant community that stretched 430 miles along a 15–35-inch west-to-east rainfall gradient. Using a meter-square quadrat method inspired by Bessey and perfected with Pound, Clements was able to document and measure the dynamic interactions of vegetation with rainfall and soils over space and time. Analyzing those dynamics with newly developed statistical techniques, he helped transform descriptive botany into modern ecology, grounded in the theory of plant succession. Largely on this basis, the University of Nebraska became the dominant force in American grassland ecology for decades to come, granting more than half of the nation's doctoral degrees in the field between 1895 and 1955 and training many of the men who invented

range science, including Arthur Sampson, William Chapline, Jared Smith, and Clarence Forsling.[24]

Clements published his two-volume magnum opus, *Plant Succession* and *Plant Indicators,* in 1916 and 1920. The first volume developed his theory, and the second applied it (in encyclopedic detail) to the plant communities of the western United States. The very first paragraph of *Plant Indicators* explained its "practical aspect" and is worth quoting in full:

> Every plant is a measure of the conditions under which it grows. To this extent it is an index of soil and climate, and consequently an indicator of the behavior of other plants and of animals in the same spot. A vague recognition of the relation between plants and soil must have marked the very beginnings of agriculture. In a general way it has played its part in the colonization of new countries and the spread of cultivation into new areas, but the use of indicator plants in actual practice has remained slight. It is obviously of the greatest importance in newly settled regions. However, it is in just these regions that experience is lacking and correlation correspondingly difficult. In fact, the pioneer is often misled by his endeavor to transfer the experience gained in his former home to a new and different region. Differences of vegetation and climate, and often of soil as well, make a wholly new complex of relations. As a consequence, the settler is very apt to go astray in reaching conclusions as to the significance of a particular plant. As the country becomes more settled, experience accumulates and makes it increasingly possible to recognize helpful correlations. But this period usually passes too quickly to establish a procedure before the native plants have disappeared, except from roadsides, meadows, and pastures. The manner and degree of utilization of natural meadows and pastures are clearly indicated by the plants in them. Yet it is exceptional that these indicators are recognized and made use of by the farmer.[25]

A successional understanding of native vegetation could help identify the cultivars to which any given site was suited by its soils and climate, facilitating rapid and efficient installation of commercially viable farms. This theme recurs throughout the book, as Clements remarks in passing on costly – or even tragic – mistakes in planting choices by settlers in various locations. The express intent of Clements's theory, then, was to aid in successful colonization and agricultural settlement in "new countries" – an anodyne allusion to the then-still-recent conquest and dispossession of Native Americans. Stronger confirmation of Libby Robin's contention that ecology is a "science of empire" could scarcely be imagined.[26]

Much of the western U.S. was rangeland, and Clements paid particular attention to how succession could aid in grazing management. Droughts and winter storms during the Cattle Boom of 1873–93 had resulted in

massive livestock die-offs and widespread, persistent rangeland degradation; how to remedy this damage while still supporting settlement was an urgent question. Clements's theory provided a reassuringly positive answer, grounded in an analogy between cattle and bison. Reviewing the accounts of early explorers and migrants, Clements found wide disparities: some described endless expanses of grass as tall as a horse, others a landscape nearly denuded of vegetation. Both were accurate, he averred: they just happened to witness different moments in the dynamic interplay of bison, rainfall, fire, and grasses. "All the statements agree as to the excessive damage done to the range by buffalo, but it seems certain that the more or less complete rest which followed brought about a fair degree of recovery in a few years."[27] Likewise with fire or drought: the bison would simply migrate elsewhere, allowing the disturbed areas to recover.

> It is obvious that an area destructively overgrazed would be abandoned by grazing animals for an untouched portion of the same climax, and that the bare area would then pass through the various stages of succession to again reach the climax in 20 to 30 years.[28]

The core ideas of Clements's theory were elegantly demonstrated in this simple, archetypal case: following disturbance, a plant community passes through stages of recovery (succession) until it returns to its equilibrium state (climax), provided the disturbing agent is removed. Cattle might not be able to migrate long distances, but their owners could simulate the process by rotating their herds between multiple pastures.

> The recognition of past and present cycles of overgrazing is of great practical importance. Its greatest value lies in the certainty that a range will return to its normal condition once it is given a chance to regenerate… all overgrazed ranges can be certainly and greatly improved by proper rest or rotation. This is the basis of all range improvement.[29]

Clements was explicit about both ends and means: "The primary object of range improvement is to secure and maintain the maximum carrying capacity. The chief factors in this are proper stocking and rotation grazing."[30] The result was managerial control: "an elementary understanding of successional processes furnishes a tool for manipulating the grazing cover more or less as desired."[31]

Clements believed that his theory of plant succession was "of universal application," valid not only in Nebraska or the Great Plains but throughout the world, forwards and backwards in time even on geological timescales.[32] This was crucial to claiming the mantle of a rigorous, formal science at the time, and it certainly aided the adoption of successional theory as the basis for range management in the U.S. Forest Service, which

dominated range science (as well as forestry) through the first half of the twentieth century.[33] But it was also an extravagant over-generalization. As Ronald Tobey points out, the droughts of the 1930s led to a wholesale shift in the composition of the prairies in eastern Nebraska even during Clements's lifetime, much to the alarm and dismay of his famous disciple and collaborator, John Weaver.[34] Degraded grassland sites in the southwestern U.S. where livestock were removed early in the twentieth century failed to conform to successional expectations, instead converting to shrub dominance. But alternative paradigms did not emerge until the 1970s and 1980s.

Only in the present century have scientists replaced Clementsian succession altogether for sites where the coefficient of variation of inter-annual precipitation exceeds 33 percent – which is not the case in Nebraska, but is true for roughly 28 percent of the world's rangelands.[35] These are now understood as non-equilibrium systems, with complex, non-linear dynamics and multiple stable states, in which abiotic factors (e.g., drought, rainfall, fire or frost) are often the main drivers of change. Recognition of this has forced a fundamental rethinking of "degradation," which had previously been defined as departure-from-climax (or various analogues thereof). Thus, rangelands at the drier, more variable end of the spectrum – such as the Sahel – are now considered *less* fragile than before, and globally less degraded than more temperate grasslands.[36] The concept of carrying capacity as a singular, static attribute of rangelands has been widely debunked, as "average" forage production almost never obtains and livestock–vegetation dynamics are simply too varied and complex to be captured by such a blunt instrument.[37] The role of fire has likewise been re-evaluated: rather than an unmitigated evil, as it was deemed by French colonial and U.S. Forest Service officials alike, fire is now seen as an unavoidable and often beneficial ecological process on many rangelands.

In short, the Euro-American conventional wisdom about rangelands that prevailed from the early nineteenth to the late twentieth centuries has been upended, at least among scholars and scientists. In addition to new models for how rangelands function, there is growing recognition that long-time rangeland inhabitants and managers – including pastoralists, indigenous groups, and multi-generation ranchers – possess important local and traditional ecological knowledge that has heretofore been overlooked or actively dismissed by professional experts. This is not to say, however, that the broader public or policymakers have absorbed the new findings, nor that scholars and scientists today are necessarily immune to the mistakes that afflicted their predecessors.

Rangelands as Climate Solution

Combatting anthropogenic climate change is a common theme of discussions about rangelands in the twenty-first century. In various

combinations, people from the environmental NGO community, ranching, philanthropy, academic science, government, and multilateral agencies have rallied around this cause, employing partially overlapping vocabularies to explain and energize their efforts: holistic management, planned grazing, regenerative agriculture, or adaptive, multi-paddock (AMP) grazing, for example. They should not be conflated, if only because they often see themselves as quite distinct, but a full examination of their differences is beyond my scope here. It is fair to say, nonetheless, that they have at least three things in common: a genuine and growing concern about climate change; a belief that rangelands, and specifically rangeland soils, can play a major role in addressing the problem; and a commitment to rotational grazing as a primary management practice for achieving this vision. What light can the history described above shed on these ideas, and vice versa?

Allan Savory's 2013 TED Talk, "How to Fight Desertification and Reverse Climate Change," has been viewed more than 7.75 million times. Described on the TED website as a "grassland ecosystem pioneer," Savory is the charismatic and controversial founder of holistic management, with ardent supporters and detractors alike. In his talk, he asserts that "about two-thirds… of the world is desertifying," and that land degradation is as important (and "maybe" more important) than fossil fuels as a driver of climate change. His core claims are captured in these passages:

> There is only one option, I repeat to you, only one option left to climatologists and scientists, and that is to do the unthinkable, and to use livestock, bunched and moving, as a proxy for former herds and predators, and mimic nature. There is no other alternative left to mankind… [I]f we do what I am showing you here, we can take enough carbon out of the atmosphere and safely store it in the grassland soils for thousands of years, and if we just do that on about half the world's grasslands that I've shown you, we can take us back to pre-industrial levels while feeding people.[38]

Savory does not mention bison or the Great Plains, and he does not acknowledge that his model and inspiration – large mobile herds of wildlife – is identical to that of Clements a century earlier, nor that rotational grazing, too, is a venerable subject in the literature, as we have already seen. Roy Behnke's summation is incisive:

> Between 1948 and 2003 roughly two out of every five articles in the *Journal of Range Management*… were about fenced "rotational" grazing systems… Despite the decades of negative or mixed results [from research], the debate about the efficacy of rotational systems in semi-arid rangelands grinds on without resolution. The safest conclusion may be that the advantages of rotational systems are

> either modest and difficult to detect, or so contingent upon local circumstances or skilled management as to make them difficult to replicate. Irrespective of the ultimate outcome of the debate, at this late date rotational grazing seems unlikely to produce any dramatic breakthroughs.[39]

Savory's claims are extreme, but his underlying arguments bear a strong resemblance to those advanced less hyperbolically in other circles. Proponents of regenerative agriculture and AMP, for example, also emphasize the potential of rotational grazing to sequester carbon in rangeland soils and thereby mitigate climate change.[40] The application of compost or other organic fertilizers to rangelands has also been studied and advocated as a climate mitigation strategy because of its potential to augment soil carbon stocks.[41]

Implicitly or expressly, the vast extent of the world's rangelands is a key plank in all these platforms. With approximately 3.4 billion hectares to work with, even small net gains in soil carbon per hectare could make very large contributions to combatting climate change. But the problem of over-extrapolation here is manifold. There is the practical matter of scaling up: Most study sites are <40 hectares in size, after all. Savory claims that 15 million hectares of land are already engaged in his effort, but the total he is invoking for his "solution" is minimally about 50 times that much, and taking him literally would suggest closer to 200 times that amount.[42] Moreover, for all of these proposals, even if practical obstacles could be surmounted, there is no reason to believe that results would be consistent across the world's diverse soils, climates, vegetation types, baseline conditions, and livestock systems. The most comprehensive meta-analyses find potential for enhanced soil carbon sequestration in rangelands, but with very significant caveats: heavy stocking may lead to net soil carbon losses; net effects may be driven not by management but by abiotic factors, especially in more xeric rangelands; soil carbon increases may be short-lived and/or intractable to reliable measurement. As one study cautions,

> these results do not apply uniformly to all grazing lands and extrapolating the results of this synthesis regionally or globally requires information about where there is scope for improvement of grassland management… it is not always the case that improved grazing management leads to increased soil C stocks. Even when it does, soil C stock responses vary as a function of climate, soil, and vegetation characteristics.[43]

On top of these issues – which can be extremely technical – is a simpler and arguably more decisive weakness: land *use* swamps management in any large-scale assessment of rangeland soil carbon. Many studies

indicate that retiring croplands is the most effective technique, per hectare, for carbon sequestration, and there is also strong evidence that avoiding the conversion of existing rangelands to other uses may be the highest priority for net carbon sequestration overall.

Conclusion

If there is any one theme that emerges from the history of rangelands since 1492, it is recursive misapprehension: seemingly authoritative or "expert" knowledge about rangelands has repeatedly turned out to be exaggerated, shortsighted, incomplete, or just plain wrong. This is not simply a matter of science and reason incrementally overcoming ignorance, moreover. I have previously written that

> Rangelands are sites where the separate and combined efforts of capital, science and the state meet their limits, not in any fixed sense but as part of ongoing processes of trying to overcome and extend those limits… It is precisely their manifold marginality that enables rangelands to defy and disrupt social forces that elsewhere seem so powerful, and thereby to illuminate core tendencies, contradictions, and limitations in modern ways of knowing, using, and governing lands and people.[44]

In a handful of individual cases, such as the Coyote-Proof Pasture Experiment, historical analysis can demonstrate conclusively that the "scientific" basis of rangeland policies was pre-determined and manipulated to suit political-administrative exigencies.[45] But it is generally unwise to speculate on the inner thoughts and motives of people, and whether scientists such as Boudy, Flahault, Clements, and Eckholm intended (or even recognized) their complicity in colonial and post-colonial injustices is impossible to judge. It is fair to say, however, that their knowledge claims reflected large measures of wishful thinking, erasure, and hyperbole. Wittingly or not, they discerned the evidence that suited their (or their patrons') needs and expectations, while downplaying, overlooking, or omitting evidence and arguments that did not. To call their conclusions false is not really much better than calling them true, however: either judgment would exaggerate the degree of certainty available, then or now. As Mark Stafford Smith remarks, desertification is a mirage: "But of course mirages are real phenomena, just not the ones that they appear to be… And if you march across the desert through one mirage, as often as not another appears ahead of you."[46]

The mirages that afflict thinking about rangelands are induced in part by the word itself. Even just employing the term attributes a measure of unity and coherence to what are in fact infinitely varied and diverse landscapes, while erasing the negative and residual nature of the category as

well as the colonial and neo-colonial positionalities embedded in its construction. Like "nature" and "the state," then, rangelands should be handled with great epistemological care – or what Pierre Bourdieu describes as *hyperbolic doubt,* questioning "all the presuppositions inscribed in the reality under analysis as well as in the very thoughts of the analyst."[47] The propensity to find in rangelands a solution to climate change, for example, must be interrogated not only in relation to the relevant scientific literature, but also in light of the political and economic marginality of rangelands relative to other land types and other land uses. Surely the fact that rangelands are less expensive than other lands – more abundant and also less politically powerful – conditions the enthusiasm of proponents of holistic management, regenerative agriculture, AMP grazing and compost application? Retiring agricultural lands would be a more reliable and effective way to sequester carbon in soils, per hectare, but it would also be much more costly and contentious; prohibiting the conversion of rangelands to other uses would eliminate capitalism's reserve of "under-employed" land and provoke pitched battles over private property rights. And, of course, the real solution to climate change – rapidly phasing out the combustion of fossil fuels – still strikes many people as impossibly utopian. Compared to all of these ideas, multiplying the results of a handful of controlled experiments by the world's 3.4 billion hectares of rangelands is tantalizingly easy. But pinning humanity's hopes on rangelands recapitulates a long history of wishful thinking, erasure and hyperbole perpetrated by outsiders – meaning non-rangeland residents – that is littered with policy failures and injustices.

Stewardship of rangelands in the twenty-first century must contend not only with the complexity of the landscapes in question but also with the political-economic forces that relegate them to the margins of power. This will require new narratives that elevate rangelands for their beauty and positive values, rather than just their vast extent and putative degradation. To succeed, it will also require strategies that engage and strengthen local communities and institutions vis-à-vis outside forces – including scientists – whose ambitions, when not openly predatory, are often still suffused with flawed assumptions and wishful thinking.

Notes

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22 The Chinese government's policies in Inner Mongolia and Tibet are among the most disturbing examples of recent years. See, e.g., Wenjun Li and Lynn Huntsinger, "China's Grassland Contract Policy and its Impacts on Herder Ability to Benefit in Inner Mongolia: Tragic Feedbacks," *Ecology and Society* 16 (June 2011): 1.
23 The closest thing to a biography that exists was penned by his wife and scientific collaborator, Edith, under the title *Adventures in Ecology: Half a Million Miles: From Mud to Macadam* (New York: Pageant Press, 1960). Ronald C. Tobey's *Saving the Prairies: The Life Cycle of the Founding School of American Plant Ecology, 1895–1955* (Berkeley: University of California Press, 1981) also contains important biographical materials. For an article-length summary of Clements's influence in range science, see Linda A. Joyce, "The Life Cycle of the Range Condition Concept," *Journal of Range Management* 46 (March 1993): 132–38. See also Sayre, *The Politics of Scale.*
24 Tobey, *Saving the Prairies,* 120; Sayre, *The Politics of Scale.*
25 Frederic E. Clements, *Plant Indicators: The Relation of Plant Communities to Process and Practice* (Washington: Carnegie Institution of Washington, 1920), 3.
26 Libby Robin, "Ecology: A Science of Empire?," in Tom Griffiths and Libby Robin, eds., *Ecology and Empire: Environmental History of Settler Societies* (Seattle: University of Washington Press, 1997), 63–75.
27 Clements, *Plant Indicators,* 310.
28 Clements, *Plant Indicators*, 307. The last section (20 to 30 years) was little more than a guess, as Clements had only been observing grasses for that long himself and the southern bison herd had been hunted to oblivion in the three years prior to his birth.
29 Clements, *Plant Indicators*, 310.
30 Clements, *Plant Indicators*, 312.
31 Clements, *Plant Indicators*, 311.
32 Frederic E. Clements, *Plant Succession: An Analysis of the Development of Vegetation* (Washington: Carnegie Institution of Washington, 1916), iii.
33 Earle Clapp, head of research for the Forest Service from 1915 to 1935, embraced succession as the basis of range research even as he acknowledged that "Practically the entire question of association development and succession… still awaits investigation." Sayre, *The Politics of Scale,* 69.
34 Tobey, *Saving the Prairies*, 201.
35 Henrik von Wehrden, Jan Hanspach, Petra Kaczensky, Joern Fischer and Karsten Wesche, "Global Assessment of the Non-equilibrium Concept in Rangelands," *Ecological Applications* 22 (2012), 393–99; Nathan F. Sayre, Diana K. Davis, Brandon Bestelmeyer and Jeb C. Williamson, "Rangelands: Where Anthromes Meet Their Limits," *Land* 6 (2017): 31.
36 According to a 2009 review by the UN's Food and Agriculture Organization, 22 percent of the world's drylands are considered degraded, compared to up to 71 percent of the world's grasslands. Constance Neely, Sally Bunning and Andreas Wilkes, eds., *Review of Evidence on Drylands Pastoral Systems and Climate Change: Implications and Opportunities for Mitigation and Adaptation* (Rome: Food and Agriculture Organization of the United Nations, 2009).
37 Clements pointed this out multiple times in *Plant Indicators,* but for various reasons the point was lost in both policy and practice (see Sayre, *The Politics of Scale*). For an influential critique of carrying capacity, see Roy H. Behnke, Jr., Ian Scoones and Carol Kerven, eds., *Range Ecology at Disequilibrium: New Models of Natural Variability and Pastoral Adaptation in African Savannas* (London: Overseas Development Institute, 1993).

38 https://www.ted.com/talks/allan_savory_how_to_fight_desertification_and_reverse_climate_change?language=en.
39 Roy H. Behnke, "Grazing Into the Anthropocene *or* Back to the Future?," *Frontiers in Sustainable Food Systems* 5 (2021), article 638806, 5.
40 Paige L. Stanley, Jason E. Rowntree, David K. Beede, Marcia S. DeLonge and Michael W. Hamm, "Impacts of Soil Carbon Sequestration on Life Cycle Greenhouse Gas Emissions in Midwestern USA Beef Finishing Systems," *Agricultural Systems* 162 (2018): 249–58; Rebecca Ryals, Melannie D. Hartman, William J. Parton, Marcia S. DeLonge and Whendee L. Silver, "Long-term Climate Change Mitigation Potential with Organic Matter Management on Grasslands," *Ecological Applications* 25 (2015): 531–45.
41 Rebecca Ryals and Whendee L. Silver, "Effects of Organic Matter Amendments on Net Primary Productivity and Greenhouse Gas Emissions in Annual Grasslands," *Ecological Applications* 23 (January 2013): 46–59.
42 Half of the world's grasslands would equal some 711 million hectares; half of the savannas, grasslands, deserts, and open shrublands would equal slightly over 3 billion hectares – which is more than the area of those biomes that is currently grazed by livestock. See Asner et al., "Grazing Systems, Ecosystem Responses, and Global Change."
43 Richard T. Conant, Carlos E.P. Cerri, Brooke B. Osbourne and Keith Paustian, "Grassland Management Impacts on Soil Carbon Stocks: a New Synthesis." *Ecological Applications* 27 (2017): 662–8, 666.
44 Sayre, *The Politics of Scale*, 2.
45 Sayre, *The Politics of Scale*, chapter 1.
46 Stafford Smith, "Desertification: Reflections on the Mirage," 540.
47 Pierre Bourdieu, "Rethinking the State: Genesis and Structure of the Bureaucratic Field," *Sociological Theory* 12 (March 1994): 1–18, 1.

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