THE GENESIS OF RANGE SCIENCE, WITH IMPLICATIONS FOR CURRENT DEVELOPMENT POLICIES

N.F. Sayre[1] and M. Fernandez-Gimenez[2]

[1]USDA-ARS-Jornada Experimental Range, Las Cruces NM, USA.
[2]School of Renewable Natural Resources, University of Arizona, Tucson AZ, USA.

1. INTRODUCTION

At the opening of the new millennium, both range science and pastoral development find themselves in a state of flux. Recent decades have witnessed widespread criticism of pastoral development programs implemented in the latter half of the twentieth century (Agrawal 1998, Ferguson 1994, Hary et al. 1996). Meanwhile, ecological research has cast doubt on the Clementsian paradigm that informed range science and policy for most of the last century (Vesk & Westoby 2001, Westoby, Walker & Noy-Meir 1989). The need to reassess and reconfigure both the theory and practice of pastoral/range management is widely acknowledged (Mearns 2002, Turner 1998). Curiously, however, little attention has been paid to the historical origins of the range science-development nexus in the United States during the late nineteenth and early twentieth centuries, from which emerged the model for much subsequent development work. As scientists, policy makers, and pastoralists work to find new models, a consideration of this history provides important perspective and lessons for the challenges ahead.

First, we examine the origins of range science in the United States from the 1890s through 1950. By the end of this period, range science had consolidated into a dominant (although not unquestioned) theoretical and research paradigm rooted in Clementsian plant ecology; a professional society had been formed; and a complex but enduring structure of management and administration had been developed for the vast, publicly owned Western rangelands. Viewed historically, the management practices espoused by the new science—including fixed, fenced property boundaries; improved breeding; regulatory imposition of carrying capacities; sedentarization; and a general orientation toward market production rather than subsistence—were artifacts of particular political and economic circumstances in the United States at that time. Nevertheless, they were elevated, *ex post facto*, to the status of abstract truths that could be applied anywhere and whose authority appeared to transcend politics and context. This elevation helped to legitimate the exportation of American range management practices to much of the world's rangelands in the second half of the twentieth century.

Second, we consider the rangelands of Mongolia, whose circumstances today resemble in some respects those of the western U.S. a century ago. Since the fall of the Soviet Union, Mongolia has embarked on a path toward a liberalized, market economy, and the ownership, administration, and management of rangelands are experiencing dramatic changes. Concerns about current and potential future environmental degradation loom in background. Many recommended reforms reflect the paradigm developed and first deployed in the western U.S. Curiously, however, some of the paradigm's central components—improved breeding; fixed, bounded grazing lands; investments in permanent range improvements such as wells; and a general orientation toward "professionalism" and enhanced production—are not new in post-Soviet Mongolia. They were in fact components of collectivization during the Cold War period, intended to increase production and consolidate state control of resources and people.

Comparison of early U.S. and contemporary Mongolian rangeland management and development suggests several conclusions. First, actual range management has not been strongly determined by "science" in either country. Rather, managers have responded to political, economic and ecological constraints and opportunities, using a dynamic mix of experiential, traditional, technological and experimental knowledge. Second, the quest for universal principles of range management has foundered on both social and ecological shoals. Social factors such as access to credit and markets; land tenure and property institutions; economic and demographic change; and cultural traditions and values have strongly determined range management, for better or worse. Ecologically, the non-equilibrial dynamics of arid and semiarid range systems constrain management in ways that equilibrium-based range science cannot easily accommodate. Finally, effective pastoral development must address these limitations in an integrated, multi-disciplinary fashion, rather than treating range management as primarily a technical or scientific matter. As Mongolia embarks on further reforms in land tenure and land use policies, and seeks to implement sustainable pasture management and resolve recent conflicts over use and allocation, we would do well to consider this history prior to imposing US-derived management practices based on our own, somewhat checkered record of "scientific" management.

Proceedings of the VII[th] International Rangelands Congress 26[th] July – 1[st] August 2003, Durban, South Africa
Editors: N. Allsopp, A.R. Palmer, S.J. Milton, K.P. Kirkman, G.I.H. Kerley, C.R. Hurt, C.J. Brown ISBN Number: 0-958-45348-9
Proceedings produced by: Document Transformation Technologies Congress Organised by: SB Conferences

2. THE GENESIS OF RANGE SCIENCE

Most treatments of the origins of range science have come from within the discipline, and they have emphasized the intellectual lineages of its major concepts and ideas (National Research Council 1994, Smith 1988, USDA 1944, Wasser 1977). Less attention has been paid to the larger social and environmental context in which these ideas were formed (for a partial exception, see Heyboer 1992). All sources agree, however, that range science developed out of the crisis conditions that afflicted the western range of the U.S. in the 1880s and early 1890s, at the tail end of the famous "cattle boom." There is also consensus that Clementsian plant ecology provided the theoretical core of range science as it coalesced into an established discipline in the first half of the twentieth century. Here, we look first at the economic, ecological, and political conditions surrounding the cattle boom. Then we ask if these conditions helped to direct the new discipline along Clementsian lines, and how the Clementsian paradigm served to universalize the findings of range science.

3. THE CATTLE BOOM AND ITS AFTERMATH

The crisis of the late 1880s and early 1890s developed from the interaction of three primary factors: free land, abundant credit, and producer-settlers who were unfamiliar with the region's environmental limits (Sayre 1999). Subjugation of the Native American population, near-extermination of the bison, and construction of railroads opened vast rangelands to settlement at a time when federal policy did not permit exclusive control of more than 64 hectares of land. (This was later increased to 256 hectares, but remained far less than required for economical range livestock production.) Insecure tenure gave each rancher strong incentive to graze public rangelands heavily, even destructively, to discourage competing claimants; overstocking was a means of securing *de facto* control over land that could not legally be controlled in any other fashion (Hadley and Sheridan 1995). This strategy was abetted by an enormous over-supply of financial capital, imported to the region from as far away as Scotland, which enabled aspiring producers to increase their herds rapidly on credit (Atherton 1961, Bentley 1898, Jackson 1956). High stocking rates coupled with extreme (if not abnormal) weather, including both droughts and blizzards, resulted in large die-offs of stock in the Great Plains and Southwest between 1884 and 1893. The boom ended in 1893, when a trans-Atlantic financial panic and depression resulted in tight credit and collapsing prices.

This "tragedy of the commons" was not the inevitable result of common property, then, but of open access to land—an absence of property institutions, really—in combination with abrupt demographic change and rampant financial speculation. Not only had outside capital underwritten the expansion of herds, it also constrained the options of managers on the ground. When prices fell in drought periods, high debt loads discouraged destocking, since selling at low prices was tantamount to defaulting on loans incurred when prices were higher. In some cases, the costs of gathering and transporting stock exceeded their value at sale. Once the bubble burst, ranchers could not borrow the additional money needed to feed starving animals or develop artificial water sources. Allowing herds to perish on the range drastically increased the environmental impacts of the boom (Bahre and Shelton 1996). Expansive areas of perennial native forage species were reduced to bare ground.

4. THE BIRTH OF RANGE SCIENCE

Science was brought to bear on U.S. rangelands only after the boom had collapsed and environmental degradation was too conspicuous to ignore any longer. In 1895, Congress created the Division of Agrostology, housed in the Department of Agriculture (USDA) and devoted to the study of grasses and forage plants. The Division—folded into the new Bureau of Plant Industry six years later—conducted the first scientific range research and strongly shaped the future course of the discipline (Sayre 2002). It is noteworthy that the Division's first acting head and author of one of its earliest studies, Jared Smith, had been a student of Charles Bessey and a peer of Frederic Clements at the University of Nebraska.

The lack of knowledge about the arid and semiarid West—among scientists as well as producers—constituted a major premise of government action. As others have noted, range science did not grow out of "pure" scientific inquiry (Heyboer 1992, Tobey 1981). Rather, it was dominated from the beginning by government institutions—especially federal land management agencies and state land grant universities—which were responding to practical, politically charged problems. In theory, scientific research would discover effective, economical management practices more efficiently than could be done by local, trial-and-error efforts (cf. Kloppenburg 1988). Incorporated into agricultural extension programs in the early twentieth century, this model assumed two things: that conditions "in the field" sufficiently resembled those of experiments to make research findings applicable, and that producers would in fact apply the findings.

The ostensive policy goal of the time was settlement of the West by family-scale, market-oriented agricultural producers (Public Lands Commission 1905). That these would have to be pastoralists, rather than farmers, was an

ecologically imposed reality that took the law decades to accept. Once accepted, moreover, it posed one question above all others: How should rangelands be allocated? Allotments needed to be big enough to support a family, but not bigger—the fear of dominating "land barons" was a strong political force. Above all, it seemed necessary that the boundaries of grazing allotments be fixed, as well as fenced, to prevent interminable squabbling among competing claimants.

This political and economic context strongly determined the questions that the new Division of Agrostology's researchers asked and the methods chosen to answer them. It is clear from the earliest reports (Bentley 1898, Griffiths 1901, Smith 1899) that the notion that rangelands had a determinable "carrying capacity" preceded formal research on the topic. All of the early researchers and commentators agreed that the principal problem (some said the only problem) was land allocation and land tenure (Clements 1920; Griffiths 1901, 1902; Public Lands Commission 1905; Sampson 1919; Secretary of Agriculture 1936; Smith 1899). Exclusive leasehold to fixed, designated areas of the range was viewed as the obvious solution to the problem, since outright privatization was politically (and probably economically) untenable (Merrill 2002). Beginning in 1905, National Forest rangelands came under a system of leases; concurrently, the USDA-Forest Service emerged as the central federal supporter of range research. Building fences to "control" grazing quickly became the first recommendation of applied range science (Clements 1920, Sampson 1926); calculating carrying capacities was among the initial research questions, because rational administration required a stable estimate of how many animals a given type of rangeland could support (Griffiths 1902, Wooton 1916). In a particularly influential series of experiments, James Jardine (1908, 1909, 1910)—who later served as Director of Research for the USDA—concluded that fencing increased the carrying capacity of sheep range by 25 to 50 percent (cf. Heyboer 1992: 118-124).

Most, if not all, of the research agenda developed in this period assumed fencing and leasing as the basic framework of range management. Improved breeding, for example, could only be accomplished if managers had control over exposure of cows to bulls; moreover, without control individual producers could not be expected to invest money in expensive genetics. Likewise, efforts to improve the distribution of grazing pressure (e.g., through water development and mineral supplementation) sought to increase the stocking capacity of allotments by eliminating under-utilization of dry or remote areas. Studies to determine the proper season of use, type of grazing animal, and date of initiation of grazing all presupposed control over the time and place of grazing. They also reflected the circumstance that most National Forest rangelands were high-elevation areas restricted to seasonal use. The regulatory requirement that leases be attached to private "commensurate property"—which effectively excluded nomadic pastoralists—was justified in terms of ensuring that livestock would not be dependent on Forest rangeland year around (Rowley 1985).

Compared to the rest of the Western federal domain—which remained unregulated "open range" until the Taylor Grazing Act of 1934—the new policies and scientific findings applied on the National Forests were apparently quite successful. A major assessment conducted by the Forest Service found that all other land ownership types—including private, state, county, and Indian reservation as well as public domain—had experienced continuing degradation in the first third of the century, while most National Forest rangelands had stabilized or improved (Secretary of Agriculture 1936). The fact that the Forests were higher in elevation and received greater precipitation than most other Western rangelands (and were thus more resilient to grazing) did not prevent the Forest Service from claiming that its methods should be applied elsewhere; this was in fact the central political purpose of the entire assessment. The USDA did not succeed in securing administrative control over non-Forest federal lands—which remained in the U.S. Department of Interior, administered today by the Bureau of Land Management—but its model for range management, founded on leases, fences, and carrying capacities, was eventually extended to Western rangelands generally. It was in lower elevation, drier settings such as the southwestern deserts and the Great Basin that the model would prove least appropriate.

5. THE CLEMENTSIAN TURN

To what extent was the Forest Service model grounded in science, and to what extent did it reflect political and economic expedience? Clearly the model had several important practical advantages, given the larger context in which it was applied. First, leases with defined carrying capacities allowed public grazing lands to obtain an indirect market value that could serve as security for loans and mortgages and which could be exchanged in the market along with private lands (Merrill 2002). In short, leases allowed public rangelands to be privately capitalized. This was critical for securing the continued support of financial institutions in underwriting ranch operations and costly improvements. As one contemporary economist put it, "Cattle production [in the Western U.S.] has always depended to an exceptional degree upon credit" (Larmer 1926: 7). Second, by reducing range management to a calculus of animal units and carrying capacities, the model facilitated uniform national bureaucratic administration across a huge and diverse area, while allowing other factors that determined range condition (e.g., fire and drought) to be set to the side. Third, from the perspective of producers, the model favored fixed over variable capital expenditures, replacing herders with fences, for example. Finally, there was political advantage in asserting a scientific basis for range policy. Elevating range

science to a discipline, with "fundamental" knowledge that could be "applied" to management, imbued a kind of impartial authority to Forest Service decisions, in keeping with Progressive-era values of expertise, efficiency, and bureaucratic administration. Informal knowledge based on experience or tradition was relegated to secondary status (it was generally assumed that ranchers lacked such knowledge in any case).

These practical advantages were, of course, specific to the legal, economic, and social-cultural circumstances of the time and place where range science was born. If credit had been unavailable, management techniques based on expensive improvements could not have succeeded and probably would not have been studied. If national bureaucratic administration had not been necessary, there might have been no need for uniform methods of defining, allocating and assessing rangelands (such as Jardine's famous "Range Reconnaissance" protocol of the 1920s), nor for a standardized set of management practices. And if local knowledge of rangelands had been strong, scientific guidance and top-down government regulation might not have been developed. In short, circumstances encouraged U.S. pastoral development to be strongly market oriented, uniform across the West, and "delivered" to producers in the form of technical guidance and regulation.

As contributors to the nascent science of ecology, however, range researchers aspired to universalism, and they found it in the work of Frederic Clements (cf. Tobey 1981). Some of their earliest reports (e.g., Griffiths 1901, Smith 1899) sought evidence to support proto-Clementsian ideas about carrying capacity and natural recovery of vegetation following disturbance. In the absence of a unifying theory, however, they struggled for predictive power and often seemed merely descriptive. In the preface to his magnum opus, *Plant Succession*, Clements claimed that the successional concepts he had developed in the Nebraska prairies were of "universal application" (1916: iii). Four years later, he prefaced his major work on rangelands with the statement: "While the results given apply only to western North America, and to the western United States particularly, the principles and methods are of universal application" (1920: iii).

Arthur Sampson, a Forest Service biologist and also a former student of Bessey's, is generally credited with adapting Clements' theory of succession to range management (Sampson 1917, 1919). Sampson characterized succession as a universal phenomenon or "law"; his findings were based on research conducted on high-elevation Forest Service lands in Utah, but he claimed that "the principles involved will apply elsewhere" (1919: 7). His studies enshrined secondary succession—the gradual, natural recovery of disturbed vegetation back to its pre-disturbance composition—at the core of range management. Sampson understood livestock grazing as a linear force that acted directly against the natural, successional tendency. It followed that one could strike a balance between grazing and succession by adjusting stocking rates (and, in seasonal pastures, timing), and that one could discern the trend of vegetation change by careful evaluation of composition. This model was later quantified by Dyksterhuis (1949), based on his work in the southern Great Plains.

The extrapolation of successional models from a handful of relatively mesic research sites to "universal application" was mistaken, even within the U.S. Gleason (1926) famously faulted the "organismic" philosophy underlying Clements' assertion that every site had a single, fixed climax, and Ellison (1949: 790) argued forcefully that accelerated soil erosion was not "retrogression" but "an irreversible process," "a new route not comparable to the successional process." Especially in arid and semiarid areas, experience has borne out these criticisms (Illius and O'Connor 1999, Westoby et al. 1989) and undermined Dyksterhuis's classification of plant species into "increasers" and "decreasers" under grazing (Vesk and Westoby 2001). And with the benefit of hindsight, one can find observations from researchers in the American Southwest as early as Griffiths (1901, 1904, 1907, 1910) that might have cast doubt on the emerging management model (Sayre 2002). Indeed, even Clements (1920) himself seems to have had some doubts that his theory applied to Southwestern desert grasslands, where fire, drought, and aridity greatly complicated grazing-vegetation dynamics on various scales.

The effects of the Clementsian turn on actual range management are difficult to assess. Hundreds of circulars, bulletins and pamphlets were produced by agencies, research stations and extension services, but very little data were collected to evaluate whether the suggested practices were actually implemented. Countless fences and water sources were developed, with costs often shared by government agencies such as the Soil Conservation Service; these improvements distributed grazing pressure more evenly, likely making impacts more extensive and less intense than they would have been otherwise. But this might well have happened regardless of range science's theoretical orientation. Enforcement of stocking rates appears to have been reasonably strong on National Forests (except during the two World Wars), but exceeding official limits may have been commonplace on state and BLM lands until the 1970s (Martin and Jefferies 1966, Rowley 1985). Stocking rates have been a major topic of disputes between agencies and permittees for decades, but the role of range research in this may have been merely supportive, generating studies but not setting the terms of the debate. Finally, it is conceivable that the promise of natural recovery by secondary succession helped some ranchers or bureaucrats to rationalize overgrazing, which during drought may have triggered threshold changes now recognized as effectively permanent (Illius and O'Connor 1999); data relevant to this supposition are, however, lacking.

One thing that can be said unequivocally is that the management norm that emerged in the Southwest by 1950—continuous year around grazing of relatively static numbers of livestock (Parker and Martin 1952)—bore almost no resemblance to the recommendations that Clements (1920) actually made, which emphasized rotation, rest periods, and highly variable stocking rates. Judging from archival documents from Southwestern research stations in the 1920s, moreover—in which references to Clements' and Sampson's famous papers and concepts are virtually non-existent—one suspects that the notion of Clements as the "father" of range science is a *post hoc* reinterpretation, not a historically documented fact. Both of these observations suggest that range science did not strongly determine range management in the U.S., but rather the other way around: practical exigencies of management and administration determined the research agenda—and thus indirectly the findings—of range science. This may not fairly characterize individual range scientists' intentions and self-understandings, but it is consistent with historical facts for the discipline as a whole (cf. Heyboer 1992).

As for ecological conditions on the U.S. Western range, the recent shift to "state and transition" models has cast doubt on the meaning of monitoring data collected under the old, Clementsian paradigm, making any longitudinal scientific assessment of the region as a whole nearly impossible (National Research Council 1994). If secondary succession cannot be assumed, then climax conditions cannot serve as the baseline for range evaluation, as they did in earlier assessments. Instead, the state and transition approach seeks to describe and quantify changes in the rates and magnitudes of underlying ecological processes such as water and nutrient cycling, shifting the focus from the composition of vegetation to the stability of soils, much as Ellison (1949) counseled half a century ago. Moreover, there is growing evidence that other factors—including fire and fire suppression, climate, introduced plant species and arroyo formation—are equally or more important than grazing intensity in driving vegetation change. In this new context, arguments over stocking rates and "original" conditions are anachronistic, but they persist nevertheless. The lease systems of the Forest Service, BLM and various state land departments have succeeded in amalgamating areas of diverse land ownership into large, relatively unfragmented blocks for management purposes, and this may prove to be the era's most significant ecological achievement. But the core management practices—including divided access to rangeland (ideally through fencing), regulatory imposition of carrying capacities, improved breeding, water development and other infrastructural investments, and a commercial, market orientation—cannot be taken as "scientifically" valid in any universal sense, and they may fail if applied in very different political, economic or environmental contexts.

6. EXPORTING U.S. RANGE SCIENCE

Despite the scientific limitations described above, by mid-century range management had evolved into an established discipline, with its own society, journal, textbooks and university departments. Federal agencies comprised a large portion of the employment base for the discipline's graduates, and the approximately 110 million hectares of federal grazing land gave range scientists and managers an important role in the West. With the reorganization of the General Land Office and the Grazing Service into the Bureau of Land Management in 1946, the basic legal and administrative framework for managing the Western range was completed.

In the subsequent half-century, the principles of range science worked out in the Western U.S. were often used to guide development programs in Third World pastoral areas. In the case of Lesotho, studied by Ferguson (1994), for example, pastoral development was understood to depend on divided access to fenced pastures, destocking to fixed "carrying capacity" estimates, and improvements in the breeding and marketing of livestock. As Ferguson makes clear, the program failed for many reasons, with the substantive content of range science being a relatively minor one. But the authority and high-mindedness of pastoral development "experts" turned in no small part on their belief in the scientific objectivity and rationality of the model they propounded. As Ferguson (1994: 186) describes it:

"Time and again I was told by officials (whose own claims to power and authority, of course, rested on their education or technical expertise) that villagers who opposed their schemes lacked education, that they did not understand the proposals, that matters needed to be explained better. However many village meetings had been held, they argued, they were obviously not enough, for the villagers still failed to understand. If stock owners continue to refuse to convert to purebred stock and commercial practices, this only means, in the words of one official, that 'they must be educated, in order to understand'."

The presumption that traditional range management practices were flawed or non-existent, even in settings where pastoralists had many generations of experience, echoed the era when U.S. ranchers were assumed to be ignorant of local conditions and therefore dependent on scientists to deliver technical expertise. In third world settings, moreover, several unstated assumptions of U.S. range science—on issues such as property relations and the profit motive—have been revealed as contestable and problematic rather than given (Agrawal 1998, Ferguson 1994).

7. RANGE SCIENCE & MANAGEMENT IN MONGOLIA

In 1990 Mongolia held its first democratic elections and embarked on a rocky transition from a centrally planned economy to a free market system. With these macro-political and economic developments came a host of other changes for Mongolia's inhabitants and ecosystems. Predictably, Mongolia's opening to the West also saw an onslaught of consultants, advisors, donors and others who sought to influence the path of future development. As one of a few nations where pastoralists remain a dominant social and economic force, and one that possesses among the last "unspoiled" expanses of native grasslands in the world, Mongolia attracted flocks of expatriate experts on livestock production, range management, pastoral development and biodiversity conservation in its first decade of democracy. (In the interest of full disclosure, the second author of this paper admits to being one of them.) In this section we consider the current situation of Mongolian rangelands and pastoralists, the challenges Mongolia faces and the potential solutions before it in light of the analysis we have offered on the history of U.S. range science and management.

For 70 years prior to the dawn of democracy, Mongolia was an independent, Soviet-influenced, socialist state. Livestock production was completely collectivized by 1960 and herders worked for the state, herding state-owned flocks and benefiting from state-subsidized inputs (emergency fodder, veterinary services, transportation, water developments) and social services. Collectives also allocated pasture and regulated pasture use, including seasonal nomadic movements. With the initiation of democracy and market liberalization, livestock collectives were dismantled and their assets privatized. As herders assumed complete responsibility for all decisions and risks, and state services vanished overnight, the gap between wealthy and poor herders widened. Poverty, which had been virtually non-existent in the socialist period, rapidly emerged. People who lost their government jobs in towns and cities flocked to the countryside to claim livestock via privatization, and the number of herding households quickly grew, doubling in some areas. The collapse of the collectives resulted in a sudden institutional void, and no formal or informal mechanisms emerged to regulate and allocate pasture as the collectives had. Further, the physical infrastructure the collectives had maintained, such as water developments, fell into disrepair. This combination of events led to a downward spiral of decreasing mobility, increasing out of season grazing of reserved winter and spring pastures, and year-round grazing of key resources such as desert riparian areas (Fernandez-Gimenez 2001). In addition, conflicts over campsites and pastures became more common as the growing number of herders competed for limited resources. In many areas, pasture was sufficient over a district, but herders lacked the means to gain access to more remote areas, overusing areas near roads, settlements and water points. Although herders still articulate traditional norms of pasture use (Fernandez-Gimenez 2000, 2001), they are constrained by externalities from following them. Increasingly, the situation resembles an opening of the commons, whereby a resource that was once managed sustainably by a group (in pre-collective times) or by the state (during the collective era), is devolving into an open access resource, characterized by a lack of access and use rules widely shared and enforced by users. These trends in use patterns and institutional disintegration coincided, in the late 1990s, with several sequential drought years and extremely harsh winters, leading, by spring 2002, to livestock losses of 7,000,000 head across the country (about 21% of the national herd in 1999), and great human suffering.

Since the beginning of economic liberalization, donor agencies have made numerous proposals on ways to revitalize Mongolia's livestock economy, promote pastoral development and conserve the nation's natural resources. Early in the transition, in 1994, the Government of Mongolia adopted a new Land Law, which specifically addresses pasture land and potentially allows for leasing of pasture. Debate and discussion on the development of implementing rules and regulations has been ongoing. A number of development studies and projects have taken shape in this environment of deteriorating use patterns and ecological conditions and ongoing debate on the implementation of the Land Law. Broadly sketched, two alternative schools of thought are represented in these proposals, and in the debates surrounding the Land Law.

One school advocates the conventional (neo-liberal?) approach to land policy, beginning with a cadastral survey and land registration system to map individual parcels of land and identify their current owners or users. Such a survey and registration program would make it possible to issue formal title (or other property rights, such as leases) over land, and facilitate the transfer of rights. The benefit of land registration (and ultimately titling) is security of tenure, which in turn is expected to lead to increased investment, stewardship, and, ultimately, productivity. These expectations rest both on the greater incentive for improvement said to obtain when all the benefits of investment are captured by the individual landowner (rather than shared with other users), and on the landowners' ability to use land as collateral to obtain credit. Land registration also benefits the state, making it possible to collect real estate and transfer taxes. Proponents of the first school tend to see the ultimate goal as a market in all types of land for Mongolia (GISL 1997).

The second school subscribes to a more participatory approach to development, and tends to recognize the rationality and cultural-historical appropriateness of common property institutions for Mongolia. Land registration makes private property possible, but may also be useful in securing the rights of groups to areas of land used collectively. In Mongolia, where private property in pasture land is currently unconstitutional, secure individual or group tenure may be

provided by leases, which would offer similar benefits. This school views the establishment of secure pasture tenure for groups as a means to overcome the current open access dilemma. One problem with these proposals is the difficulty of delineating clear spatial boundaries and group memberships in Mongolia's mobile pastoral system (Fernandez-Gimenez 2002). Further, the call to establish set boundaries is often accompanied by an effort to establish a determined "carrying capacity" for the area in question, a concept with arguably limited utility given Mongolia's dynamic ecosystems and tradition of mobile and highly flexible pastoralism.

Mongolia in the early 21st century thus shares some similarities with the Western US in the late 19th century. In both situations, open access either characterized the situation (US) or threatens it (Mongolia). In the Western US abundant credit led to overcapitalization, collapse, and recapitalization based on leasehold on public lands; in Mongolia there are calls to make credit (currently in short supply) more available by allowing herders to collateralize leased pastures. The establishment of the allotment system in the Western US allowed the sale of leases attached to base property, and in Mongolia there is a similar desire by some to create a market in natural forage by allowing leases (or other property rights in pasture) to be bought and sold. Ecologically, both regions contain a mix of equilibrium and non-equilibrium rangeland ecosystems, with the implication that the scientific paradigms and management practices that apply to the former may not be appropriate for the latter.

Some differences between the Western US of the 1890s and Mongolia in the early 2000s include Mongolia's long history of grazing by domestic livestock in contrast to the relatively recent large-scale introduction of cattle, sheep and horses to the US. This history is important for three reasons. First, it suggests that Mongolian rangelands have evolved with continuous grazing pressure from wild and, subsequently, domestic herbivores, making it likely that Mongolian ecosystems are more resistant and/or resilient to grazing impacts than ecosystems in some regions of the US (such as the Southwest) where large grazers were absent between the end of the Pleistocene and the introduction of domestic livestock 500 years ago. Second, Mongolian pastoralists have had centuries to acquire experiential knowledge of the ecosystems they inhabit and the animals they husband, and to develop management practices finely tuned to the variability in their environments (Fernandez-Gimenez 2000; Fernandez-Gimenez and Swift 2003). These management practices encompassed not only daily, seasonal and annual grazing strategies, but also the institutional arrangements for allocating and managing pasture. Both customary and formal institutions for managing pastoral land use have existed in Mongolia for centuries (Fernandez-Gimenez 1999). Most types of pasture were and are used jointly by groups of herders, and established norms and rules governed their use. Only very recently, since the demise of socialism and the dismantling of herding collectives, has something like a tragedy of the commons emerged on the steppes in the institutional void left by the defunct collective system. Third, the combination of the evolutionary history of grazing and the evolution of indigenous pastoral practices and institutions has meant that most Mongolian ecosystems are still largely intact, in contrast to the post-cattle boom devastation of the American West. Degraded areas certainly exist in Mongolia, and the trend towards unsustainable practices further threatens Mongolia's rangelands, but most areas do not appear to have crossed irreversible thresholds of change in vegetation structure or soil quality and stability.

Two final and important differences between the Western US and Mongolia are the extremely different cultural orientations towards private property, and the different production goals and planning horizons of herders and ranchers. Whereas private property is the norm and an ideologically sacred institution in the US, Mongolia has never had strong private property institutions. Rather, common and state property institutions have dominated Mongolia's history. Mongolian pastoralists remain, almost universally, opposed to privatization of pasturelands, and the nation's 1992 constitution makes private ownership of pastureland unconstitutional.

The production goals and planning horizon of Mongolia's pastoralists also differ from those of US ranchers, both at the turn of the 20th century and today. Though they have always relied on market transactions to obtain necessities that they cannot get directly from their animals, pastoralism in Mongolia remains primarily a subsistence enterprise, in contrast with the speculative nature of the US cattle industry in the 1890s and the profit motive of ranchers.

Our review of the genesis of range science in the US points to the importance of understanding the social-historical conditions in which science is conducted, new knowledge emerges, and management is promoted. It behooves us, then, to look at the evolution of range science and management in 20th century Mongolia. Mongolia's scientific infrastructure, which was strongly influenced by the Soviet Union, displays several striking similarities to the rise of "scientific management" in the US, as well as important differences. The major difference is the degree to which state-sponsored science and state-promoted management did take into account traditional Mongolian pastoral practices and knowledge, drawing directly on the experience of herders. At the same time, the state promoted a number of innovations that closely resemble those advanced by range science and management in the US. These included a move away from traditional multi-species herds towards single-species herds, genetic improvement of stock with imported breeds, water developments to improve distribution, provision of veterinary services and transportation, and state control over the allocation and management of pastures. While the basic tenet of mobility was retained, and even enforced, by the collectives, the scope of movements was severely reduced and flexibility decreased by the implementation of new administrative units of much smaller size than the pre-revolutionary *Khoshuu*. (Some 100

Khoshuu were divided into 300 *sum* or districts, each of which contained 3-5 *bag* or subdistricts, to which herders in a particular "brigade" of a collective were confined.)

By the 1980s, two decades into collectivization, there was an increasing emphasis in propaganda materials on pasture management that incorporated concepts of rotational grazing, and even fencing. The emphasis on rotational grazing can be understood to have its origins in traditional practices of transhumance between distinct seasonal pastures, and among different grazing areas within seasonal pastures. The socialist regime both enforced seasonal mobility and encouraged sedentarization by promoting the practice of *otor*, which involved rapid, long-distance movements of a part of the herd and household, while the main household remained in a set location. The emphasis on fencing pastures seems to have come late in the socialist era, and is evident in a 1989 publication produced by the Research Institute for Animal Husbandry called "Natural Pasture Use and Protection: the Current State." At least 3 of the 12 short papers in this proceedings contain the following recommendation: "To properly use pasture there are two methods: first, pasture must be divided into seasonal use areas and used accordingly; second, [pastures] should be divided into fenced sections." However, pasture fencing never took hold in Mongolia, and most herders remain opposed to fencing, which, like exclusive tenure over pastures, they perceive limits their flexibility. As one herder once remarked to me, "Fences don't make grass grow." Rather, rain does, and herders need the flexibility to move their herds to productive areas and avoid overusing areas with poor growth in a given year.

The similarities in the management practices promoted by the Soviet-influenced socialist regime and those advanced in the Western US suggest common structural imperatives. In both instances the case can be made that political considerations, not science, drove management recommendations. In Mongolia, the state's need to control a mobile population, increase production, and integrate livestock production into a modern agro-industrial economy led to mandates that would hasten sedentarization and increase the specialization, professionalization and productivity of livestock husbandry. In the US, scientific research responded first to the widespread ecological crisis caused by the cattle boom, and always cast itself as a biological science with universal aspirations. But the needs of private producers and their financial backers fundamentally determined which policy reforms were deemed acceptable, and these in turn shaped the questions asked by range scientists and the assumptions built into their models. Chief among these assumptions was a fixed conception of carrying capacity, which was borrowed, according to Zimmerer (1994), from 19th century chemistry experiments involving cultured organisms in carefully controlled laboratory settings.

8. CONCLUSION

Mongolian pastoralism differs from US ranching in a number of ways: an ecological context of continuous evolutionary pressure by large grazers, wild and domestic; the presence of extensive traditional knowledge among herders; difference in production goals (subsistence vs. profit); the absence of capital and credit and the presence of a low discount rate and long planning horizon; and the existence, historically, of both formal and customary institutions to allocate and manage pasture. Nevertheless, there are certain parallels in the evolution of rangeland management in Mongolia and in the US, notably the rise of "scientific management" in Mongolia during the latter part of the socialist era. As in the western US, the case could be made that Soviet-influenced socialist Mongolian government promoted management practices that were politically expedient (enhanced control over a traditionally peripatetic population) and met the state's economic goals (for increased production), rather than practices that were based on science. Unlike the western US, however, Mongolia's long history of domestic livestock grazing and the traditional knowledge, practices and institutions that emerged from it were strong enough to significantly influence (for the better, we believe) the evolution of "scientific management" of Mongolian rangelands.

There is a tendency on the part of foreign advisors to recommend measures that are closely patterned on the policies of their homeland. In Mongolia, this tendency is evident in environmental legislation drafted with the assistance of US consultants and in the establishment and administration of a large network of protected areas fashioned after the US National Park System. When leasing of pastureland entered the discussion, the Taylor Grazing Act emerged as a potential model on which to base the administration of leases. While pastureland leases may be a legitimate part of the solution to the current chaos, great care should be taken to devise institutions attuned to the ecological and cultural conditions and history of grazing in Mongolia. The Taylor Grazing Act may have arguably "rescued" Western rangelands, but it has engendered its own set of thorny and apparently insoluble contradictions. Just as the universality of the fundamental tenets of Clementsian range science have been called into question, the broad applicability of a limited set of institutional arrangements for pasture tenure based, in part, on certain ecological assumptions, should be treated with even greater suspicion. Past outcomes of promoting pastoral development policies based on US range science and management have been less than encouraging, and led to a precipitous decline in pastoral investment by key donor agencies in the 1980s and 1990s. Let us learn from these mistakes. Non-equilibrium ecology offers a very different set of management implications than did Clementsian range succession theory, including an emphasis on the need to maintain mobility and flexibility, and to act opportunistically in variable environments (Ellis & Swift 1988, Westoby et al. 1989). Institutions that support these strategies may look very different from those that were justified by

the old theories. These new theories do appear to be having some influence on development policy, at least at the level of donors. However, we caution against overenthusiastic embrace of non-equilibrium theory as well, as it, like its predecessor, does not apply in all situations. Perhaps the most valuable lesson to be learned from Mongolia is the rationality of sticking with or building on historical, locally-evolved management practices and institutions. Whatever ills the socialist system wrought, the architects of the collective system were astute enough to realize that mobility was the key to sustainability in this semi-arid landscape, and to ensure that this strategy was not abandoned, even as it was transformed to suit their own political agenda.

9. REFERENCES

Agrawal A 1998. Greener pastures. Duke University Press, Durham.

Atherton L 1961. The Cattle kings. Indiana University Press, Bloomington.

Bahre CJ & Shelton ML 1996. Rangeland destruction: cattle and drought in southeastern Arizona at the turn of the century. Journal of the Southwest 38(1): 1-22.

Bentley HL 1898. Cattle ranges of the Southwest: a history of the exhaustion of the pasturage and suggestions for its restoration. USDA Farmer's Bulletin No. 72.

Clements FE 1916. Plant succession. Carnegie Institute of Washington Publication 242.

Clements FE 1920. Plant indicators. Carnegie Institute of Washington Publication 290.

Dyksterhuis EJ 1949. Condition and management of rangeland based on quantitative ecology. Journal of Range Management 2: 104-115.

Ellis JE & Swift DM 1988. Stability of African pastoral ecosystems: alternate paradigms and implications for development. Journal of Range Management 41: 450-459.

Ellison L 1949. The ecological basis for judging condition and trend on mountain rangeland. Journal of Forestry 47: 785-795.

Ferguson J 1994. The anti-politics machine. University of Minnesota Press, Minneapolis.

Fernandez-Gimenez ME 1999. Sustaining the steppes: a geographical history of pastoral land use in Mongolia. The Geographical Review 89(3): 315-342.

Fernandez-Gimenez ME 2000. The Role of Mongolian nomadic pastoralists' ecological knowledge in rangeland management. Ecological Applications 10(5): 1318-1326.

Fernandez-Gimenez ME 2001. The effects of livestock privatization on pastoral land use and land tenure in post-socialist Mongolia. Nomadic Peoples 5(2): 49-66.

Fernandez-Gimenez ME 2002. Spatial and social boundaries and the paradox of pastoral land tenure: a case study from postsocialist Mongolia. Human Ecology 30(1): 49-78.

Fernandez-Gimenez ME & Swift DM 2003. Strategies for sustainable grazing management in the developing world. In this volume.

GISL 1997. Strengthening Land Use Policies in Mongolia. ADB/TA No2458-MON/Final Report Phases I and II.

Gleason HA 1926. The individualistic concept of the plant association. Bulletin of the Torrey Botanical Club 53: 1-20.

Griffiths D 1901. Range improvement in Arizona. USDA Bureau of Plant Industry Bulletin No. 4.

Griffiths D 1902. Forage conditions on the northern border of the Great Basin. USDA Bureau of Plant Industry Bulletin No. 15.

Griffiths D 1904. Range investigations in Arizona. USDA Bureau of Plant Industry Bulletin No. 67.

Griffiths D 1907. The Reseeding of depleted range and native pastures. USDA Bureau of Plant Industry Bulletin No. 117.

Griffiths D 1910. A Protected stock range in Arizona. USDA Bureau of Plant Industry Bulletin No. 177.

Hadley D & Sheridan TE 1995. Land use history of the San Rafael Valley, Arizona (1540-1960). USDA Rocky Mountain Forest and Range Experiment Station General Technical Report RM-GTR-269.

Hary I, Schwartz H-J, Pielert VHC & Mosler C 1996. Land degradation in African pastoral systems and the destocking controversy. Ecological Modelling 86: 227-233.

Heyboer M 1992. Grass-counters, stock-feeders, and the dual orientation of applied science. Ph.D. dissertation, Virginia Polytechnic Institute and State University.

Illius AW & O'Connor TG 1999. On the relevance of nonequilibrium concepts to arid and semiarid grazing systems. Ecological Applications 9(3): 798-813.

Jackson WT 1956. British interests in the range cattle industry. In Frink M, Jackson WT & Spring AW (eds.). When grass was king. University of Colorado Press, Boulder.

Jardine JT 1908. Preliminary report on grazing experiments in a coyote-proof pasture. USDA Forest Service Circular 156.

Jardine JT 1909. Coyote-proof pasture experiment, 1908. USDA Forest Service Circular 160.

Jardine JT 1910. The pasturage system for handling range sheep. USDA Forest Service Circular 178.

Kloppenburg JR 1988. First the seed. Cambridge University Press, Cambridge.

Larmer FM 1926. Financing the livestock industry. Macmillan, New York.

Martin WE & Jefferies GL 1966. Relating ranch prices and grazing permit values to ranch productivity. Journal of Farm Economics 48(2): 233-242.

Mearns R 2002. Taking stock: policy, practice, and professionalism in rangeland development. In: Fernandez-Gimenez ME & Kreuter UP (eds.) Rangeland professionals and policy: prospects for effective influence in the developed and developing worlds. Proceedings of the Society for Range Management International Affairs Committee Symposium, February 17, 2002, Kansas City MO, USA.

Merrill KR 2002. Public lands and political meaning. University of California Press, Berkeley.

National Research Council 1994. Rangeland health. National Academy Press, Washington DC.

Parker KW & Martin SC 1952. The mesquite problem on southern Arizona ranges. USDA Circular No. 908.

Public Lands Commission 1905. Grazing on the public lands. USDA Forest Service Bulletin No. 62.

Rowley WD 1985. U.S. Forest Service grazing and rangelands. Texas A&M University Press, College Station.

Sampson AW 1917. Succession as a factor in range management. Journal of Forestry 15: 593-596.

Sampson AW 1919. Plant succession in relation to range management. USDA Bulletin No. 791.

Sampson AW 1926. Grazing periods and forage production on the National Forests. USDA Department Bulletin No. 1405.

Sayre NF 1999. The Cattle boom in southern Arizona: towards a critical political ecology. Journal of the Southwest 41(2): 239-271.

Sayre NF 2002. Ranching, endangered species, and urbanization in the Southwest. University of Arizona Press, Tucson

Secretary of Agriculture 1936. The Western range. Senate document No. 199.

Smith EL 1988. Successional concepts in relation to range condition assessment. In: Tueller PT (ed.). Vegetation science applications for rangeland analysis and management. Kluwer Academic Publishers, Dordrecht, Boston, London.

Smith JG 1899. Grazing problems in the Southwest and how to meet them. USDA Division of Agrostology Bulletin No. 16.

Tobey RC 1981. Saving the prairies. University of California Press, Berkeley.

Turner MD 1998. The interaction of grazing history with rainfall and its influence on rangeland dynamics in the Sahel. In: Zimmerer KS & Young KR (eds.). Nature's geography. University of Wisconsin Press, Madison.

USDA 1944. The history of Western range research. Agricultural History 18: 127-143.

Vesk PA & Westoby M 2001. Predicting plant species' responses to grazing. Journal of Applied Ecology 38: 897-909.

Wasser CH 1977. Early development of technical range management ca. 1895-1945. Agricultural History 51(1): 63-77.

Westoby M, Walker B & Noy-Meir I 1989. Opportunistic management for rangelands not at equilibrium. Journal of Range Management 42(4): 266-274.

Wooton 1916. Carrying capacity of grazing ranges in southern Arizona. USDA Bulletin No. 367.

Zimmerer KS 1994. Human geography and the "new ecology": the prospect and promise of integration. Annals of the Association of American Geographers 84(1): 108-125.