Sustainability of Animal Production Systems: An Ecological Perspective[1]

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ABSTRACT: The question of sustainability of agricultural production and the use of natural resources has become a popular topic. Most scientists agree that current systems are generally non-sustainable. Current rates of resource extraction will lead us to a depleted earth in the future. Sustainability is defined in many ways. For this paper sustainability should be considered the overlap of what is wanted and what is ecologically possible. Attempts have been made to place a quantitative measure on sustainability. However, it should be considered a trajectory or goal, a direction that guides constructive change, rather than a single quantitative measure. Research and extension personnel may have to take a broader look at their efforts and expand their knowledge base in order to address the issue of sustainable production systems. Both natural events and those caused by humans bring about changes in production potential that require shifts in management. Uncertainty and change should be incorporated into adaptive management strategies. Interdisciplinary efforts are needed to confront these issues. Animal scientists need to formulate management systems that are environmentally compatible or face restrictive legislation that will force change. Members of the American Society of Animal Science seem to agree: efficient and sustainable use of natural resources appears in the draft of the Strategic Plan of the Society, and a poll of members revealed that environmental concerns about animal agriculture was a primary issue facing animal scientists.

Key Words: Animal Agriculture, Adaptive Management, Ecological Agriculture, Research

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Introduction

This symposium has addressed various aspects of the sustainability of animal production systems into the next century. In fact, scientists from such diverse fields as economics and ecology are working hard to address the question of, and derive a working definition for the term, “sustainability”. Several definitions are offered in the papers from this symposium. Both economists (Bishop, 1993) and ecologists (Lubchenko et al., 1991) agree that the current generation is using natural resources at historically unprecedented rates and that renewable resources are being exploited and degraded on a global scale. At this rate, future generations will inherit a much depleted and degraded resource base (Bishop, 1993).

Dovers and Handmer (1993) warn that the development and application of technology has enabled and encourages an increase in consumption of resources and the production of wastes that threaten the biosphere and our own and nature’s survival. The authors go on to state that if the developing and less-developed world were brought up to the level of consumption seen in the industrialized countries, a fivefold energy use increase on the biosphere would result.

This concern with over-utilization of the earth’s renewable and non-renewable resources is not new. It was clearly defined in an excellent symposium titled “Man’s Role in Changing the Face of the Earth” (Thomas et al., 1956). Darling (1956) stated it well when he remarked that humans advance materially and ultimately in our civilization by breaking into the stored wealth of the world’s natural ecological climaxes. The process gives us leisure, much needed for the art of civilizing. Sauer (1956) also questioned the timber and agricultural industries, both being questioned today as well, in regard to the lack of sustainable practices.

The term sustainability takes on many forms and is defined differently. Scientists, depending on their outlook, vary from the pessimistic (Ludwig, et al. 1993) to the optimistic (Bishop, 1993). In this paper I

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will explore a philosophical discussion of sustainability and make application to sustainability from an ecological perspective.

Defining Sustainability

Current literature is awash with papers on sustainability, and more specifically, the philosophy of whether or not sustainability is attainable and how it should be approached. Ludwig (1993) found early application of sustainability in 1849 in calculations of a forest-rotation period. The time period that maximized economic benefits from tree cutting to tree cutting was termed sustained yield. Ludwig et al. (1993) related that, in the past, fisheries management was guided by the concept of Maximum Sustained Yield, a concept that did not work. Only recently has much attention been applied to sustainability in agriculture, and more specifically, livestock production. The current USDA program of competitive grants in Sustainable Agriculture Research and Extension (SARE) and the Environmental Protection Agency's Agriculture in Concert with the Environment (ACE) programs serve as examples.

Sustainability has been defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs (Bishop, 1993; Dovers and Handmer, 1993). Wilkinson (1992) felt that good science, good laws, good economics, and good communities come together in the idea of sustainability. Bormann et al. (1994) defined sustainability as the degree of overlap between what people collectively want, reflecting social values and economic concerns, and what is ecologically possible in the long term. The overlap is dynamic because both societal values and ecological capacity continually change. They advocated that desires of future generations be protected by maintaining options for unexpected future ecosystem goods, services, and states.

In livestock production, sustainability can mean being able to harvest the same quantity of meat or fiber from a given land base indefinitely. In other words, the offtake of products (meat or fiber) does not decay the ability of the land-base to continue providing the materials (e.g., forage) for further offtake. However, although the potential commodity production of the land-base is protected by this approach, the integrity of the ecosystem (the interaction of native plants and animals and their environment) is not considered in this definition. Forage could simply be a monoculture of an introduced grass and no remnant of the natural system need remain. On private lands where the sole purpose of production is a livestock enterprise to provide income to the producer, this could be considered sustainable.

On public lands in the western United States, where concepts of multiple use are employed, a different definition is in order. Here, livestock production must be accomplished at a level that provides for the maintenance of such diverse entities as habitat for neotropical migrants (song birds), large native herbivores (deer, elk), fish habitat (water quantity and quality as well as streamside vegetation), and watershed health (safe capture, storage, and release of precipitation). When this compatibility is questioned, livestock may be removed by court order (Sleeth, 1994), as is the case with livestock grazing along streams serving as spawning habitat for endangered Chinook salmon. Sustainability of livestock grazing in these cases has to meet the criterion of an offtake of product (forage) without disruption to the functioning of the ecosystem.

A simple definition of sustainability, then, seems impossible to develop. For this paper the definition of Bormann et al. (1994) seems appropriate. Sustainable systems are those that exist in the overlap of what the current generation wants for itself and future generations, and what is biologically and physically possible in the long term.

Measuring Sustainability

After about 400 years of European settlement and nonsustainable use we must realize that what we are now trying to sustain is but a remnant of what was here prior to European invasion of the New World (Vavra et al,. 1994). The good news is that unlike some areas of the old world, where for thousands of years past civilizations practiced land use that does not meet the current definition of sustainability (Sauer, 1956), we have a greater percentage of our land and resource base somewhat intact. The potential for developing sustainable systems that are highly productive for food is still there.

The initial problem was stated by Holling (1993), who noted that sustainable development may be an oxymoron. The author based this belief on the comments of Ludwig et al. (1993). In many cases of renewable natural resource management, success in managing a target variable for sustained production of food and fiber leads to an ultimate pathology of more brittle and vulnerable systems, more rigid and unresponsive management agencies, and more dependent societies. Holling (1993) gave as examples the rigid regulation of toxic materials by the Environmental Protection Agency and the narrow implementation of the Endangered Species Act by the U. S. Fish and Wildlife Service. Ludwig et al. (1993) went on to further state that we shall never attain scientific consensus concerning the systems that are being exploited. There have been numerous failed attempts to exploit systems and still maintain their sustainability. Two reasons were given: controlled and replicated experiments were unable to perform in large-scale systems, and the long time scales involved negate observational studies that could provide timely remedial measures.

Hilborn and Ludwig (1993) added another difficulty. Ecological systems change over time and what was true in one decade may not be true in the next. Short-term weather cycles (10 years) can make resource extraction seem more or less optimistic. For example, in the last 8 y, drought in the Pacific Northwest and warm ocean conditions have led to a decline in Columbia River salmon stocks. These events, added to spawning habitat degradation, intensive fishing (both legal and illegal), water extraction for irrigation, and hydroelectric dams have resulted in the listing of several salmon stocks as endangered. Salmon harvest has been drastically curtailed along with other uses such as grazing, irrigation, and hydropower generation. Drought in spawning areas and the warm, infertile ocean currents (El Nino effect) alone would have caused a decline in salmon stocks. Human interference just made the decline worse.

These are not new revelations. Malin (1956) stated that human intervention on ecosystems has been a real and dramatic force of change, but natural changes ("disasters," to human thinking) have always occurred and greatly confound analysis of the causative agents of change. Defining what should be there now and providing a pathway to return to that state is in most cases impossible, due to the natural and imposed changes. How then to determine whether or not a management system is sustainable?

First, we must abandon the idea that sustainable use is an endpoint. Fuentes (1993) preferred to define it as a trajectory with certain bounds, rather than a particular state. Scientists could help in envisioning the maximum stresses that various subsystems can tolerate at various moments, and still maintain future options. Lee (1993) termed sustainability a goal, like liberty or equality, not to be reached, but a direction that guides constructive change. Sustainability may be like global warming. If we wait for all the data to come in so a final conclusion can be made, it will take too long and it may be too late to do anything about it. Malin's (1956) suggestions seem to hold true today. What must be developed is a management pathway (for livestock production) based on ecological soundness that provides the essentials of vegetation cover, water-holding capacity, and lack of erosion to the landscape. To that list we can add efficiency of energy use (Heitschmidt, 1996), the maximization of feedstuffs not utilizable by humans (Oltjen and Beckett, 1996), economic feasibility, provisions for animal welfare, and quality of life for producers and society (Honeyman, 1996).

The Role of Research and Extension

Animal scientists in research and extension at land grant universities and with the Agricultural Research Service have the opportunity to participate in the development and implementation of sustainable livestock production systems. The question is: Are we as professionals accomplishing this goal? A concise answer seems to be elusive. However, I believe a partial answer can be found in the report of the Western Council of Administrative Heads of Colleges of Agriculture Committee on Public Lands. This committee was composed of a scientist from each land grant institution in the western states (CAHA, 1993). Their comments related to public land management in the West, but, I believe, can be applied to the issue of sustainable livestock production. To quote from the report:

> If land grant universities are successful in identifying what society expects from its public lands and applies the land grant model to new issues, they can be as effective today as they were in changing America from a country of rural poor to the well fed, industrial power of the 20th century. If they ignore public concern for new issues and listen only to their traditional client groups, they will find themselves increasingly at odds with the people Land Grant Universities are supposed to serve. If they refuse to acknowledge or are insensitive to societal changes, they will become irrelevant.

Marston (1993) has been a critic of business as usual at Land Grant Universities. He warns that they are fleeing their responsibility to the region (the west). The author puts part of the blame on the public and the media for basically ignoring the Land Grant Universities. He goes on to state that what is needed is the pursuit by the universities of new approaches to natural resources and the reform of old approaches.

It is my belief that these concerns (CAHA, 1993; Marston, 1993) are also directly applicable to the issue of sustainable livestock production. Although research has been conducted that emphasizes the better utilization of crop residues (Klopfenstein et al., 1987; Conner and Richardson, 1987; and Males, 1987), only small portions of these materials form a part of production systems. In Oregon, over one million metric tons of grass straw are produced annually from the grass seed industry, yet less than 5% is used for livestock feed, even though research has developed the methodology (Chamberlain and DelCurto, 1991).

Research is also needed on the impact of livestock production on the environment, both physical features such as water quality and biological, the impacts of livestock production on other organisms. Most animal scientists have little or no training in these interactions. Why should they, and who would have thought it necessary? The important point is, scientists in other disciplines are studying livestock's effects, and their results may change how animal scientists and the animal industry do business. On public lands in the West new grazing systems are being implemented by the Forest Service and Bureau of Land Management. These systems are designed by people with applied plant ecology backgrounds and perhaps only token animal science course work in college. The systems are designed to be environmentally friendly but may not be compatible to animal behavior or economical livestock production. To my knowledge neither federal agency employs even one animal scientist.

How can animal scientists in research and extension become more effective? One way is through interdisciplinary efforts. Research or extension programs developed for whole systems, and the impact of those systems on the environment, is one approach. Sustainable management means more than continued commodity production at a given rate. It also addresses the social and environmental issues associated with harvesting the resources (Meyer and Helfman, 1993).

This may lead us to a reevaluation of the reward system in the university setting. Currently, first or second authorship of refereed publications ranks high in the reward system. Interdisciplinary research and extension may require more time and effort with less individual recognition. Change at the promotion and tenure level within the university may also have to change in order for interdisciplinary efforts to be attractive to scientists, especially those early in their careers.

When I began my career 23 years ago, I never imagined that I would be cooperating with range scientists and a fish biologist on a research project titled "The impact of livestock on the spawning behavior and redd (egg nest) integrity of chinook salmon." And yet issues like this are, in many cases, the driving forces limiting livestock production today.

The Eastern Oregon Agriculture Research Center, where I am employed, has an advisory committee that includes livestock producers. Their suggestions for research do not place a high priority on increased weaning weights, heifer development, or growth-stimulating hormones. Rather, their plea has been for research directed at the environmental effects of livestock production, because that is perceived as the biggest threat to their future. Where once our primary mission was increased livestock production, we have now put emphasis on a much broader set of parameters involving the environmental impacts of current livestock production, and developing environmentally compatible livestock systems.

Animal scientists in research and extension have to be involved in efforts that are broader in scope than the typical research or extension project that addresses only one narrow component of a potential production system. However, we must not totally abandon the individual projects, because the whole is still made up of a sum of the parts. More effort does have to be put on the system levels. One obvious goal is to develop and evaluate alternative methods of production for livestock producers. The other is to counteract the misinformation and criticisms of individuals or groups that attempt to create a negative public image of animal agriculture (Vavra et al., 1994).

I have already made the point that identifying change over time, either humanly induced or natural, is the greatest challenge to sustainability. Drought, flood, soil erosion, weed infestations, and other such confounding occurrences provide uncertainty and impose new constraints on production. Walters (1986) proposed systems of management of renewable natural resources that included uncertainty and change into a process of adaptive management. Application of his principles to livestock production seems appropriate to the development of long-term sustainable systems. Salwasser (1993) agreed, because everything in ecosystems constantly changes, physical substrates, climates, biota, and human technologies, incentives, and values. Long-term management of ecosystems must be adaptive rather than deterministic.

A major hurdle to redefining livestock production systems is the resistance to change. In most cases the only change visible is that which is intended to capitalize on new opportunities to serve or extend the status quo (Dovers and Handmer, 1993). The authors went on to say that this form of change was actively pursued but was a major impediment to developing a real, active change that might lead to sustainability. When real change is resisted sharp redirection is often difficult and is likely put off until it happens in a very painful way (Dover and Handmer 1993). Issues of animal welfare, manure disposal (Honeyman, 1994), and livestock grazing and salmon (this paper) serve as examples of painful change that in some cases are not yet perceived by livestock operators (Honeyman, 1994). Research and extension need to provide the leadership in developing alternative systems that provide for the broad view of sustainability suggested by Bormann et al. (1994) before we are painfully forced into it by restrictive legislation.

Livestock Production and Ecological Responsibility

In today's changing world a major question begs to be asked: Do livestock producers have a larger responsibility to protect natural ecosystems? For livestock producers in the West that use public lands this question has been answered by a portion of the public calling for the removal of livestock. Court actions against livestock grazing are becoming more commonplace (Sleeth, 1994). The land management agencies are responding by developing new approaches to management (BLM, 1990; Aldon et al., 1992; and Wood, 1994). New methods to evaluate rangeland health are being developed and put into use (Laycock, 1994; NRC, 1994).

Being proposed are new approaches and different objectives to managing private lands (Chaney et al., 1990, 1993). The benefits of private lands as wildlife habitat and watersheds, concerns over soil erosion and weed infestation, and potential sources of pollution are voiced for private lands (USDA - Soil Conservation Service, no date). A voluntary action plan that realized ecologic and economic benefits was also proposed by the SCS.

Private land livestock operators must address these issues or face restrictive legislation on federal and state levels that dictate standards of operation. During the 1993 session of the Oregon legislature, Senate Bill 400 sponsored by the Committee on Agriculture and Natural Resources was introduced. The bill was essentially a grazing practices act that dictated how private land could be grazed. The bill was defeated but will probably be reintroduced in the next session.

Leopold (1949) felt there was as yet (in 1949) no land ethic dealing with humans' relation to land and to the animals and plants that grow upon it. Land was still property and the land-relation was still strictly economic, entailing privileges but not obligations. According to Leopold, industrial landowners and users, especially lumber and stock producers, were inclined to wail long and loudly about the extension of government ownership and regulation of land. They showed little disposition to develop the only visible alternative: the voluntary practice of conservation on their own lands. Are we any different today? Do we have a "larger" obligation than just providing sustainable systems that allow continued production of a given kilograms of meat per hectare? Leopold (1949) went on to say that a system of conservation based solely on economic self-interest (kilograms of meat per hectare) is hopelessly lopsided. It tends to ignore, and thus eventually eliminate, many elements in the land community that lack commercial value but that are essential to its healthy functioning. It tends to relegate to the government many functions eventually too large, complex, or too widely dispersed to be performed by government. An ethical obligation on the part of the private landowner (in our case animal scientists and livestock producers) is the only visible remedy for these situations.

Implications

Are these issues that animal scientists should address, or at least aid in addressing? Are they the real issues of sustainable livestock production in the next century? I think they are, and I think we should. Animal scientists seem to agree. The Proposed Strategic Plan for the American Society of Animal Science has as a strategic direction, "Increase public understanding and awareness of the ongoing commitment of animal scientists to improving. . . the efficient, sustainable use of natural resources. . . ." A member poll conducted by ASAS revealed that a primary issue facing the field of animal science was environmental concerns about animal agriculture. Given, then, that animal agriculture should be environmentally sensitive and compatible, not just to sustainability of the land base, but in some cases to biotic communities, we should pursue the development of such systems. This does not mean abandonment of traditional research pathways, because they still play the important part of providing pieces to the whole. What is needed is the development of systems that provide alternatives to traditional livestock production. These systems should be team-developed to encompass efficient animal production, including economic evaluations, social acceptability, and ecological compatibility.

Literature Cited

Aldon, E., D. Ellis, D. McArthur, B. Partido, R. Ratliff, A. Tiedemann, D. Uresk, and A. Winward. 1992. Change on the Range: New Perspectives for Rangeland Research in the 90's. USDA, Forest Service, Forest Environment Research, Washington, DC.

BLM. 1990. State of the Public Rangelands 1990. USDI, BLM, Washington, DC.

Bishop, R. C. 1993. Economic efficiency, sustainability, and biodiversity. Ambio 22(2–3):69.

Bormann, B. T., M. H. Brookes, E. D. Ford, A. R. Kiester, C. D. Oliver, and J. F. Weigand. 1994. A Framework for Sustainable-Ecosystem Management. Gen. Tech. Rep. No. 331. USDA, PNW, Forest Service.

CAHA. 1993. Managing Transitions: Western Agricultural Colleges and Public Lands. A report of the CAHA Committee on public lands. Western Council of Administrative Heads of Colleges of Agriculture.

Chamberlain, D., and T. DelCurto. 1991. Use of Grass Seed Residues as a Winter Feed Resource. Eastern Oregon Agric. Res. Ctr. Circular of Information, 2.

Chaney, E., W. Elmore, and W. S. Platts. 1990. Livestock Grazing on Western Riparian Areas. Northwest Resource Information Center, Inc., Eagle, ID.

Chaney, E., W. Elmore, and W. S. Platts. 1993. Managing Change: Livestock Grazing on Western Riparian Areas. Northwest Resource Information Center, Inc., Eagle, ID.

Conner, M. C., and C. R. Richardson. 1987. Utilization of cotton plant residues by ruminants. J. Anim. Sci. 65:1131.

Darling, F. F. 1956. Man's ecological dominance through domesticated animals on wild lands. In: W. L. Thomas, Jr., C.O. Sauer, M. Bates and L. Mumford (Ed.). Man's Role in Changing the Face of the Earth. p 778. University of Chicago Press, Chicago, IL.

Dovers, R. S., and J. W. Handmer. 1993. Contradiction in sustainability. Environ. Conserv. 20(3)217.

Fuentes, E. R. 1993. Scientific research and sustainable development. Ecol. Appl. 3(4)576.

Heitschmidt, R. K., R. E. Short, and E. E. Grings. 1996. Ecosystems, sustainability, and animal agriculture. J. Anim. Sci. 74:1395.

Hilborn, R., and D. Ludwig. 1993. The limits of applied ecological research. Ecol. Appl. 3(4)550.

Holling, C. S. 1993. Investing in research for sustainability. Ecol. Appl. 3(4)552.

Honeyman, M. 1996. Sustainability issues of U.S. swine production. J. Anim. Sci. 74:1410.

Klopfenstein, T., L. Roth, S. F. Rivera, and M. Lewis. 1987. Corn residues in beef production systems. J. Anim. Sci. 65:1139.

Laycock, W. A. 1994. Implications of grazing vs. no grazing on today's rangelands. In: M. Vavra, W. A. Laycock, and R. D. Pieper (Ed.) Ecological Implications of Livestock Herbivory in the West. p 250. Society for Range Management, Denver, CO.

Lee, K. 1993. Greed, scale mismatch, and learning. Ecol. Appl. 3(4)560.

Leopold, A. 1949. A Sandy County Almanac. Oxford University Press, New York.

Lubchenko, J., A. O. Olson, L. B. Brubaker, S. R. Carpenter, J. M. Holland, S. P. Hubbell, S. A. Levin, J. A. MacMahon, P. A. Matson, J. M. Melillo, H. A. Mooney. C. H. Peterson, H. R. Pulliam, L. A. Real, P. J. Regel, and P. G. Risser. 1991. The sustainable biosphere initiative: an ecological research agenda. Ecology 72(2)371.

Ludwig, D. 1993. Environmental sustainability: Magic, science, and religion in natural resource management. Ecol. Appl. 3(4)555.

Ludwig, D., R. Hilborn, and C. Walters. 1993. Uncertainty, resource exploitation, and conservation: Lessons from history. Science, (Wash., DC) 260:36.

Males, J. R. 1987. Optimizing the utilization of cereal crop residues for beef cattle. J. Anim. Sci. 65:1124.

Malin, J. C. 1956. The grassland of north america: its occupance and the challenge of continuous reappraisals. In: W. L. Thomas, Jr., C. O. Sauer, M. Bates, and L. Mumford (Ed.). Man's Role in Changing the Face of the Earth. p 350. The University of Chicago Press, Chicago, IL.

Marston, E. 1993. Don't look for free inquiry at the West's land-grant colleges. High Country News. March 8, 1993.

Meyer, J. L., and G. S. Helfman. 1993. The ecological basis of sustainability. Eco. Appl. 3(4):569.

NRC. 1994. Rangeland Health. National Academy Press, Washington, DC.

Oltjen, J. W., and J. L. Beckett. 1996. Role of ruminant livestock in sustainable agricultural systems. J. Anim. Sci. 74:1406.

Salwasser, H. 1993. Sustainablility needs more than better science. Ecol. Appl. 3(4):587.

Sauer, C. O. 1956. The agency of man on the earth. In: W. L. Thomas, Jr., C. O. Sauer, M. Bates, and L. Mumford (Ed.). Man's Role in Changing the Face of the Earth. p 49. University of Chicago Press, Chicago, IL.

Sleeth, P. 1994. Court action forces pullout in eastern Oregon forests. In: Oregonian. August, 4, 1994. Portland, OR.

Thomas, W. L., Jr., C. O. Sauer, M. Bates, and L. Mumford (Ed.). 1956. Man's Role in Changing the Face of the Earth. University of Chicago Press, Chicago, IL.

USDA - Soil Conservation Service. No Date. A Grazing Lands Conservation Initiative for Private Grazing Lands. USDA, Washington, DC.

Vavra, M., W. A. Laycock, and R. D. Pieper. 1994. Ecological Implications of Livestock Herbivory in the West. Society for Range Management, Denver, CO.

Walters, C. 1986. Adaptive Management of Renewable Resources. Macmillan Publishing Co., New York.

Wilkinson, C. F. 1992. Crossing the Next Meridian. Island Press, Washington, DC.

Wood, C. A. 1994. Ecosystem Management: Achieving the New Land Ethic. Renewable Res. J. 12(1):6.