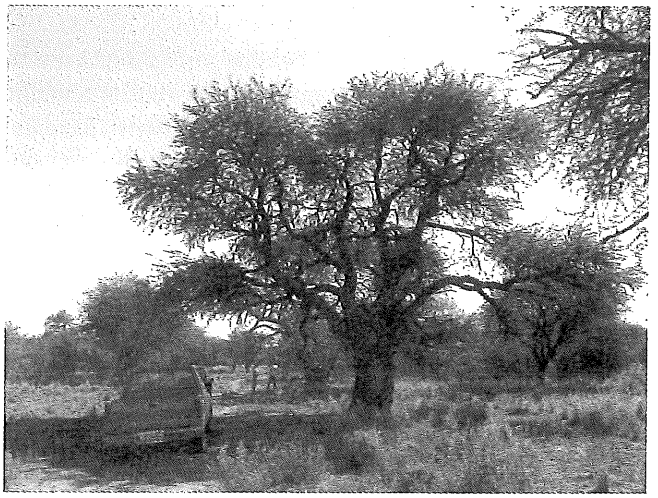

TELEN 2010

Estos estudios finalmente confirman el alto potencial de crecimiento de los caldenes comparado con arbóreas exóticas bajo condiciones de dosel abierto, en todos los sitios de estudio, la reducción de este crecimiento en condiciones de alta densidad.
También demuestran el efecto negativo del fuego en estas poblaciones a través de la perdida de producción de madera en los individuos adultos y la deformación masiva de su regeneración en individuos multicaules.

SUSTAINABLE LIVESTOCK PRODUCTION ON RANGELANDS: EMERGING TRENDS IN THE USA

Producción Ganadera Sustentable en Ambientes de Pastizal Natural: Tendencias Emergentes en los EE.UU

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Abstract: A recent review of statistics published by the United Nations Food and Agriculture Organization showed that global livestock numbers have increased steadily over the past 30 years. By 2030, livestock numbers in the developing world are expected to reach record highs that will surpass livestock population levels of the entire planet recorded at the turn of the 20th century while by native grassland areas worldwide are expected to shrink by more than 12 million hectares over the same time period. This predicted trend is likely to trigger a substantial increase in forage demand, placing unprecedented pressures on rangelands of developing nations. The review of FAO data also revealed that counter to global trends, livestock inventories of developed countries have tended to decrease over the same period. This phenomenon has been particularly evident on rangelands of the western US where management emphasis has shifted from heavy investments in land improvements (common until the 1970s) to systems characterized by low capital investment focused on optimizing efficiency of per-capita livestock production. Knowledge-intensive management approaches involving selection of livestock biotypes better adapted to arid environments, and development of geospatial technology that allow more precise manipulation of the ruminant/plant interface have emerged as a result of this trend. Nonetheless, expected increases in the price of oil and costs of agricultural crop production used as animal feed could dramatically change this scenario, augmenting the role of rangelands as a source of forage for US livestock in the near future. Thus, development of strategies to increase sustainable herbivory of a broader array of native arid land forages (including woody plants) will most probably become a top priority shared by pastoral livestock systems of the developed and developing world alike.

Resumen: Una revisión reciente de datos publicados por la FAO muestra que en los últimos 30 años ha habido un incremento sostenido en el número de rumiantes domésticos a nivel global. Esta tendencia, que se piensa continuará en el futuro, se debe fundamentalmente a un crecimiento pronunciado en las existencias ganaderas de los países en vías de desarrollo. Para el año 2030, se espera que la población de ganado de dichos países alcance niveles record que se piensa superarán las existencias ganaderas de todo el planeta registradas a fines del siglo XX mientras que se prevé la pérdida de más de 12 millones de hectáreas de pastizal natural. Es de esperar que esta tendencia desencadene un incremento sustancial en la demanda de forrajes, fenómeno que se cree impondrá presiones sin precedentes sobre los pastizales naturales de las naciones en vías de desarrollo. La revisión de datos de la FAO también demuestra que a diferencia de las tendencias globales, las existencias ganaderas de los países desarrollados han disminuido en el período considerado. Este fenómeno ha sido particularmente evidente en los pastizales naturales del oeste de los EE.UU. donde el énfasis de manejo que privilegiaba fuerte inversión en mejoras a la tierra (comunes hasta la década del 70), ha sido reemplazado por sistemas caracterizados por bajas inversiones de capital y una optimización de la eficiencia per-cápita de la producción ganadera. Estrategias de manejo que demandan conocimiento científico y que involucran la selección de biotipos ganaderos mejor adaptados a los ambientes áridos, o la aplicación de tecnologías geo-espaciales que permiten una manipulación más precisa de la interface planta/rumiante han emergido a raíz de estos cambios en los sistemas de producción. Se piensa, sin embargo, que los incrementos proyectados en el precio mundial del petróleo y el aumento concomitante en el costo de producción de cultivos agrícolas utilizados para la alimentación animal podrían cambiar el escenario actual dramáticamente aumentando la importancia del rol que desempeñan los pastizales naturales en la alimentación de la población ganadera de los EE.UU en el futuro cercano. Por lo tanto, es probable que el desarrollo de estrategias que incrementen la herbivoría sustentable de una gama más amplia de potenciales forrajes nativos de tierras áridas (incluyendo especies leñosas) sea prioritario en sistemas ganaderos pastoriles tanto en los países en vías de desarrollo como en los países desarrollados.

Overview

The objective of this paper is to provide a perspective on emerging trends in rangeland-based livestock production systems focusing mostly on the western United States. Our approach will consist of synthesizing viewpoints presented by coauthors in three recent articles. First, we highlight global challenges associated with diminishing native grassland areas worldwide and concurrent increases in livestock inventories discussed in detail by Estell et al. (2012). Second, we provide a general description of rangeland-based livestock production systems in the western United States, focusing on current land tenure and land use regulations and historical prevailing management strategies (Cibils and Holechek, 2011). Our final section provides an outlook on emerging trends in rangeland-based livestock production systems of the United States and other developed and developing regions of the world. This section draws on an upcoming article by Holechek (2013) and revisits a few of the most pressing future challenges and opportunities identified by Estell et al. (2012). Readers are referred to the articles mentioned above for a more in depth discussion of topics highlighted in this paper.

Global context

Rangeland-based livestock production systems worldwide are under increasing pressures from interacting human and environmental stressors which pose substantial challenges for producers and their families, scientists, policy makers, and society as a whole (Estell et al., 2012; Holechek, 2013). Arid and semiarid lands that support native grasses and grass-like plant communities, which are the often the sole forage source of grazing-based livestock systems, are increasingly being lost to woody plant encroachment and conversion to croplands (Estell et al., 2012). This phenomenon directly impacts an estimated one-third of the ruminant livestock population worldwide (Estell et al., 2012).

At the same time, global livestock inventories are steadily increasing. Rates of livestock population growth over the past 30 years are somewhat alarming, particularly in the case of small ruminants in the developing world. Based on statistics published by the FAO, Estell et al. (2012) estimated that the number of goats on the planet has grown at a rate equal "to a net increase of nearly 1.2 million goats per month" (p.555) over the past three decades. Increasing demand for red meat, particularly in

emerging economies of Asia, is thought to be partly responsible for fueling this trend, which is particularly pronounced in developing countries and which is expected to continue into the future (Estell et al., 2012; Holechek, 2013).

By 2030, livestock inventories in the developing world are expected to reach record highs that will surpass livestock population levels of the entire planet at the turn of the 20th century (Estell et al., 2012). Furthermore, loss of productive rangelands (most likely native grasslands) through cropland conversion is projected to reach 1.2 million square km (and area equivalent to approximately half the land area of Argentina) over this time period (Estell et al., 2012). This predicted phenomenon, which will occur against a backdrop of more extreme weather events (such as droughts) and heightened energy costs, is likely to trigger a substantial increase in global forage demand. Collectively, these factors will place unprecedented pressures on shrinking rangeland resources, particularly in developing nations (Estell et al., 2012; Holechek, 2013).

Counter to global trends, livestock inventories of developed countries have tended to decrease over the recent past (Estell et al., 2012). This phenomenon has been especially evident on rangelands of the western U.S. where a number of factors (discussed in the following section) have resulted in sharp decreases in the number of cattle raised in rangeland-based operations. According to USDA statistics, only 20% of the U.S. cattle inventory (~ 92.6 million) and approximately 50% of its sheep inventory (~5.53 million) grazed in western rangeland states in 2011. Emerging global economic scenarios along with rising oil-based energy costs could change this trend in coming decades (Holechek, 2013).

Rangeland-based livestock production systems of the western United States

Almost all arid and semiarid lands used for livestock grazing in the United States are located in the 11 states west of the 100th meridian. Most of these lands are public and their use is regulated by federal or state laws enforced by agencies of the federal or state governments or by the governing bodies of sovereign Native American nations. Public lands under federal jurisdiction are mostly administered by the U.S. Department of Interior Bureau of Land Management (USDI-BLM) and the U.S. Department of Agriculture Forest Service (USFS), and account for 30 to 80% of the land area of the 11 states mentioned above (Holechek et al., 2011). Federal and state public lands must serve multiple (and often simultaneous) uses, including livestock grazing, recreation, oil and gas extraction, timber extraction, and wildlife habitat, among others.

Mean annual precipitation on most western rangelands rarely exceeds 600 mm (except those in higher altitudes in the Rockies and Sierra Madre mountain ranges) and livestock carrying capacity ranges from approximately 2 to 45 hectares per animal unit year (Holechek et al., 2011). Public land grazing permits stipulate stocking rates and kind of livestock (mainly cattle or sheep). Annual adjustments intended to reflect yearly oscillations in rainfall and forage conditions are established for each grazing allotment. Cow-calf operations are the most common livestock enterprise on western rangelands. Sheep ranching has steadily declined in recent decades but is still locally important in some areas. Access to public land grazing requires a long term contract and involves paying grazing fees which vary from region to region. In 2011 for example, grazing fees on federal vs. state lands were 1.35 US$/AUM and 3.00 to 5.00 US$/AUM, respectively.

The history of livestock grazing on western U.S. rangelands shares many elements of other European colonial land settlement movements of the new world. Overestimation of grazing capacity due to an excessively optimistic perception of arid land productivity and prevailing climate was a common phenomenon during the early years of European occupation of the West. These perceptions, in addition to speculation by land investors and homesteading legislation that was frequently inadequate for arid land settlement (Homestead Acts of 1862, 1909, and 1916), set the stage for generalized rangeland degradation which became evident at the turn of the 19th century. During the last two decades of the 1800s, overgrazing in conjunction with record droughts followed by extremely harsh winters brought about one of the largest and most widespread livestock die offs on record. It is estimated that 80% of livestock from Texas to the Canadian border died as a consequence of starvation (Holechek et al., 2011). An environmental and economic catastrophe of this magnitude set the foundation for modern land use practices and for the legislation that regulates grazing on present day rangeland-based livestock enterprises across the West.

Although livestock grazing was historically the most prevalent use of western rangelands, in recent decades rangeland-based ranching operations have faced increasing challenges on two fronts: 1)

increasing demand for alternative uses of public lands by the general public; and 2) decreasing profitability of livestock operations. The first factor is thought to be partly responsible for substantial livestock reductions on federal lands. For example, stocking rates on rangelands administered by the Bureau of Land Management, the federal agency that manages the largest area of public grazing lands, has declined by 50% over the past 45 years, decreasing from 15.5 million AUMs in 1960 to 7.3 million AUMs in 2005 (Holechek et al., 2011). Similar yet less pronounced trends have been reported by the U.S. Forest Service for grazing lands under its jurisdiction. Low profitability of rangeland-based cow-calf operations is also thought to be partly responsible for declining trends in livestock numbers across the West. An analysis of profitability of cow-calf ranching enterprises in New Mexico showed that mean annual return on capital investment over four decades ranged between 2 and 6%, with returns barely above 1% for many years in this series (Holechek et al., 2011).

The combination of factors mentioned above has led to a new type of livestock producer who ranches as a means of embracing the traditional cowboy lifestyle and is therefore willing to subsidize the livestock enterprise with off-ranch income sources to achieve desired quality of life objectives (R. Skaggs, personal communication). In New Mexico, Torell et al. (2005) monitored 10-year trends in ranch property prices and found that only 20% of the value of the land could be attributed to its livestock production potential. According to these authors, most of the price of a ranch property in New Mexico is derived from the aesthetic value associated with its geographic location. Although this trend is widespread across the 11 western rangeland states, it is believed that an increase in the price of oil and consequent increase in the price of grains used for animal feed could promote renewed interest in policies that promote rangeland-based beef production systems (Holechek, 2013). In addition, there are an increasing number of consumers in large urban centers that seek to consume animal products raised in humane and environment-friendly operations which are often associated with rangeland-based free-ranging grass-fed beef production systems (Holechek et al., 2011). Therefore, it is possible that macroeconomic factors and changes in consumer preferences may trigger renewed interest in rangeland-based livestock production in the western United States.

Historically, two management intervention strategies have characterized western U.S. rangeland-based livestock systems. Each of these was largely a product of prevailing economic conditions at the time. The earlier strategy, common until the 1970s, consisted of maximizing production per unit area with heavy investments in range improvements aimed at enhancing forage production. Brush control, planting of tame pastures, or investment in fences needed to implement specialized grazing systems were a few of the tactics employed during this earlier era (Holechek et al., 2011). The second strategy, common since the 1980s, has consisted of minimizing financial risk and reducing investment in land improvements while maximizing per capita animal production efficiency. This strategy focuses on tactics such as implementing conservative grazing, selecting genetically superior animals, increasing the ability to detect unproductive animals, minimizing mortality and predation losses, and reducing supplement feeding costs (Holechek et al., 2011). Low cost tools to improve spatial distribution of livestock and promote more efficient use of forage resources are also common tactics of this strategy. Whereas the earlier intervention strategy demanded basic agronomic knowledge to implement modification tactics, the latter strategy demands higher levels of knowledge in the areas of ruminant nutrition, genetics, and foraging behavior.

Emerging trends in rangeland livestock production systems in the United States

Prevailing low capital investment management tactics described above have generated demand for tools that allow fenceless management of grazing in extensive paddocks. The cost of building typical livestock fences (four barbed wire strands) was approximately $5,181 per km in 2010 (Knight et al., 2011). Even with government programs that subsidize land improvements (e.g., USDA-NRCS EQUIP and similar cost-share incentives), these cost levels are prohibitive for the average rancher. This phenomenon has re-kindled the debate regarding the benefit of specialized grazing systems that require large investments in fencing. The rationality of investing sizeable amounts of government moneys to promote costly grazing schemes is being questioned by policy makers and members of the academic community who have repeatedly pointed to the lack of empirical support for perceived benefits of such systems, especially in drier environments (Briske et al., 2008; Holechek et al., 2011). Partly due to this trend, interest in fenceless grazing management alternatives such as old fashioned herding (Holechek et al., 2011) or virtual fencing systems that meld electronics with animal behavior

such as Directional Virtual Fencing (DVF™, Anderson, 2007), and selection of environment-adapted livestock (Peinetti et al., 2011; Estell et al., 2012; Wesley et al., 2012) is beginning to gain momentum. These emerging management approaches seek to harmonize livestock production efficiency, animal welfare needs, and enhancement of ecosystem services. Animal welfare for both domestic animals (Lund, 2006) and wildlife (Ditchkoff et al., 2006) engenders much discussion and has become an increasingly important global concern (Thornton, 2010). Though welfare may be considered a relative rather than an absolute term, it is indisputable that animal management practices directly impact animal welfare (Anderson and Estell, 2009). Management practices that foster positive animal welfare typically provide low stress animal handling (Smith, 1998) which has been shown to improve production efficiency (Grandin, 1998) and production economics (Lawrence and Stott, 2009). Using innate animal behaviors (Bracke and Hopster, 2006) to accomplish management goals has produced positive results in several areas, including: obtaining free-ranging animal liveweights (Anderson and Weeks, 1989), protecting small ruminants from canine predators (Anderson et al., 2012) and the containment and movement of animals across landscapes (Anderson, 2007).

Ecosystem services enhancement through vegetation management programs that promote shifts from woody- to grass-dominated plant communities continue to be applied selectively on rangelands of the western United States. Their main focus is to improve ecosystem services such as watershed function and wildlife habitat. "Restore New Mexico", a statewide program implemented by USDI-BLM in New Mexico is a good example of these initiatives. Although herbicides are the tool of choice in most of these programs, alternatives that use focalized grazing/browsing by livestock (referred to as *targeted grazing*) are becoming more common in integrated vegetation management plans. Targeted grazing, which enjoys broad support among non-agricultural urban communities, is viewed as an opportunity for diversification for some ranchers who provide vegetation restoration services. This fairly new approach involves a shift in traditional paradigms; livestock are used as ecosystem service providers while production of agricultural commodities becomes a secondary goal of the enterprise. Both this approach and fenceless livestock management tools described above entail low capital investment but are knowledge-intensive because they require manipulating animal behavior to affect grazing selectivity at the scale of diets (targeted grazing) and landscapes (fenceless control) using behavior conditioning techniques and/or genetic selection.

Regardless of the tools employed, vegetation management is costly and reverting trends of woody plant encroachment in the western United States and other rangelands worldwide seems highly unlikely (Estell et al., 2012). Thus, sustainable utilization of woody plants as an additional source of livestock feed is possibly inevitable given the global and local scenarios that we describe in previous sections. Shrubs will more than likely become an increasingly necessary low-cost and rational feed alternative in rangeland-based livestock systems of both the developing and developed world (Estell et al., 2012). There is a large body of literature reviewed in detail by Estell et al. (2012) that has investigated the biochemical and physiological mechanisms underlying livestock voluntary intake limitations imposed by sophisticated chemical defense systems of rangeland browse species. It is interesting to note that a number of common shrub secondary metabolites have shown promise in reducing methane emissions from ruminant digestion and could, somewhat ironically, aid in reducing the carbon footprint of grazing-based livestock production systems on rangelands (Estell et al., 2012). Close to half a century of research in woody plant-ruminant interactions has shown some promising avenues for success, but again, as with other emerging management approaches discussed above, integral knowledge-intensive solutions will be critical to transforming woody plant biomass into animal protein (Estell et al., 2012).

Rangeland-raised livestock production systems in the western U.S. are also being increasingly impacted by the ongoing quest for viable clean energy alternatives to replace declining planetary oil reserves (Holechek, 2013). In some instances, these trends are generating opportunities for local ranching communities, particularly in the area of renewable cellulosic fuel sources. The American economy is projected to demand 36 billion gallons of renewable transportation fuel per year by 2022 to meet congressional goals mandated by the 2007 Energy Independence and Security Act (U.S. EPA, 2010). Up to 62 million tons of woody biomass per year could be required from western forests and woodlands, assuming a yield of 70 gallons of cellulosic ethanol per dry ton of woody biomass (USDA, 2010). Despite transportation-related challenges associated with woody feedstock production from rangelands, interest in woody biomass in central New Mexico is steadily increasing. Private

consultants are seeking to create consortia with sufficient woodland area to insure supply of sizeable volumes of juniper biomass to power Midwestern industrial plants (Barbara Sultemeier, New Mexico Rancher, personal communication). Ranchers are welcoming this opportunity as a means of restoring areas of their land that have been degraded in recent decades due to tree encroachment. However, impacts of other kinds of alternative energy such as the installation of wind farms have not been as favorable (Holechek, 2013). For an in-depth analysis of the impacts of energy generation on rangelands of the U.S. and elsewhere, readers are referred to Holechek (2013).

Conclusions

Shrinking areas of native grasslands and rising ruminant populations worldwide, which are occurring against a backdrop of increasing weather extremes and escalating energy prices, will pose significant challenges for rangeland-based livestock production systems worldwide. Although these trends are expected to be more pronounced in developing nations, western U.S. rangeland-based ranching is being increasingly affected by this global scenario. Emerging management trends on western rangelands are predicted to be driven by knowledge-intensive management tools that require low capital investment and promote increases in per-capita production by improving foraging efficiency while enhancing animal welfare and the provision of ecosystem services from rangelands. Fenceless livestock control, selection of adapted livestock biotypes, and increased use of woody browse are expected to become increasingly important elements of these systems.

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FACTOR HUMANO Y MANEJO DE PASTIZALES. ALGUNAS EXPERIENCIAS DE MANEJO ADAPTATIVO CON DIFERENTES TIPOS SOCIALES Y ESCALAS ESPACIALES.

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Introducción

Recurrentemente se retoma la controversia acerca de las ventajas y desventajas de los sistemas de pastoreo rotativos sobre los de pastoreo continuo. Pese a que las evidencias no muestran ventajas del pastoreo rotativo sobre el continuo (Briske et al., 2008), prevalece entre técnicos y productores la idea de que el primero tiene ventajas sobre el segundo (Briske et al., 2011). Una de las explicaciones a esa contradicción es la certeza de que el éxito de cualquier sistema de pastoreo está condicionado por el factor humano, relacionado con el aprendizaje que adquieren tanto los técnicos como los encargados del manejo durante la implementación de los sistemas de pastoreo. Así, el mejor sistema de pastoreo rotativo fracasará si los recursos humanos no están capacitados para manejarlo y/o comprometidos con el sistema. Viceversa, sistemas de manejo de pastoreo continuo más sencillos obtendrán resultados muy positivos si son implementados por recursos humanos excelentes.
En el marco de estas consideraciones, el concepto de manejo adaptativo (Holling, 1978; Walters, 1986) parece mucho más unificador y útil para socializar experiencias que la simple adhesión rígida a uno u otro sistema de pastoreo en particular (Briske et al., 2011). El manejo adaptativo supone un proceso de aprendizaje continuo, tanto por parte del técnico como por parte del encargado del manejo, que consiste en el diseño de una propuesta de manejo, su posterior puesta en práctica y el monitoreo de sus resultados. La interpretación de éstos conduce, a su vez, a una reformulación del sistema, que se traduce en un nuevo diseño, mejor que el anterior.
En este trabajo presentaremos algunas experiencias de manejo adaptativo con distinto grado de desarrollo, tipos sociales y escalas espaciales que muestran la importancia del factor humano en el diseño de sistemas de pastoreo sustentables. Se trata de dos experiencias realizadas en áreas de más de 50.000 ha y dos experiencias a escala de pequeño predio. Además, una de las experiencias de gran extensión tuvo lugar en un establecimiento capitalizado de Río Negro, dedicado a la cría ovina y vacuna, mientras que la otra tuvo lugar en una Colonia Pastoril Mapuche del Chubut, formada por varios pequeños predios familiares de 625 ha cada uno, dedicados a la cría ovina y caprina. Por su parte, las dos experiencias a escala de predio correspondieron a productores cabriteros, unos de Córdoba y los otros de Santiago del Estero. Finalmente, la experiencia de manejo adaptativo a la