ECONOMICALLY EFFICIENT RANGELAND MANAGEMENT TO SUSTAIN ECOSYSTEM FUNCTION AND LIVELIHOODS

W. R. Teague
Texas AgriLife Research and Department of Ecosystem Science and Management, Texas A&M University System, Vernon, TX, USA

U.P. Kreuter
Department of Ecosystem Science and Management, Texas A&M University, College Station, TX, USA

W. E. Fox
Texas AgriLife Research and Department of Ecosystem Science and Management, Texas A&M University System, Temple, TX, USA

Keywords: Ecological economics, ecosystem goods, ecosystem services, natural capital, sustainable capitalism, sustaining livelihoods

Contents

Summary

Generally, management of rangelands has aimed at optimizing short-term benefits from the production of food, fiber and fuel. However, we have compromised the ecological integrity of global ecosystems and caused negative impacts on our social environment by not accounting fully for environmental and social costs. For humans to live sustainably, we must manage natural resources in a way that prevents their depletion

and protects their potential for self-replenishment. Compared with mainstream economics, ecological economics provides a framework for conducting a more realistic accounting by placing a value on ecosystem services so they are enhanced rather than depleted. It is in the interests of humankind that agricultural managers do not merely increase production but link ecology with economics to make a profit over the long-term. Our current industrial economy and agriculture are highly dependent on cheap energy. As energy becomes more expensive we will have to manage for healthier ecosystems and with fewer purchased inputs. This will require changing from a maximum production to a minimum cost, regenerative philosophy of land use. Greater management expertise will enable us to manage smaller areas of land with less labor, less capital and fewer inputs more effectively. We will have to become more adapted to the landscapes we live in and breed livestock that are able to thrive locally without the large inputs that characterize our current agriculture. To achieve the highest levels of sustainable productivity and profit, managers should aim for the highest ecosystem biodiversity, function and resilience. To be more sustainable environmentally and economically we need to maximize the natural capital productivity of ecosystem goods and services and invest in increasing their supply in the long-term. We can do this by developing grazing management that enhances the well being of soils, plants, livestock, wildlife and people.

1. Introduction

The people living in rangeland ecosystems rely on natural plant communities to provide livelihoods principally by grazing domesticated livestock. These ecosystems also provide essential services upon which both rural and adjacent urban populations depend. Such ecosystem services include maintaining stable and productive soils, delivering clean water, and sustaining plants, animals and other organisms that support livelihoods and human aesthetic and cultural values. As highlighted by the Millennium Ecosystem Assessment compiled in 2005, the ecological integrity of global systems is rapidly being compromised with negative impacts on human well being. Gaps in ecological knowledge, shortcomings in economic approaches and flaws in decision support systems and policy initiatives diminish our ability to effectively address and manage changes in ecosystems and to enhance human well being. Rangelands are no exception.

Traditionally rangeland management has aimed at optimizing short-term benefits from the production of food, fiber and fuel with little regard to negative impacts on ecosystem services, despite acknowledgement of the need to manage sustainably. It is in the interest of land managers to sustain or enhance the ecological functions and processes that support their livelihoods, and it is also in the interests of society at large that other non-marketable ecosystem services, upon which human well being depends, be similarly maintained or improved.

Land use and changes in land use are governed by changing environmental, socio-economic and technological factors that are influenced by state, national and international policies. However, the final outcome of land use changes is largely determined by the ways in which land managers respond to these factors and policies. For rangeland management practices to continue to provide essential goods and services to society, rangeland-based enterprises must not only remain financially profitable but must also respond to growing demands to reduce the deleterious environmental impacts of traditional agricultural practices.

For rangeland to be managed in a manner that ensures adequate livelihoods for producers and that serves the needs of society at large, managers at all scales need to be able to make informed decisions that are ecologically sound, economically feasible and socially acceptable. To achieve this goal, they need an information base, decision framework and decision support tools that help determine the effect of management decisions not only on the profitability of an enterprise but also on the affected ecosystem services. As outlined by Brian Walker and his coworkers, coupled social-ecological systems behave as complex adaptive systems in highly uncertain and unpredictable environments. Therefore, it is imperative to develop decision frameworks to help people live sustainably within these dynamic ecosystems rather than to try to control their inherent uncertainties.

Traditionally, economic planning and accounting have been conducted by managers of individual business entities, generally at the scale of individual farms or ranches (firm scale in business terms). Government taxes, incentives and subsidies have influenced such decisions. However, while such measures may result in positive effects on livelihoods they often lead to negative impacts on ecosystem services. Accordingly, they are often referred to as perverse incentives.

To achieve environmentally sound production, outcomes must be evaluated not only at the individual property scale but also at catchment, regional and national levels. Accordingly, goals that lead to ecologically sound management will need to be complimentary across this range of geographic scales which are nested in a hierarchical structure with interactions between them. Policies can be helpful or counterproductive, and for the achievement of desirable goals, regional policies and management on individual properties must both function effectively and be complimentary.

In this chapter we outline the information base and decision framework required to achieve economically efficient rangeland management aimed at sustaining ecosystem function and livelihoods at ranch, catchment and regional scales. We include an outline of: (1) global sustainability of ecosystems; (2) accounting framework necessary to manage for sustainability rather than merely financial profit on rangelands; (3) critical ecosystem goods and services we need to account for when managing rangelands; (4) a framework to assist rangeland managers simultaneously sustain livelihoods and ecosystem function; and (5) major gaps in existing knowledge and future research priorities in this subject area.

2. Global Sustainability of Ecosystems

Humans have manipulated ecosystems and ecosystem function more in the last 50 years than at any other time in human history. Many of the resulting changes have improved human well being through the supply of more food, fiber, fresh water, timber and fuel.

Conversely, the increased delivery of these provisions has caused the degradation of many ecosystems. The most important drivers of ecosystem change include overexploitation; biodiversity loss and invasion of alien species; soil loss, pollution and impairment of watershed function; desertification and climate change. These factors are leading to a loss of natural capital (productivity) and, therefore, the ability of ecosystems to deliver services upon which human well being depends. An estimated 60% of the global ecosystems have been degraded and are used unsustainably, which has elevated poverty among numerous groups of people. Such negative impacts have been ascribed to rapid human population growth and increasing affluence and consumption due to technological advances. Moreover, projections are that causes of ecosystem change will remain constant or increase in most global ecosystems and, therefore, the rate of ecosystem degradation will increase unless we change the way that we manage them. Some authors have claimed that the accelerating conversion of remaining natural habitats is resulting in erosion of human welfare for short-term gain for relatively few private entities. As a result, current development trajectories are not resulting in benefits for all people, income disparity is increasing globally, and most countries are not on track to meet goals for human development and poverty eradication by 2015 as set out in the Millennium Ecosystem Assessment complied in 2005. This includes such fundamental aspects of human well being as reducing poverty, hunger, child and maternal mortality, ensuring education for all, controlling and managing diseases, and tackling gender disparity.

Clearly, it is in the interest of people across the globe to stop or reverse ecosystem degradation that is occurring in most parts of the world. This will be particularly challenging as the demands for ecosystem services are increasing and the skills of societies in managing for successful outcomes are a significant factor determining if and how well they prosper. While changes in management practices have been shown to yield significant improvements in the delivery of ecosystems services, to adequately meet future challenges ecosystem restoration initiatives will have to be implemented at a far larger scale than has historically been the case. Furthermore, while significant reversals in degradation have been documented for some ecosystem services, it is not uncommon for other ecosystem services to deteriorate; this indicates a need to integrate efforts on many fronts Actions that have resulted in positive outcomes include: investments in education and health, reductions in poverty and socioeconomic disparities, active adaptive management to avert environmental problems before their full consequences are experienced, and investments in environmentally compatible technology.

In order to reverse degradation and ensure sustainable management of ecosystems at local, regional and national levels it will be necessary to coordinate goals and planning activities to specifically address future needs in the following categories: (1) institutions and governance; (2) economics and incentives; (3) social and behavioral guidance and support; (4) technological development; and (5) knowledge development. Effective and efficient organization does not currently exist at these levels of cooperation and governance but will have to be developed and coordinated to achieve desired ecosystem management goals.

3. Management for Sustainability rather than just Financial Profits

For humans to live sustainably, natural resources need to be managed in a way that prevents their depletion and protects their potential for self-replenishment. Sustainability is widely recognized as having 3 overlapping elements: environmental, economic and social (Fig. 1) where the economy is a component of society and both depend on the environment. These three elements represent three forms of capital (stock that generate dividends), which are all necessary for any economy to function properly. They include: (1) natural capital, which generates ecosystem goods and services upon which human endeavors depend; (2) social capital consisting of human intelligence, labor, culture and organization, which interact to generate productive capacity; and (3) economic capital, which consists of financial and manufactured capital (infrastructure, vehicles, equipment, tools, etc) that facilitate the use of resources.

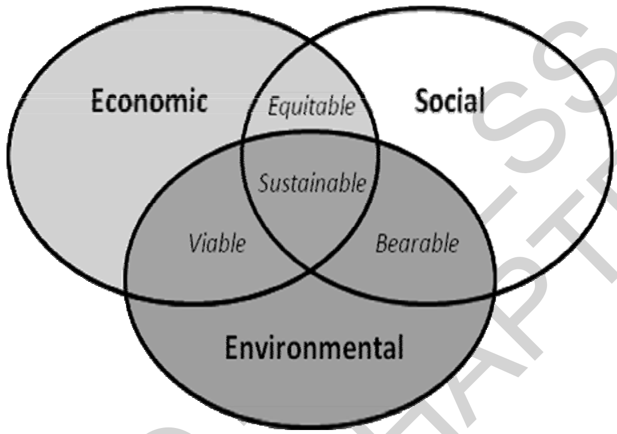

Figure 1. A schematic illustrating the need for adequate integration between environmental, social and economic elements in order to achieve sustainability was developed by W.M. Adams at Cambridge University. (Modified from http://en.wikipedia.org/wiki/Ecological_economics)

While modern capitalism has greatly increased material wealth it has done so by depleting the natural capital upon which human well being depends Prevailing neo-classical economic models emphasize profit maximization through the efficient allocation of scarce resources including land, labor and financial capital. As outlined by Robert Costanza and coworkers, analyses based in such models often deviate from basic accounting principles by liquidating natural and social capital and counting it as income. Such analyses do not relate to knowledge about the functioning of natural systems, they do not address bio-physical constraints of economic systems and they neglect the living ecosystems and socio-cultural systems that represent the largest capital stocks upon which all human economic activity depends. At best they incorporate the environment as a subset of the human economy.

Economists who use such models believe that resources are supplied by human ingenuity rather than nature; they work on the assumption that there is an infinite resource base, with infinite waste and pollutant sinks with no feedbacks, and they do not acknowledge that economic activity is constrained by the laws of thermodynamics. Such assumptions allow them to claim that theoretically, infinite growth is both possible and desirable.

In contrast to neo-classical economics, ecological economics (EE) is based on the assumption that the economy is embedded within an environmental system. This relatively new trans-disciplinary approach was pioneered by Herman Daly, previously a senior economist with the World Bank, to fuse ecology and economics aims to improve human well being through the development of sustainable societies that account for externalities created by human economic activity, that adhere to constraints imposed by finite natural capital, and that incorporate equity of wealth distribution.

Ecological economic analysis is based on the premise of environmentally sustainable development, intergenerational equity, irreversibility of environmental change and the uncertainty of long-term outcomes. This perspective is based on the fact that environmental sustainability is linked to social issues because poverty and inequity lead to increased pressure being placed on natural resources. Achieving sustainability, therefore, depends on attaining fairness in opportunity and distribution, adequate health and education, gender equity, and political participation.

Ecological economics also rejects the idea that natural capital can be substituted for human-made capital. Therefore, whereas neo-classical economic analyses focus primarily on the efficient allocation of three categories of scarce resources (land, labor and financial capital), ecological economics adds natural capital in the analysis of resource allocation, such that ecosystem services serve as additional scarce resources. Since ecological economic analysis accounts for ecosystem, social and economic criteria, it is has been described as the appropriate model for achieving sustainable development. By contrast, D.J. McCauley of Stanford University has criticized ecological economics for attempting to place economic values on natural capital and the associated ecosystem services because assigning a monetary value to them is not only difficult and imprecise but also risks viewing Nature as a commodity. Nevertheless, it does provide a broad accounting framework that facilitates decision making leading to more sustainable development of ecosystems and societies.

Not placing an economic value on natural capital and the ecosystem services that it generates leads to a conundrum. In such a situation, ecosystem services will be disregarded (because they are assumed to have zero value) in analyses that compare the net benefits of alternative resource allocation options. On the opposite extreme, ecosystem services are considered to be infinitely valuable thereby trumping all other resource allocation considerations; this perspective ultimately precludes the use of all resources because all human economic activity generates environmental impacts that ultimately impinge on the "invaluable" ecosystem services.

Environmental sustainability is predicated upon the maintenance of a stable resource base, the avoidance of over-exploitation of renewable resources and the re-investment of proceeds from the extraction of non-renewable resources in the development of renewable resource alternatives. In other words, it is critical to maintain ecosystem resilience, which is the ability of the ecosystem to return to its fully functional capacity after a disturbance event or damage to the system (see *New Thinking in Ecology*). The key to resilience is high biodiversity of adapted organisms to maintain an adequate genetic pool that can adapt to changing conditions.

-
-
-

Bibliography

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R., Paruelo, J., Raskin, R.G., Sutton, P. and van den Belt, M. (1998). The value of ecosystem services: putting the issues in perspective. *Ecological Economics* 25:67-72. [A seminal paper that sets out the thinking behind ecological economics and placing a value on ecosystem goods and services].

Daily, G.C. (1997). *Nature's Services: Societal Dependence on Natural Ecosystems*. Island Press, Washington, D.C. [This book clearly demonstrates the economic value of safeguarding natural habitats and shows that human destruction of biodiversity is threatening the very foundation of sustainable development].

Daly, H.E. (1996). *Beyond Growth: The Economics of Sustainable Development*, Beacon Press, Boston. [Daly is considered the dean of Ecological Economics. This book presents economic concepts that account for the wealth of nature, the value of community and questions the notion that growth is always good].

Holling, C.S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics* 4:1-23. [This is a seminal paper on the subject].

Ikerd, J.E. (2005). *Sustainable Capitalism: A Matter of Common Sense*. Kumarian Press, Inc., Bloomfield, CT. [This book is a seminal contribution to the concept of sustainability. It illustrates a whole new way of thinking about the economics of a sustainable agriculture and provides a framework to ensure economic sustainability and intergenerational equity].

Kroeger, T. and Casey, F. (2007). An assessment of market-based approaches to providing ecosystem services on agricultural lands. *Ecological Economics* 64:321-332. [This paper discusses different forms of market-based approaches to ecosystem services and identify the characteristics of services that make them better suited to one or another of these approaches].

Ludwig, D., Brock, W. A. and Carpenter, S. R. (2005). Uncertainty in discount models and environmental accounting. *Ecology and Society* 10(2): 13. [online] URL: http://www.ecologyandsociety.org/vol10/iss2/art13/. [This paper gives an excellent overview of the potential problems in using cost-benefit analysis for environmental accounting for making environmental decisions].

Millennium Ecosystem Assessment. (2005). *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC. [This overview of the current conservation status of global ecosystems was compiled by 13 of the world's leading social and natural scientists. It is an indispensable reference for scientists, environmentalists, agency professionals, and students].

Pimentel, D. and Pimentel, M.H. (2008). *Food, Energy, and Society*. Taylor and Francis, Boca Raton, Fl. [This book shows how to achieve the necessary balance between basic human needs and environmental resources and provides potential solutions to the host of problems we face today].

Provenza, F.D. (2008). What does it mean to be locally adapted and who cares anyway? *Journal of Animal Science* 86:E271-E284. [This paper provides an excellent systems overview of why and how rangeland agriculture will have to restructure to be sustainable in the future].

Van Cauwenbergh, N., Biala, K., Bielders, C., Brouckaert, V., Franchois, L., Garcia Cidad, V., Hermy, M., Mathijs, E., Muys, B., Reijnders, J., Sauvenier, X., Valck, J., Vanclooster, M., Van der Veken, B., Wauters, E., Peeters, A. (2007). SAFE—A hierarchical framework for assessing the sustainability of agricultural systems. *Agriculture, Ecosystems and Environment* 120:229–242. [This paper outlines a framework to assess the sustainability of agro-ecosystems that encompasses the three pillars of sustainability: the environment, economic and social pillars].

Walker, B.H., Abel, N., Anderies, J.M. and Ryan, P. (2009). Resilience, adaptability and transformability in the Goulburn-Broken catchment, Australia. *Ecology and Society* 14(1):12. URL: http://ecologyandsociety.org/vol14/iss1/art12. [This paper outlines the scope of considerations and planning required when assessing and adaptively managing to achieve regional ecosystem resilience and sustainability].

Biographical Sketches

Richard Teague is a Professor and Associate Resident Director with Texas AgriLife Research at the Vernon Research and Extension Center. He grew up and received his schooling in Zimbabwe, Africa. He received his BS (Grassland Science) from the University of Natal, South Africa and Ph.D. (Botany-Ecology) at the University of the Witwatersrand, South Africa. He has practical and research experience in grazing management systems, brush control with fire and chemicals on semi-arid rangeland in Africa and North America. He specializes in sustainable management, ecological restoration and ecological economics modeling. He uses a systems approach in developing land and livestock management principles that sustain natural rangeland resources and the livelihoods of people depending on the land. He uses four key elements to achieve this goal: a systems research program, resource accounting, long-term assessment and partnering with rancher clientele.

Urs Kreuter is a Professor in the Department of Ecosystem Science and Management at Texas A&M University. He received his schooling in Zimbabwe, Africa. He received a B.S. (Grassland Science) and M.S. (Grassland Science) from the University of Natal, South Africa, and a M.A. (Economics) and Ph.D. (Range Science) from Utah State University. He currently teaches an undergraduate capstone course in Ecosystem Management, a Study Abroad Course in South Africa that focuses on biodiversity conservation and eco-tourism, and a graduate course in Ecological Economics. His research focuses on elucidating the human dimensions of ecosystem management and aims to inform policy makers to create positive incentives for the sustainable use and management of terrestrial ecosystems under a broad range of land tenure systems. His research has both a national and an international focus.

Bill Fox is an Assistant Professor with Texas AgriLife Research at the Blackland Research and Extension Center (BREC) in Temple, TX. He received a BS (Range Science) from Texas A&M University, a M.S. (Animal and Range Science) from New Mexico State University and a Ph.D. (Rangeland Ecology and Management) at Texas A&M University. His research focuses on restoration of drastically disturbed rangelands. He is working with scientists at BREC to determine the feasibility of using simulation models as decision aids for land managers. These efforts have resulted in the development of the Integrated Social, Economic & Ecological Conceptual (ISEEC) Framework to test the applicability of Criteria & Indicators developed by the Sustainable Rangelands Roundtable in assessing sustainability of rangelands in the United States.