Ranch-Level Economic Impact Analysis for Public Lands: A Guide to Methods, Issues, and Applications

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Abstract

Legal mandates require public land managers to consider social and economic impacts in planning efforts, and analysts seek models and tools for use in resource planning and impact assessment. In this paper we review state-of-the-art methods and models that can be used to evaluate ranch-level decisions and land-use policy impacts. Most ranch models use profit-maximization as the decision criterion, but it must be recognized that ranchers make decisions with personal objectives that are broader than just profit. Investments in rangeland improvement practices or management changes can be assessed using standard investment analysis (e.g., net present value, benefit/cost, or internal rate of return). Ranching is a year-round endeavor and changes in a specific season of grazing use or management activity may have greater impact on the whole ranch operation than can be accounted for by analyzing seasons or levels of grazing use in isolation. Impacts will vary with available forage alternatives, ranch resources, and management options. Current models use recursive linear programming or simulations to assess impacts over multiple years. Ranching and grazing on rangelands can affect the production of a variety of ecosystem services, though these are often not quantified or included in either investment analysis or economic models that describe ranch businesses. Because no formal markets exist for many ecosystem services, establishing a value has proven difficult. The few studies that have attempted to quantify ecosystem service values report said values without strong justification for the defined level of goods and services expected under alternative actions and policies.

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Key Points

▸ *Land managers, conservation groups and others should be apprised of potential economic impacts before instituting management plans on rangelands.*

▸ *Three basic methods can be used to determine if proposed management changes or improvement practices will pay off: Benefit/Cost ratio, Internal Rate of Return, and Net Present Value.*

▸ *Challenges to effective economic analysis of rangeland and livestock management options include the general lack of available livestock cost and return information to predict adjustments that a typical livestock producer will make in response to a policy change; and, knowing the biophysical and ecological responses from such changes.*

▸ *The impacts of reducing or eliminating grazing during selected seasons will depend on ranch resources and the substitute forage alternatives that are economically and physically available.*

▸ *The most fundamental challenge for valuing ecosystem services is an adequate description and assessment of the linkages between the structure and function of natural systems and the goods and services derived under alternative actions.*

Introduction

Economic impacts of management plans are important considerations for managers of natural resources. Whether the resource manager is caring for public, private or mixed ownership parcels, the impacts on financial conditions of rural America should be estimated and used in the decision-making process. In fact, economic impact assessments are as important to decision-making as factors like forage production, threatened or endangered species, erosion and other resource concerns. Federal and state land managers, private landowners, conservation groups and others should be apprised of anticipated economic and social impacts before

implementing critical management plans on the nation's rangelands.

Legal mandates for public land managers to consider social and economic impacts in planning efforts, coupled with their own limited social science staff, have motivated land management agencies to seek models and tools for use in resource planning and assessment. Agencies including the Bureau of Land Management (BLM) and the US Forest Service (USFS) seek tools for estimating economic impacts of grazing plans and other resource management decisions. The level of analysis ranges from calculating the economic impacts of proposed changes at the Resource Management Plan level to evaluation of grazing plans in the permit renewal process. The National Environmental Policy Act (NEPA) of 1969 (PL 91-190, as amended) directs public land managers to specify and consider economic and social impacts concurrently with the environmental impacts of their decisions. The Act also established the President's Council on Environmental Quality (CEQ), which in turn, created policy guidelines related to the process and analysis included in Environmental Impact Statements (Protecting the Environment, 2007).

This document summarizes a process for developing economic impact assessments for western public and private rangelands. We summarize relevant applied research and list sources of information related to ranch-level economic assessments. Taylor et al. (2014) provide a similar summary and discussion for social impact assessments and for community and regional economic assessments. Both papers provide recommendations on approaches for gathering and analyzing the critical economic and social impacts required by NEPA.

Ranch Investment and Impact Analysis

Ranchers and agency land managers often want to know if a change in management or an investment in a rangeland practice is going to pay for itself. There are three common methods used to make this determination and all require the same basic information: the Benefit/Cost ratio, Internal Rate of Return, and Net Present Value. For each method, one must know the initial investment cost, the annual

operation and maintenance costs, the expected annual benefits, expected project life, and a discount rate to account for differences in timing between benefits and costs.

Providing an estimate of the expected benefits is perhaps the most challenging part of a rangeland investment analysis. Traditionally, economic evaluations of range improvements focused on the value of additional livestock grazing capacity and livestock production that could be achieved by implementing the improvement (Workman 1986). However, other reasons for implementing range improvements, such as those aimed simply at good range management, have tacitly justified at least part of the cost of range improvement practices and government subsidies for those practices. Improving range condition, rangeland health, and promoting watershed and wildlife benefits are now the motivating reasons why government agencies spend money on range improvements (Briske 2011). As discussed in greater detail below, placing an economic value on these ecosystem services creates new challenges for benefit estimation because adequate definition of key linkages about the structure and function of rangeland systems is limiting, and non-market economic valuation procedures must be used (Torell et al. 2013).

If you make an investment in range improvements like water developments, fencing, seeding, brush control, or even a management change, there will usually be an initial expenditure for materials and labor. In an economic analysis, these are considered to occur in time 0 (today). Many of these types of investments will also incur annual operating and maintenance costs – things like power to run a pump, fence repair, and other periodic expenses.

When making long-term investments, one expects to realize economic benefits in the future. These could be more animal unit months (AUMs) of grazing, improved animal performance, and/or reduced costs. Benefits may not be the same every year of the project. For example, if you do a brush control project, you expect more grass to eventually grow, for it to reach a peak in some future year, and then for it to slowly decline as brush re-establishes in the project area.

The discount rate is the factor used to recognize the time value of money. It basically states that a dollar received or spent in the future is not the same as a dollar received or spent today. It is only through the process of discounting that one can make valid comparisons of the costs and benefits of a proposed action. The discount rate used in most economic analyses of these types would be a risk- and inflation-free long-term rate such as what one would expect on a long-term treasury bond. An economic analysis can consider a range of discount rates to see if the decision is sensitive to the discount factor.

 As Workman and Tanaka (1991) argued, the **Net Present Value** (NPV) method provides the best answer for decision-making.

NPV = Initial Investment + $\sum$((Annual Benefits$_n$ – Annual Costs$_n$) * (1-discount rate)$^{-n}$)

The NPV equation describes the initial investment (a negative value) at time zero (today) and adds the sum of annual net benefits that have been discounted back to today's dollars. The result is the estimate of NPV. Note that this estimate does not necessarily identify the profit-maximizing alternative, just those alternatives that are financially feasible. If the calculated NPV is positive it is considered a feasible investment alternative. When funds are limited, a combination of feasible alternatives can be selected that would maximize the overall NPV of the selected investment alternatives and this is the major benefit of the NPV method of investment analysis.

The **Benefit/Cost** (B/C) ratio is used by most federal agencies. Ideally, it captures all the social benefits and costs of each alternative. In actual use, it uses the same data as used in the NPV since we are not able to value all of the ecosystem services that could potentially be part of the calculations. In this case, we calculate the sum of the present value of future benefits and divide by the initial investment plus the sum of the present value of future costs. The result is expressed as a ratio. The decision rule is that if the B/C ratio is greater than 1.0, the project will be economically feasible.

The **Internal Rate of Return** (IRR) is a little different in that a discount rate is not specified. In this case, a discount rate that will make the present value of benefits equal to the present value of costs is sought.

Or, the IRR is the interest rate that will bring a series of cash flows (positive and negative) to a NPV of zero (Workman 1986). The calculated rate can then be compared to whatever a rate of return needs to be for an individual to consider this a sound investment. If the calculated IRR is more than the desired rate of return, then it would be a feasible alternative. If it is necessary to borrow funds for the project, the IRR can be compared to the interest rate on borrowed capital. Once the cost of capital hurdle has been cleared, the project with the highest IRR would be the wiser investment, all other things being equal (including risk). One of the disadvantages of using IRR is that all cash flows are assumed to be reinvested at the same discount rate and this may or may not be true. This makes comparison of projects of different lengths problematic.

None of these investment analysis methods will ensure that profit is maximized. These investment tools only provide an indication that the investment or management change will be financially feasible. The methods described in the next section describe how to find profit-maximizing solutions. The final thing to keep in mind is that past research has indicated that very few rangeland improvement practice investments or management changes are financially feasible for the average or typical ranch operation (Tanaka et al., 2011).

Numerous resources are available for assistance and guidance in conducting an investment analysis and in using standard investment analysis tools. These tools are discussed in all basic and advanced financial management textbooks. For federal program assessments, the Office of Management and Budget circular A-94 provides guidance for conducting benefit-cost and cost-effectiveness analyses (OMB 1992). It also provides specific guidance on the discount rates to be used in evaluating federal programs whose benefits and costs are distributed over time.

Ranch-Level Policy Impact Analysis and Models

Analyzing the potential impacts of land-use policy changes to livestock producers requires definition of the current production situation and an estimate of how impacted individuals will likely adjust to a

proposed policy change. The basic tools of analysis have included enterprise budgets, simulation, and optimization (profit-maximizing) models. In all cases, the analysis starts with producer-provided information to describe economic, production and resource characteristics for representative ranches in the study area. These representative ranches are typically categorized by size and type of livestock, season of grazing use, and other criteria like level of federal land dependency. Many "representative" ranch models could be defined for an area but in most cases a limited number of models and budgets are used. If further analysis of regional impacts is to be considered, the estimated ranch-level impacts are aggregated to total impacts based on the number of ranches or livestock supposedly described by each representative ranch model.

Ranch Enterprise Budgets

Basic ranch budget information describing the characteristics, resources and seasonality of resource use for a typical ranch is crucial to the analysis. Availability of this basic cost and return data is perhaps the most limiting information required for impact assessment studies. A limited number of university cost and return studies provide the basis for many impact assessment studies (see for example, Teegerstrom & Tronstad, 2000; Gray et al., 2012). Another source of livestock cost and return information is the USDA Economic Resource Service (USDA-ERS, 2011). Cost and return data are generally gathered from livestock producers using procedures similar to those described by Richardson and Nixon (2012) as they reference defining and updating the Farm Level Income and Policy Simulation Model (FLIPSIM) that has been widely used in federal policy and farm program impact analysis. As described, producers that are representative of operations in the area are identified by a local facilitator, often a county Extension agent. Producers are asked to build a typical farm or ranch drawing from their personal operations and experiences. Key factors like herd size, production rates (e.g., sale weights, calf crop, hay yields, rangeland productivity), available forage and crop resources, expenses by enterprise and by expense category (e.g., fuel, labor, raised and purchased feed), and investment levels are identified.

In addition to a general lack of available livestock cost and return information that is appropriate for resource area specific or even state specific analysis, a second challenge in the impact assessment is predicting the adjustments that the typical livestock producer will make because of a proposed policy change. Consider as an example a policy to increase public land grazing fees, a controversial proposal that has been debated numerous times. If it is assumed that public land ranchers will merely pay the higher fee the impact analysis is simple: multiply the quantity of federal AUMs used by the change in the fee rate. If, however, demand for federal grazing is price sensitive at the proposed fee rate, the analysis is much more complicated as producers will at some point reduce federal grazing use, reduce herd size and/or substitute alternative forages. Profit maximization has been widely used as the criteria upon which production adjustments are assumed to be made and evaluated. Ranchers are assumed to adjust production strategies with the profit objective in mind. Linear programming (LP) models that maximize profit subject to resource constraints for a representative ranch have been widely used for impact assessment. A base run provides a benchmark against which alternative policy scenarios are compared.

Ranch-level Economic Models

Many of the initial profit-maximizing LP models used for ranch impact analysis were single-year models where profit was maximized over one year (Olson & Jackson, 1975; Torell et al., 1981; Wilson et al., 1985). More recent applications have been multi-period recursive models where information about debt, herd inventories by animal class, family living expenses and off-ranch income in the previous year (t-1) is used as input to calculate values for the current year (t). One model developed by the authors as a part of regional research efforts has been widely used for policy impact analysis (Torell et al., 2002; Rimbey et al., 2003; Taylor et al., 2004; Taylor et al., 2005). The general structure of the multi-period LP model is shown in Figure 1.

This model is ultimately constrained by available land (i.e., forage) and cash with numerous equations to transfer animals, forage and cash among years and seasons. In this application, variable seasonal and annual forage supply and demand may be explicitly considered. The NPV of discounted net returns is maximized over a T-year planning horizon subject to constraints that define resource limitations, resource transfers between years, and production characteristics. Seasonal forage supply and demand within a particular year is explicitly considered to recognize that certain forage sources may be restricted in use to only selected seasons, because of regulation, physical availability or production limitations. The importance of the model structure for impact assessment is recognition that in addition to access to forage, a policy change may also alter the length and timing of allowed grazing use. Policy impact assessments can be handled in the model by changing the allowed seasonal use, resource availability, and cost definitions.

Figure 1 -Policy analysis LP model structure (from Torell et al., 2002). Maximize Net Present Value NPV of discounted profit = Livestock Sales + Crop Sales – Expenses.

Profit Maximization: A Critical Assumption

It is widely recognized that western ranchers do not have profit maximization as the primary goal of their ranching enterprises. Instead, desired recreational opportunities, the rural lifestyle and agrarian values are the primary motives for ranch ownership (Torell et al., 2001; Gentner & Tanaka, 2002; Gosnell et al., 2006). Pasture and rangeland values have been significantly inflated by many factors not related to livestock production (Rimbey et al., 2007; Doye & Brorsen, 2011; Torell et al., 2012). As noted by Van Tassell and Richardson (1998), western public land ranchers will, for the most part, continue to ranch until forced to do something else. How then, is the profit maximization objective justified in impact assessments? The utility-maximization model that ranchers subscribe to is impossible to measure and quantify. Individual ranchers and ranch families have differing levels of commitment to the ranching lifestyle and decreasing annual ranch income through altered land-use policies can be expected to dampen enthusiasm for ranching to widely varying degrees. It will not be possible to accurately predict how many ranchers a particular land-use policy will force out of business, yet it is a question often asked.

The profit-maximizing objective provides a measurable criterion against which to judge policy changes[6]. It is tempered by considering only investment alternatives related to ranching and livestock production, and by including cash flow restrictions. The LP model determines the optimal production strategy with the current policy prescription and how optimal production changes with a new policy. The implicit assumption is that ranch families will continue to consider only the limited investment opportunities associated with the ranch property; they prefer more money to less and will continue to ranch until cash flow restrictions can no longer be met and they are forced, or decide, to leave the
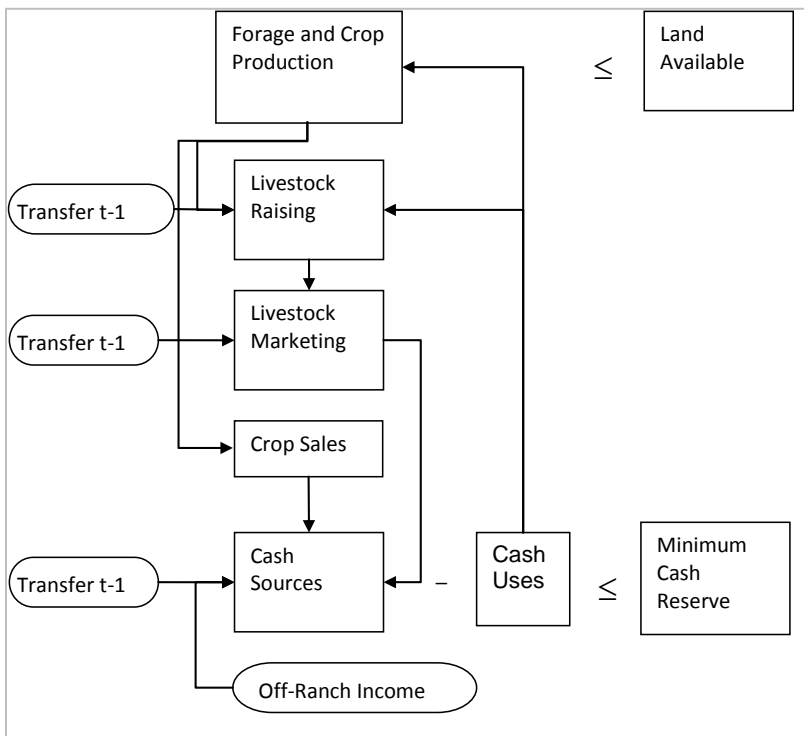
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[6]An alternative, as used with simulation models such as FLIPSIM, is to use feedback from livestock producers and professional judgment of the analyst as to how livestock producers would adjust to altered land use policies.

business.

Livestock Price Scenarios

One of the decisions to be made is the appropriate livestock prices to consider in an analysis. A common strategy is to use inflation-adjusted, average, or projected prices with potential alternative levels also considered. An alternative a stochastic process where price trends, cycles, price distributions, and price correlations between animal classes are considered and the impact models are run numerous times at different price levels. Average impacts are tabulated across the numerous price scenarios (Torell et al., 2002). Other factors like crop yield and livestock production rates that are influenced by precipitation and other variables can also be stochastic inputs to the impact assessment (Richardson & Nixon, 2012).

FLIPSIM and the LP model detailed in Figure 1 represent current state-of-the-art analysis tools for ranch-level impact assessment. In many cases, this modeling effort will be beyond the capabilities, budgets, and time allotted for the analysis. Simpler budgeting procedures can be, and have been, used but the analysis still starts with data describing economic, production and resource characteristics for representative ranches in the study area (Tanaka et al., 1987). The general lack of detailed cost and return data is a limitation regardless of the assessment tool used. Using budgeting tools, revenues, expenses, and net returns under current policies are compared to similar budgets defined under a policy of interest. Without the profit-maximizing criteria to determine optimal adjustment strategies, the analyst must use judgment to determine which production and marketing strategies will likely be followed with the altered policy.

Forage Input Costs

Many times a policy assessment requires an estimate of forage value, as when public land forage is proposed for re-allocation to alternative uses or to protect other resource values. Bartlett et al. (2002) provided a detailed description of how forage can be valued and the interested reader is referred to this paper for a more complete description and discussion. As described, valuing forage for livestock production has strong ties to profit-maximization, suggesting use of the profit-maximizing models

described above. If the forage market is efficient, it also suggests a comparison to the private forage market, and in fact, comparison to the private market has been the primary way of valuing public land forage. The comparison is based on the opportunity-cost concept, whereby a profit-maximizing lessee of forage will not pay in excess of the amount that must be paid for the next-best alternative. If private and public forage are perfect substitutes, economically motivated ranchers should be willing to pay equal amounts for the two sources of forage. Because of policies governing the issuance and regulation of public grazing permits, there is no market competition to determine public forage value. Consequently, it has generally been accepted that the fair market value of public land forage would have to be estimated indirectly by comparison to the private forage market after appropriately adjusting for landowner-provided services and lease characteristics on private leases that are not provided by the public land agencies (Bartlett et al., 2002). Non-fee grazing costs on public lands are substantially higher as compared to private land leases. Based on indexing values from a 1993 grazing cost comparison conducted in Idaho, Wyoming and New Mexico, Rimbey and Torell (2011) estimated that in 2010, public land ranchers paid a total cost including both fee and non-fee expenses of $35/AUM as compared $32/AUM for private land leases.

Attempts have been made to statistically determine how private land lease rates vary when selected landlord-provided services are included with the lease (e.g., periodic checking of water and livestock, supplemental feeding, maintenance of improvements and facilities). These studies (Rimbey et al., 1992; LaFrance & Watts, 1995; Bartlett et al., 2002; Bioeconomics Inc., 2011) have consistently found the service value component of private land grazing leases to comprise about 30% of the average lease price reported by USDA-National Agricultural Statistics Service (USDA-NASS, 2012). This 30% rule-of-thumb has been widely used to adjust NASS-reported lease rates to a payment for grass-only leases in range improvement economic studies (Bastian et al., 1995; Torell et al., 2005), ranchland valuation studies (Rimbey et al., 2007; Torell et al., 2012), and as an adjustment in estimating the market value of public and state trust land grazing fees (Torell et al., 1990;

Rimbey et al., 1992; LaFrance & Watts, 1995; Bioeconomics Inc., 2011).

Forage values implied by comparison to the private grazing market can be estimated down to the state level, as USDA-NASS (2012) reports private grazing lease rates annually on both a $/head and $/AUM basis for each of the western states. The NASS lease rate data is the only consistently reported information available for the western states. Limitations of the data include concern about potential range quality differences between private and public land leases, a small sample size for each state, and the hearsay factor, as survey respondents are asked to recall or speculate on lease rates in the area (Brokken & McCarl, 1987; Torell et al., 2003).

The average forage value estimated from NASS data will also not recognize or consider seasonal differences in value. As noted by Torell et al. (2002), if a ranch is seasonally dependent on federal forage, as is typically the case for many western ranches in northern climates, a reduction in federal AUMs can create forage imbalances and produce a greater reduction in grazing capacity than just the loss of federal AUMs. Seasons with limited forage availability (typically winter and spring) have the highest forage value and using hay price (the next best alternative) may be a better alternative when seasonality of forage use is important. However, the impact(s) of eliminating or reducing grazing during selected seasons will depend on ranch resources and the substitute forage alternatives that are economically and physically available. Simulation and linear programming models, as described above, that recognize seasonal forage uses and alternatives are the best evaluation tool when seasonality is important.

Valuing Ecosystem Services

Recently there has been an increasing emphasis placed on valuing ecosystem services. Textbooks describe how this might be done with many examples from aquatic systems (Champ et al., 2003; NRC, 2005; Barbier, 2007). For rangeland systems, failure to include a measure of the benefits of range improvements and resource decisions beyond livestock production implicitly assigns a value of zero to those outputs in the traditional economic assessment. Recognizing

this, there has been an increased awareness for the need to value alternative outputs in land management planning efforts. Many of the issues addressed by land management agencies are now related to enhancing and protecting threatened and endangered species, providing wildlife habitat, improving degraded rangelands and watersheds, reducing the threat of fires, and enhancing numerous other ecosystem services that society values (Torell et al., 2013). For example, in the Owyhee area of Idaho, factors such as Wild and Scenic Rivers, wilderness designation, water quality, and restoration of western juniper (*Juniperus occidentalis*) invaded sagebrush rangelands are all examples of ecosystem services that should be considered in an assessment of the ecological, economic, and social assessment.

As noted by Taylor and Rollins (2012), despite a growing recognition of the need for placing an economic value on the ecosystem services provided from rangelands, there is a perception among scientists and public land decision makers that economic theory and methods are not capable of providing accurate, timely and policy-relevant estimates of the values associated with ecosystem change for informed decisions. Taylor and Rollins (2012) dismissed this pessimistic view and suggested there are steps that can be taken to counter criticisms about attempting to place an economic value on the ecosystem services provided on both public and private lands. Loomis (2012) similarly dismissed the notion that economists are not up to the task and details ways to integrate non-market values into land management decision making. While we agree that resource economists can provide site-specific valuations of rangeland ecosystem services, we believe there are major obstacles that will result in questionable reliability of those estimates at various levels. Most notably, suggested valuation procedures require a reliance on the Contingent Valuation Method (CVM) with its many noted shortcomings (Hausman 2012). The weaknesses of CVM include an extrapolation of study results using benefits transfer and reliance on rangeland state-and-transition models to measure ecosystem differences between management alternatives. The linkages required to value rangeland ecosystem services are poorly defined and care must be taken to

not extrapolate value estimates beyond an appropriate area of applicability.

The most fundamental challenge for valuing ecosystem services is an adequate description and assessment of the linkages between the structure and function of natural systems and the goods and services derived under alternative actions (NRC, 2005). Several scientists from different disciplines suggest the ecological site and state-and-transition modeling (STM) framework has promise for providing the necessary linkage detail needed to measure rangeland ecosystem provisioning under alternative management actions (Bestelmeyer & Brown, 2010; Herrick et al., 2010; Bestelmeyer et al., 2011; Taylor & Rollins, 2012). As Brown and MacLeod (2011) noted, the STM framework is a soil/vegetation-based system in which similar climate, geomorphology, and soil properties are grouped into ecological sites based on their response to disturbance. Within each ecological site, a unique state-and-transition model describes the dynamics of vegetation and soil properties, and provides indicators of the vegetation structure and soil properties. Alternative management actions potentially prompt changes among states. Because the ecological model is soil/vegetation-based, provisioning of different types of ecosystem services can be predicted if there is a defined and predictable linkage to soil and vegetation characteristics.

While soil and vegetative conditions link directly to livestock grazing output potential and the benefits from vegetation management practices, estimating the complex linkage from the altered soil and vegetation conditions to provisioning of wildlife habitat, watershed health, wilderness, and other rangeland outputs is complex and largely undefined. An assessment of Natural Resource Conservation Service (NRCS) rangeland conservation efforts indicated that it was not possible to determine the magnitude or trend of conservation benefits originating from NRCS conservation investments because of the paucity of information documenting benefits (Briske, 2011). Furthermore, the benefits of conservation practices are seldom quantified and lack consistent measurement (Briske, 2011).

A proposed ecosystem valuation procedure suggested in the works of Loomis (2012) and Taylor

and Rollins (2012) would use benefit transfer (which uses economic values and other information) from a "study site" where data is collected to a "policy site" with little or no data. A site-to-site transfer function would be defined that considers the spatial, temporal, and ecological details specific to the target ecosystem (Taylor & Rollins, 2012). Meta-analysis equations have also been used to tailor the benefit transfer to a specific study site (Loomis et al., 2012). The biggest problem we see for benefit transfer application for ecosystem valuation on rangelands is the limited number of studies from which to extrapolate and project response differences. As noted by Briske (2011), conservation practices have seldom been monitored across spatial areas (even within the same ecological site) and through time as needed to adequately assess conservation practice outcomes.

The Sustainable Rangeland Roundtable developed a framework to assess rangeland sustainability that compares the expected direction of change resulting from alternative rangeland uses (Fox et al., 2009; Kreuter et al., 2012). In this framework, ecosystem services are the nexus between the biophysical world and the social and economic systems that utilize it. Indicators of social, economic, and ecological sustainability are monitored over time and impacts are assessed by the decision- and/or policy-maker. Assessment is more related to direction of change, tradeoffs, and expected strength of change rather than applying values and conducting economic efficiency analyses. Relationships among indicators remain a missing link even in this framework. It is left to the decision- and/or policy-maker to determine whether the direction of change is "good or bad." We argue that in most cases this is the best that can reliably be done given the current state of knowledge about the critical linkages required for rangeland ecosystem valuation. We are far from being able to estimate the levels of goods and services provided under alternative rangeland management actions, to extrapolate those value estimates across the western public lands, or to use those values to evaluate trade-offs in management and policy decisions at this stage of development.

Opportunities for Management and Research

Assessments of the economic benefits, costs and social impacts of management decisions and policy changes are critical to rangeland managers and users. A major challenge in applying ranch-level economic evaluations is a general lack of available livestock cost, return, and production information that is appropriate for a specific ranching area and policy analysis. Understanding trade-offs, likely production changes, changes in ecosystem services, and predicting the adjustments a typical livestock producer will make in light of a proposed land-use change are additional requirements. Economic evaluations use profit maximization as a goal even though it is widely recognized that western ranchers do not have profit as their primary objective. Finally, ranching is a yearlong activity and changes in one season or one management activity may have greater impact on the whole ranch operation than if only analyzed in isolation. This cumulative effect should be included in an effective economic analysis and will vary with forage substitutes, available ranch resources, and management options. Managers need to evaluate the economic impacts of proposed policy and management changes in order to understand how ranching operations are going to be affected. In addition, understanding the public and private land implications and interactions from those changes will be important for understanding societal impacts.

Rangelands are valued for many ecological services beyond providing forage for livestock and wildlife. It is often perceived that economic theory and analytic approaches are not able to provide accurate, timely and policy-relevant estimates of the values associated with ecosystem change in response to proposed land-use decisions. There are, however, methods and approaches that can be used to integrate non-market values into land management decisions and provide site-specific valuations of rangeland ecosystem services. The most fundamental challenge for valuing ecosystem services is an adequate description and assessment of the linkages between the structure and function of natural systems and the goods and services derived under alternative actions. Development and understanding of ecological sites and state-and-transition models may provide a framework that can be used to evaluate ecological services in dynamic settings.

Research is critically needed to quantify production impacts from management changes and the relationships between the structure and function of rangeland systems and the goods and services derived under alternative actions. Research is also needed to define explicit ranch models that can address local conditions and specific policy and management changes.

Acknowledgments

Literature Cited

Barbier, E. B. (2007). Valuing ecosystem services as productive inputs. *Economic Policy, 22*(49), 177-229. doi:10.1111/j.1468-0327.2007.00174.x

Bartlett, E. T., Torell, L. A., Rimbey, N. R., Van Tassell, L. W., & McCollum, D. W. (2002). Valuing grazing use on public land. *Journal of Range Management, 55*(5), 426-438. doi:10.2307/4003220

Bastian, C. T., Jacobs, J. J., & Smith, M. A. (1995). How much sagebrush is too much: An economic threshold analysis. *Journal of Range Management, 48*(1), 73-80. doi:10.2307/4002508

Bestelmeyer, B. T., & Brown, J. R. (2010). An introduction to the special issue on ecological sites. *Rangelands, 32*(6), 3. doi:10.2111/rangelands-d-10-00088.1

Bestelmeyer, B. T., Brown, J. R., Fuhlendorf, S. D., Fults, G. A., & Wu, X. B. (2011). A landscape approach to rangeland conservation programs. In D. D. Briske (Ed.), *Conservation benefits of rangeland practices: Assessment, recommendations, and knowledge gaps* (pp. 337-370). Washington, DC, USA: USDA, Natural Resource Conservation Service.

Bioeconomics Inc. (2011). *Montana trust land grazing lease rate valuation analysis*. Missoula, MT, USA: Bioeconomics, Inc.

Briske, D. D. (2011). *Conservation benefits of rangeland practices: Assessment, recommendations, and knowledge gaps*. Washington, DC, USA: USDA, Natural Resource Conservation Service. Retrieved from: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/ceap/ ?&cid=stelprdb1045811

Brokken, R. F., & McCarl, B. A. (1987). *A theoretical evaluation of fee systems for private grazing on Federal lands* (Economic Report No. 570). Washington, DC, USA : U.S. Dept. of Agriculture, Economic Research Service.

Brown, J., & MacLeod, N. (2011). A site-based approach to delivering rangeland ecosystem services. *The Rangeland Journal, 33*(2), 99-108. doi:10.1071/RJ11006

Champ, P. A., Boyle, K. J., & Brown, T. C. (2003). *A primer on nonmarket valuation*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Doye, D., & Brorsen, B. W. (2011). Pasture Land Values: A" Green Acres" Effect?. *Choices. The Magazine of Food, Farm and Resource Issues, 26*(2), 14-19.

Fox, W. E., McCollum, D. W., Mitchell, J. E., Swanson, L. E., Kreuter, U. P., Tanaka, J. A., Evans, G. R., Heintz, H. T., Breckenridge, R. P., & Geissler, P. H. (2009). An integrated social, economic, and ecologic conceptual (ISEEC) framework for considering rangeland sustainability. *Society and Natural Resources, 22*(7), 593-606. doi:10.1080/08941920802247894

Gentner, B. J., & Tanaka, J. A. (2002). Classifying federal public land grazing permittees. *Journal of Range Management, 55*(1), 2-11. doi:10.2307/4003256

Gosnell, H., Haggerty, J. H., & Travis, W. R. (2006). Ranchland ownership change in the Greater Yellowstone Ecosystem, 1990–2001: Implications for conservation. *Society and Natural Resources, 19*(8), 743-758. doi:10.1080/08941920600801181

Gray, W. C., Painter, K., & Rimbey, N. R. (2012). Livestock budgets. *Costs of production >> Idaho AgBiz*. Retrieved from: http://web.cals.uidaho.edu/idahoagbiz/enterprise-budgets/.

Hausman, J. (2012). Contingent valuation: from dubious to hopeless. *The Journal of Economic Perspectives.* 26:43-56. doi: 10.1257/jep.26.4.43

Herrick, J. E., Lessard, V. C., Spaeth, K. E., Shaver, P. L., Dayton, R. S., Pyke, D. A., Jolley, J., & Goebel, J. J. (2010). National ecosystem assessments supported by scientific and local knowledge. *Frontiers in Ecology and the Environment, 8*(8), 403-408. doi:10.1890/100017

Kreuter, U. P., Fox, W. E., Tanaka, J. A., Maczko, K. A., McCollum, D. W., Mitchell, J. E., Duke, C. S. & Hidinger, L. (2012). Framework for comparing ecosystem impacts of developing unconventional energy resources on western US rangelands. *Rangeland Ecology and Management, 65*(5), 433-443. doi:10.2111/REM-D-11-00190.1

LaFrance, J. T., & Watts, M. J. (1995). Public Grazing in the West and "Rangeland Reform'94". *American Journal of Agricultural Economics, 77*(3), 447-461. doi:10.2307/1243215

Loomis, J. (2012). Ways to make stated preference methods more valuable to public land managers. *Western Economics Forum, 11*(1), 22-29.

Loomis, J., Kroeger, T., Richardson, L., & Casey, F. (2012). The benefit transfer and use estimating model toolkit. *Agricultural and Resource Economics – Colorado State University*. Retrieved from http://dare.agsci.colostate.edu/outreach/tools/

NRC [National Research Council]. (2005). *Valuing ecosystem services: Toward better environmental decision-making*. Washington, DC, USA: National Academies Press.

Olson, C. E., & Jackson, J. W. (1975). The impact of change in Federal grazing policies on south central Wyoming mountain valley cattle ranches (Vol. 96). Laramie, WY, USA: Agricultural Experiment Station, University of Wyoming.

OMB [Office of Management and Budget]. (1992). Guidelines and discount rates for benefit-cost analysis of federal programs (Circular No. A-94 Revised). Washington, DC, USA: Executive Office of the President, Office of Management and Budget. Retrieved from: www.whitehouse.gov/omb/circulars_a094

Protecting the Environment, 40 C.F.R. § 1507 (2007). Chapter V - Council On Environmental Quality (Parts 1500 - 1518). Retrieved from: www.gpo.gov/fdsys/pkg/CFR-2007-title40-vol31/pdf/CFR-2007-title40-vol31-chapV.pdf

Richardson, J., & Nixon, C. (2012). Description of FLIPSIM: The farm level income and policy simulation model. *The Agricultural and Food Policy Center*. Retrieved from: www.afpc.tamu.edu/models/flipsim/

Rimbey, N., & Torell, L. A. (2011). *Grazing costs: What's the current situation?* (Report No. 2011-02). Moscow, ID, USA: University of Idaho, University of Idaho, Department of Agricultural Economics and Rural Sociology, Agricultural Economic Extension Series.

Rimbey, N. R., Krebill-Prather, R., & Carlson, J. E. (1992). *Range and pasture forage: What's it worth?* (Report No. 92-3). Moscow, ID, USA: University of Idaho, Department of Agricultural Economics and Rural Sociology, Agricultural Economic Extension Series.

Rimbey, N. R., Darden, T. D., Torell, L. A., Tanaka, J. A., Van Tassell, L. W., & Wulfhorst, J. D. (2003). *Ranch level economic impacts of public land grazing policy alternatives in the Bruneau Resource Area of Owyhee County, Idaho* (Report No. 03-05). Moscow, ID, USA: University of Idaho, Department of Agricultural Economics and Rural Sociology, Agricultural Economic Extension Series.

Rimbey, N. R., Torell, L. A., & Tanaka, J. A. (2007). Why grazing permits have economic value. *Journal of Agricultural and Resource Economics, 32*(1), 20-40. http://www.jstor.org/stable/40987349

Tanaka, J.A., Torell, L. A., & Workman, J. P. (1987). FEEDSTORIS: A micro-computer program for ranch planning. *Rangelands, 9*(2), 51-55. http://www.jstor.org/stable/3901062

Tanaka, J.A., Torell, L. A. , & Brunson, M. W. (2011). Chapter 9: A social and economic assessment of rangeland conservation practices. In Briske, D. E. (ed.). *Conservation benefits of rangeland practices: Assessment, recommendations, and knowledge gaps* (pp. 371-422). Washington, DC, USA: USDA, Natural Resources Conservation Service.

Taylor, D. T., Coupal, R. H., Foulke, T., & Thompson, J. G. (2004). *The economic importance of livestock grazing on BLM land in Fremont County, Wyoming*. Laramie, WY, USA: University of Wyoming, Department of Agricultural and Applied Economics. Retrieved from: www.uwagec.org/WyoCRE/Publications/Fremont%20County%20final26Oct04.pdf

Taylor, D. T., Coupal, R. H., & Foulke, T. (2005). *The economic importance of Federal grazing on the economy of Park County, Wyoming*. Laramie, WY, USA: University of Wyoming, Department of Agricultural and Applied Economics. Retrieved from http://wyocre.uwagec.org/Publications/ParkGrazFinalRpt23Aug05.pdf

Taylor, M. H., & Rollins, K. (2012). Using ecological models to coordinate valuation of ecological change on western rangelands for ex post application to policy analysis. In D. M. McLeod, (Ed.), *Western Economics Forum 11*(1), 13-21. Laramie, WY, USA: University of Wyoming, Department of Agriculture and Applied Economics.

Taylor, D. T., J. D. Wulfhorst, L. A. Torell, N. R. Rimbey, & J. A. Tanaka. (2014). Economic and social impact assessment of ranching on public lands: Guides to methods, issues, and applications. *Journal of Rangeland Applications, 1,* (In Press).

Teegerstrom, T., & Tronstad, R. (2000). *Arizona livestock budgets* (Publication AZ1193). Tucson, AZ, USA: Universtiy of Arizona, College of Agricultural and Life Sciences, Cooperative Extension. Retrieved from http://cals.arizona.edu/arec/pubs/livestockbudgets.html.

Torell, A., Garrett, J. R., & Ching, C. T. K. (1981). The economic effects of three changes in public lands grazing policies. *Journal of Range Management, 34*(5), 373-376. doi:10.2307/3897907

Torell, L. A., Ghosh, S., & Fowler, J. M. (1990). *Economic considerations for setting grazing fees on New Mexico state trust lands* (Special Report No. 81). Las Cruces, NM, USA: New Mexico State University, Agricultural Experiment Station.

Torell, L. A., Rimbey, N. R., Tanaka, J. A., & Bailey, S. A. (2001). The lack of a profit motive for ranching: implications for policy analysis. In L. A. Torell, E. T. Bartlett & R. Larrañaga (Eds.), *Proceedings of the Annual Meeting of the Society for Range Management* (Research Report No. 737; pp. 47-58). Las Cruces, NM, USA: New Mexico State University, Agricultural Experiment Station. Retrieved from http://ageconsearch.umn.edu/handle/16629

Torell, L. A., Tanaka, J. A., Rimbey, N., Darden, T., Van Tassell, L., & Harp, A. (2002). Ranch-Level impacts of changing grazing policies on blm land to protect the Greater Sage-Grouse: Evidence from Idaho, Nevada and Oregon (Policy Paper SG-01-02). Caldwell, ID, USA: Policy Analysis Center for Western Public Lands.

Torell, L. A., Rimbey, N. R., Van Tassell, L. W., Tanaka, J. A., & Bartlett, E. T. (2003). An evaluation of the federal grazing fee formula. *Journal of Range Management, 56*(6), 577-584. doi:10.2307/4003931

Torell, L. A., McDaniel, K. C., & Ochoa, C. G. (2005). Economics and optimal frequency of Wyoming big sagebrush control with tebuthiuron. *Rangeland Ecology & Management, 58*(1), 77-84. doi:10.2111/1551-5028(2005)58<77:EAOFOW>2.0.CO;2

Torell, L. A., Dixon, B., & McCullom, D. (2012). *The market value of ranches and grazing permits in New Mexico 1996 – 2010* (Report No. 779). Las Cruces, NM, USA: New Mexico State University, Agricultural Experiment Station.

Torell, L.A., Torell, G.L., Tanaka, J.A., & Rimbey, N.R. (2013). The potential of valuing rangeland ecosystem services on public rangelands. *Western Economics Forum, 12*(1), 40-46.

USDA-ERS. (2011). *Commodity costs and returns: data*. Retrieved from: www.ers.usda.gov/Data/CostsAndReturns/TestPick.htm

USDA-NASS. (2012). *Agricultural Prices Monthly*. Available at: http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1002

Van Tassell, L. W., & Richardson, J. W. (1998). Impact of federal grazing reductions on Wyoming ranches. In *Stubble height and utilization measurements : Uses and misuses* (Research Bulletin No. 682; pp. 50-56). Corvallis, OR, USA: Oregon State University, Agricultural Experiment Station.

Wilson, J. R., Gee, C. K., & Marousek, G. (1985). *Economic impacts of BLM grazing policies on Idaho cattle ranchers* (Research Bulletin No. 136).Moscow, ID, USA: University of Idaho, Agricultural Experiment Station.

Workman, J. P. (1986). *Range economics*. New York, NY, USA: McMillan Publishing Co. p. 217.

Workman, J. P., & Tanaka, J. A. (1991). Economic feasibility and management considerations in range revegetation. *Journal of Range Management, 44*(6), 566-573. doi:10.2307/4003037