Sustainability and Resilience in Beef Cattle Systems

Jason E. Sawyer, M.S., Ph.D.

Chief Science Officer, East Foundation

Graduate Faculty, Texas A&M University, Dept. of Animal Science

Adjunct Professor, Texas A&M University – Kingsville, King Ranch® Institute for Ranch Management

Abstract

Sustainability and resilience are familiar terms, but are often poorly defined in the context of management. While managers have implicit incentive to achieve sustainability and resilience, it is not always apparent how to manage toward these objectives. Development of a systems orientation toward management may improve incorporation of these objectives. Recognizing that both are emergent, and not directly observable properties of complex systemssuggests that indicators that can inform decision making are important if operation-level management toward sustainability and resilience are to be achieved. A management framework that defines the purpose for ranch management, and characterizes this purpose with recognition of a timeframe, allows for development of indicators important for decision making. Desired attributes of indicators are described, and potential indicators of the likelihood of achieving sustainability and resilience in operating contexts are suggested. Managers are likely reliant on professional assistance in developing key indicators, especially related to social dimensions of sustainability which include animal well being.

Keywords: Indicator, systems management, ranch

Introduction

Sustainability has become a familiar term in society. The connotation is generally favorable, implying the continuance of a necessary or beneficial process or outcome. Conflict arises when alternate definitions are utilized, or when particular activities are deemed (justly or otherwise) as inherently ‘unsustainable’. In beef production, operators have incentive at several levels to develop sustainable systems. Managing for sustainability has inherent challenges. Management decisions must be informed by reliable information and have relevant indicators, but both information and indicators may be lacking or ill-defined.

Resilience, like sustainability, is perceived to be a desirable feature of a production system, particularly at the operational level. While most managers have an implicit understanding of resilience, its definition for management objectives is elusive and the relationships between management action and resilience may not be well characterized.

The objective of this article is to define and describe sustainability and resilience in a systems context, and better characterize these elements so that functional management frameworks can be developed. Managers can benefit from the participation of professionals and practitioners in the development of indicators and therefore management strategies toward sustainable and resilient operating systems.

Definitions

Particular definitions of sustainability have been promulgated widely[16, 14], and the notion of a tri-partite description of sustainability (applied really to development of emerging economies) was introduced[1] as an element of many of these definitions, creating the now familiar economic, environmental, and social domains often referenced. Importantly, many of these definitions have their genesis in a well-known systems dynamics modeling exercise[9], “Limits to Growth”, in which sustainability of global systems was predicted based on resource constraints that evolved over time in a dynamic system. Importantly, sustainability is an emergent property of a system. It cannot be observed instantaneously, but can only be observed post-hoc (as in ‘the system has persisted from a prior point until the present’) or predicted over future states. Measuring sustainability is fundamentally a forecasting problem[5]. This is a key challenge for operationalizing ‘sustainable actions’, but also offers insight into approaches for management - forecasting based on relevant indicators (or predictors) is essential for effective decision-making.

Strictly, 'sustainability' is a noun derivative of the verb 'sustain', to provide for existence or continuance, or to support persistence. As a noun, 'sustainability' is the ability, capacity, or property of performing these actions. In an effort to predict whether a system is 'sustainable', elements of the system or actions of adaptation might be evaluated based on their effects on the expected likelihood of sustaining various outputs in productive systems (such as food systems or beef production systems) over defined timeframes[12].

Resilience is also a property of a system, and like sustainability can be difficult to define in the context of management actions. Systems are described by their components (and by exclusion of components, their boundaries), and by the interactions and feedbacks among system elements over time that ultimately influence the rates of consumption of inputs, their regeneration or depletion rates, and rates of output[13]. Like sustainability, resilience is an emergent property of a system[2]. It is most often defined as the ability of a system to 'absorb' exogenous shocks and maintain or return to its functional state[15]. High resilience in a system does not imply that outputs are unchanging (a property that might be better defined as resistance), but that changes are reversed over some period of time to resemble prior output, or at least maintain some level of output (i.e., the system persists, albeit in a modified state of productivity).

As with sustainability, resilience is an intuitively beneficial property, but management to increase resilience lacks reliable information and indicators known to forecast its likelihood.

The need for assessment

Over the last 5 decades, substantial effort has been made to define, describe, and assess sustainability at multiple scales. While the particular drivers of interest in assessment have varied across time and among systems, the framework is typically large (global) and built around fear of collapse of sustaining systems for humanity. Driving scenarios can be loosely grouped into those with prominent environmental, social, or economic focal areas, recognizing the interrelatedness of these elements.

Environmentally focused efforts have often been at global or national scales, and include climate and climate change, environmental degradation, or resource depletion, all of which follow from the Limits to Growth archetype. Many proclaim systemic consumption of finite resources (e.g., the 'small planet' argument) that is predicted to lead to system collapse, orpoint to 'negative externalities' of particular subsystems (e.g., energy or food production) that impair system function and thus lead to failure. The source of impairment and particular types of failures predicted are often predicated on the structure of the model used. Social dimension assessments often focus on inequity among populations, exploitation, or other moral/ethical considerations; these often call for reformation or transformation of systems rather than claim overt structural failures. Economic assessments may, in some ways, be the most refined and seek to evaluate the structural integrity of economic systems, particularly the stability or resilience of these systems, which may be driven by or drivers of environmental or social system elements.

While these assessments can be valuable to identify areas of concern and seek solutions, they also often result in scapegoating or proposed solutions (e.g., 'don't produce energy or food') that may be reactive and themselves hasten system demise. Some of these outcomes have indirect or direct effects on the participants in productive systems; at the very least the public sentiment that can be driven by such assessments should be considered in the evaluation and management of individual operations or firms. Caution should always be used in these sorts of inferences, and where possible, based on observed behaviors rather than expressed sentiment. It is well documented that self-reported willingness to pay does not correspond with actual consumer behavior[10].

Critical assessment and development of refined predictors of sustainability and resilience remain important, but may still fail to effectively inform management actionor forecast sustainability. Often utilized approaches such as life-cycle analysis[11]can effectively describe and other metrics of interest to information consumers such as emissions intensity (i.e., carbon footprint), resource use intensity, or aggregate yield efficiency, but are difficult or impossible to translate to a management context. In some cases, these approaches have been used to compare systems across time[4], andhave provided insight about production metrics that may be beneficial to sustainability or resilience, often in conflict with the sentiment toward alternate systems.

Development of management frameworks

Managers have an implicit incentive to increase the likelihood of sustainability and improve operational resilience and adaptivity, although these objectives may or may not be well articulated. If a responsibility of management is the beneficial organization, control, and allocation of resources; and 'stewardship' is management for long term value, then the objectives of stewardship-oriented management are well aligned to the operating concept of sustainability described here. It is useful to recognize certain organizing principles to initialize the management framework:

- ***Sustainable systems*** consider the environmental (rangeland health, ecosystem services), economic (value, profitability), and social (human capital, community, consuming public) dimensions and consequences of decisions.
- ***The value of the ranch is a metric for stewardship and sustainability***. Good stewardship means increasing the long-term value of the asset over time, across generations.
    - Environmental: Improving [degrading] rangelands result in increasing [reduced] productivity and profitability, increasing [reducing] the long-term value of the ranch. Wildlife are valuable natural [environmental] assets, improvements and operations must consider impacts on wildlife to maximize long-term value.
    - Economic: The value of the ranch is the combination of its production value (livestock, primarily), extractive value (minerals, timber, etc.), amenity value (beauty, wildlife, hunting), and capital preservation and generation over time. Therefore, seeking to maximize long term value cannot be destructive, excessively consumptive, or without regard to the portfolio of features.
    - Social: Human capital provides the planning, control, decision-making, and labor to effect productive outcomes. Development and care of employees, partners, and communities result in more valuable ranches over the long run.
- ***The relationships among system components are complex***, and outcomes may lag decisions and are impacted by exogenous shocks. Part of good stewardship is to develop management strategies that acknowledge system relationships and are resilient to shocks.
- ***Better information leads to better decision quality.*** To work toward continuous value creation means to seek new, more complete, and more reliable information from which to make stewardship decisions and build more resilient, sustainable systems.
- ***The ranch [firm] is a laboratory for knowledge creation*** that allows more consistent progress toward the long-term goal of value creation. Not faster, but more consistent, with better

risk/reward profiles. Applying scientific principles inspires confidence in the knowledge gained, and allows more reliable application in the future. *Manage by experiment.*

With these concepts, management is oriented toward addressing complexity through systems thinking, has an embedded temporal frame, anappreciation of the implicit reliability of information derived through comparative observation, and recognition that management action is fundamentally the result of decision-making in multiple related dimensions. All of these are consistent with the objective of increasing the likelihood of persistence of the firm over time as a value creation vehicle, and theyimply the need for indicators that can drive effective decisions.

A framework for management and relevant metrics provide opportunities for strategy development and tracking outcomes. As such data are accumulated, especially when alternatives can be compared (management informed by experimentation), capacity for forecasting improves (recalling that sustainability estimation is largely a forecasting problem) and mechanisms of resilience can be identified (perhaps in the context of risk management or decisions under uncertainty).

Development of indicators

Within a systems framework, selection of relevant indicators for sustainability forecasting and resilience estimation can be challenging. In many sustainability reporting frameworks, ‘indicators’ are often overly general (not effective for informing decisions)or so numerous and difficult to measure that they cannot be implemented effectively or the cost of implementation cannot be recovered (see reporting frameworks such as the Global Reporting Initiative[7]. These reporting frameworks are geared toward external audiences, not to overtly or directly inform operational management.Desirable characteristics of sustainability indicators have been described[6]. These features provide useful guidance for development of operationally specific metrics. “Good” indicators should be: Practical, Sensitive to stressors, Unambiguous, Anticipatory, Predictive (i.e., related to the likelihood of sustainability), Estimable, and as a collection, sufficient for the purpose. An optimum suite of indicators might be the smallest number of individual metrics that meet these criteria.

*Economic viability.*Several resources exist that describe key performance indicators for ranching businesses[3, 8], and these types of indicators are often already familiar to managers. While well defined, many of these metrics have only occasionally been explicitly associated with sustainability or resilience[8] but may be among the most useful for these purposes at the firm level. Such metrics include measures of profitability, return on assets, unit costs, and measures of solvency and liquidity.

These metrics possess many of the desirable features of sustainability indicators. They are practical in the sense that they can be obtained through normal practices, although frankly many ranching operations have insufficient financial accounting practices and the selection of specific metrics may be limited by this practicality. They are sensitive to certain stressors in the system, although unless careful evaluation is conducted, the signal may substantially lag the initiating process. A key example is the generation of revenue from asset sales – if these capital gains and losses are not properly treated and separated from operating income, liquidation of the primary producing asset (the cow herd) can give a false signal of higher income ratios. However, after sufficient depletion, the inventory of assets available is depleted, reducing both production that generates revenue through product sales and capital gains income. This effect is observed when destocking occurs due to drought or disease outbreak. Indicators derived from accounting data are unambiguous, to the degree that the accounting structure is adequate and appropriate to the business.

Financial metrics are typically retrospective – they are based on events that have already occurred and been recorded, and so may lack an anticipatory feature. However, it is common for managers to make financial projections. These projected values are useful for anticipation of potential outcomes and serve as triggers for management action to offset those anticipated events. While such metrics may have to be projected forward to anticipate future events and drive action, many retrospective financial metrics are still “Predictive” of the likelihood of sustaining the system, as the current status of the business is itself a critical indicator of its likely future persistence. These metrics are also readily estimable, and even forecast values can be compared to actuals so that variances can be known and improved.

Financial indicators alone, however, are not sufficient for predicting overall enterprise sustainability. Without physical indicators related to productivity, resource use and regeneration, and inventory levels; and social indicators related to human capital, societal or regulatory assurance, or community relations; financial indicators alone may not have sufficient context for valid forecasting of sustainability in complex systems. At minimum, scaling variables are needed (as seen in some of the referenced KPIs) so that revenue per unit of output or unit costs of production can be evaluated. These are often more informative to management than the gross values. A set of tracked financial metricsinform the likelihood of the organization to persist (perhaps especially Return on Assets, in the long term[8], and also provide measures associated with resilience (solvency, often described by the Equity to Asset ratio) and liquidity (often described by the Current ratio). These provide an index of the capacity of the business to absorb shocks, often exogenous and uncontrollable by management.

*Environmental indicators.*While environmental indicators in many discussions of sustainability are global in nature (e.g., climate change) there are indicators at the operating level that are likely informative metrics for management. Obvious indicators here include exogenous drivers such as precipitation, and resource productivity measures such as forage growth or standing crop. Less obvious, but potentially important, are resource condition indicators such as plant species composition (biodiversity), bare ground or invasive plant cover, wildlife population density or size, and measures of rates of recovery from prior conditions or shocks (resilience).

Environmental indicators potentially useful for management that possess all of the desired features are less available than the economic indicators described. Many of these metrics are difficult to quantify, especially at large spatial scales, and the degree to which they are under the control of management is ambiguous. Development of technologies associated with automated data collection or remote sensing may improve access to these types of indicators at relatively low cost.

As with financial indicators, scaling variables for resource metrics are useful – forage production or standing crop *en masse* is difficult to interpret, but when scaled to livestock (and potentially wildlife) inventory, the ratio describes stock density; with the addition of a time variable this becomes stocking rate. Arguably, this is the most impactful operational decision made by managers, and it should be driven by these indicators.

Some measures may seem less practical and are also difficult to estimate, such as biodiversity. While there is some evidence that increased diversity increases system resilience, these relationships are not well quantified, and biodiversity may or may not be sensitive to shocks or management influence. Alternately, biodiversity may lend social credence and so may contribute to resilience through mitigation of reputational (social) or regulatory risks.

*Social indicators.*On the surface, indicators associated with the social dimension of sustainability are perhaps the most difficult to identify, and for some managers, to justify. In part this results from the relatively vague definitions for such indicators even at higher system levels, and the difficulty in measuring these factors. They are often ambiguous estimates of ‘consumer’ sentiment, or perception based on media reports which may be sensationalized. For management at the operational level, however, there are some accessible metrics that have many desirable features. Many are associated with human capital, and the management of business associates (including family shareholders in many cases), employees, and transactional partners.

These concepts may be more directly relatablebut are still difficult to quantify. Internal indicators such as employee retention and turnover may be useful indicators for management and are relevant to both continuance and resilience. The operation’s reputation with employees can stabilize the workforce – being a ‘good place to work’ attracts better applicants and reduces turnover, which further enhances reputation and stability.

External indicators in the social dimension often include metrics associated with animal welfare, and this is likely the most accessible to management and relates to economic metrics (through cost controls and productivity). However, operators may need assistance from professionals to fully develop these metrics to inform management action. Many current systems of welfare assessment require third party participation, and they rely on observed behavioral indices that operators may not perceive as relevant (allogrooming, for example). It is more likely that measures associated with health and well-being are perceived by managers as more relevant, predictive, and potentially responsive to management action.

Categories of assessment or indicator development might include prophylaxis and herd health plans of work, with additional quantitative metrics to assess efficacy and outcomes. Many operators already adhere to Beef Quality Assurance program guidance, and likely have a Veterinarian-Client-Patient in place. Additional development of metrics may be more appropriate in context of that relationship.

Antibiotic usage is another indicator often utilized at the sector or industry level but could potentially be translated to the operational level. This occurs regularly for margin operations but is under evaluated within cow-calf operations, typically due to low volume of use. Even so, usage metrics that are expressed with a scaling variable are important, as gross volume of usage without context can be misleading. In some settings, zero aggregate usage might be viewed as a goal, but in others, might be an indication of slow response and a negative indicator of welfare. Scaled metrics may also serve as complimentary indicators of efficacy of prophylaxis strategies.

Surveillance measures associated with animal health may also be useful predictors of large shocks to the system, and these could be enhanced with development of routine surveillance programs, depending on cost. Extensive operators often suffer from insidious and unrecognized losses. In situations where direct daily observation, particularly of young calves, is impossible, methods of population level disease surveillance might help to mitigate these chronic losses. These measureswould likely help to avoid catastrophic outbreaks when coupled with other metrics, including the synthesis of production outcomes with direct evaluation of animal well-being. Sources of endemic or environmental exposure could also be considered, and most operators would require consulting services to develop these programs. In many environments, risks and losses associated with reproductive disease are not well characterized, and these have substantial and long-lasting impacts on operations (i.e., most operations have low resilience to this particular shock).

Conclusion

If management seeks to generate long term value, then they are implicitly motivated to increase the likelihood of sustainability and resilience in their operations. Managing for these features is challenging, as they are both emergent properties of the system over time, and not directly observable. Using a systems-oriented management framework can aid operators and consulting professionals in developing a relevant suite of indicators that inform management decisions and increase the resilience of the operation, ultimately contributing to its sustainability.

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