A Conceptual Framework & Monitoring System for Rangeland Ecosystem Goods, Services & Processes

Rangelands constitute approximately 770 million acres in the U.S. and provide commodity, amenity, and spiritual values that are vital to the well-being of our Nation. The Sustainable Rangelands Roundtable (SRR) recognized a critical need to understand the extent of rangeland ecosystem services, in association with monitoring, as a way to promote improved rangeland conservation. SRR sponsored a workshop, attended by 47 participants representing 14 states, 9 agencies, 10 universities, and 9 NGO's, that identified rangeland ecosystem goods and services (EGS) (see list below). Terms for goods and services are meant to be value-neutral and convey their use by, or effect on, humans.

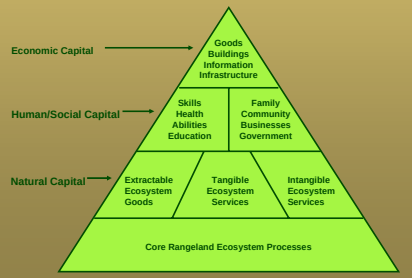
Biological	Hydrological/Atmospheric	Miscellaneous
Domestic Livestock	Drinking Water	Views and Scenes
Other Food for Human Consumption	Water for Economic Benefit	Cultural and Spiritual Resources
Forage for Livestock	Floods for Channel and Riparian Area Rejuvenation	Historical/Archeological Sites
Fiber	Flood Mitigation	Scientifically Significant Sites
Biofuels	Water bodies for recreation /tourism	Recreation and Tourism Sites
Fishing, Hunting and Viewing Wildlife	Minimizes Contributions of Chemicals and Particulates (PM 10)	Ornamental Resources
Biochemicals	Contributes to Clean, Fresh Air	Ceremonial Resources
Genetic Material	Hydrologic Energy Potential	
	Solar Energy Potential Wind Energy Potential	

Future markets will require well-defined and quantifiable environmental goods and services, accentuating the need for inventory and monitoring systems. Since 2001, SRR, an open partnership involving rangeland scientists and managers, ecologists, sociologists, economists, policy and legal experts, environmental advocates, and industry supporters, representing nearly 50 organizations, has distilled a set of five criteria and 64 indicators embodying social, economic, and ecological factors for monitoring sustainable rangeland management. The criteria are:

Criterion 1: Conservation & Maintenance of Soil & Water Resources on Rangelands
Criterion 2: Conservation & Maintenance of Plant & Animal Resources on Rangelands
Criterion 3: Maintenance of Productive Capacity on Rangelands
Criterion 4: Maintenance & Enhancement of Multiple Economic & Social Benefits for Current & Future Generations
Criterion 5: Legal, Institutional & Economic Framework for Rangeland Conservation & Sustainable Management

Intact, functioning ecosystems provide the foundation necessary to support natural, social, and economic capital. However, trends in supplies of rangeland resource capital needed to ensure availability of ecological, economic, and social benefits are not consistently tracked. These three forms of capital and their relationships to each other highlight the importance of valuing rangeland ecosystem services.

Natural capital includes the resources we consume, the processes that sustain us, and the aesthetics of nature we enjoy. **Human capital** consists of people's skills, training, values, education, etc. **Social capital** is the synergistic way humans interact in a community. Considered within the framework shown below, ecosystem processes provide the foundation for all community capital. As more is learned about relationships among ecosystem services and ecological and socioeconomic conditions, the rationale for rangeland conservation and management becomes more important.



Adapted from Hart, M. 1999. Guide to Community Indicators. Hart Environmental Data. Andover, MA.

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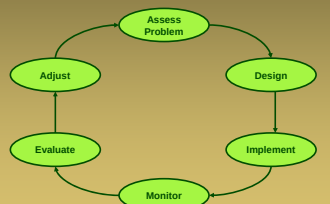
Within government, monitoring provides essential information to measure and assess agencies' performance. Indicators proposed by the SRR provide a mechanism for agencies to see whether they are achieving strategic goals and annual performance objectives as they pertain to rangeland EGS. As shown below, such use of indicators is described as part of an **adaptive management cycle**. Information gathered through suites of indicators allows land managers to evaluate strategies and, thus, provide an objective basis for making management adjustments.. However, there are challenges to monitoring for rangeland EGS within an adaptive management framework. Managers must show how data will be incorporated into planning in order to make decisions. Involving stakeholders in the design of monitoring protocols can help avoid future conflicts.

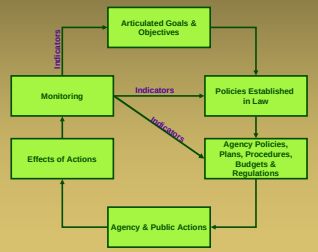


Adaptive Management Cycle

Adapted from Williams, B.K., R.C. Szaro, and C.D. Shapiro. 2007. Adaptive Management: The U.S. Government Working Group, U.S. Department of the Interior, Washington D.C.

Ecosystem goods and services have value because they increase the satisfaction of human needs. Value arises from human interactions with EGS. Interactions vary to include eating a good steak or lamb chop, watching a sunset from a high butte, meditating in wilderness, and fishing in a mountain stream. Values are personal and subjective, but there are commonalities that make it possible to measure them. Values people place on goods and services are closely related to the choices they make. Value can be signaled by prices in **market transactions** or revealed by other human behaviors. Using prices derived from market transactions for goods and services is one way the economic system shapes economic behavior, generally through the greater production of goods and services having bigger differences between price and cost (i.e., profit). **Non-market values** may be estimated by methods such as travel cost or contingent valuation. In principle, all entities, conditions and processes in rangeland ecosystems that contribute to valued EGS also have value, though in many cases their values will not be signaled by market prices or be measurable through methods revealing peoples' preferences.

Policymaking can affect the production of rangeland EGS. Society's values, which change slowly over time, are manifested in beliefs and objectives. Beliefs and objectives, in turn, drive laws and policy. The public places high value on environmental protection, and, by association, EGS. Consequently, public policy tends to promote objectives such as protecting watersheds, promoting ecosystem health, and providing for resource dependent communities. **The policy cycle** starts with articulated **goals**. Objectives are translated into measurable **objectives**. **Laws** address an objective and contain provisions for determining whether, or how well, the objective is being met. Laws are implemented into **actions** after agencies write **policies** and **regulations**, create plans, and receive budgets. **Monitoring** provides information to those who write laws and policy to comply with reporting provisions engrained in these statutes.



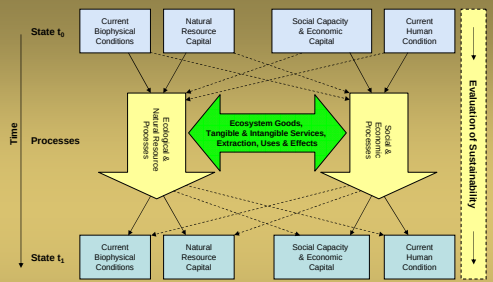
Adapted from Heintz, H.T. 2002. The Use of Indicators in the Policy Cycle.

Core ecological processes are the fundamental processes that occur in ecosystems through which life is sustained and through which all ecosystem goods and services are produced. Most ecosystem goods and services result from complex interactions among these processes. Almost all core ecological processes contribute to numerous categories of goods and services.

Rangeland ecosystem services may be intangible or tangible, but their value to humans results from direct experiences *in situ*, where they are produced on rangelands, rather than through extraction and processing elsewhere. **Intangible services** yield value to humans through experiences that are primarily perceptual, such as visual or kinesthetic experiences. **Tangible services** are direct interactions with ecosystems that occur *in situ* – like hunting, or enjoying other recreation.

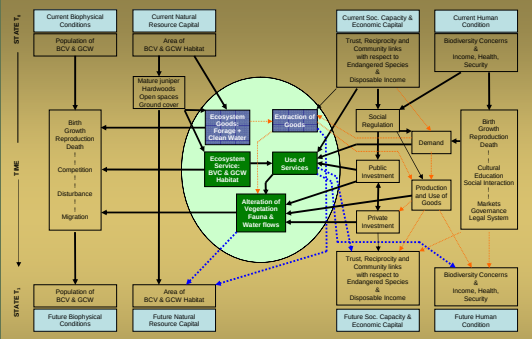
Rangeland ecosystem goods are tangible outputs from ecosystems, made available to humans through human activities beginning with extraction. Once outputs enter the economic system, they are transported, and usually transformed or combined with other goods and services to yield value to humans. Social and economic processes needed for extraction and subsequent processing and use of rangeland ecosystem goods are structured by our legal, institutional and economic frameworks.

Tier 1 Model



The SRR Integrated Social, Ecological, and Economic Concept (ISEEC) for Sustainable Rangelands recognizes EGS as the primary bridge between the ecological and social/economic sides of SRR's conceptual model (Tier 1 is shown above). Humans extract and use natural resources, affecting biophysical conditions and natural resource stocks. Integration of ecological and social/economic factors is highlighted as the horizontal arrow linking "ecological & natural resource processes" and "social & economic processes." This recognizes that ecological and natural resource processes affect and are affected by social and economic capital stocks, capacities, conditions, and processes. Ecological systems and processes provide the biological interactions underlying ecosystem health and viability. Social and economic infrastructures and processes provide the context in which rangeland use and management occurs. These systems and processes interact and feedback on one another over time and space. To adequately assess rangeland sustainability and EGS, a synthesis of ecologic, economic, and social perspectives is needed.

Tier 2 Model



The Leon River Restoration Project (LRRP) in Texas provides a case study of how biophysical and human conditions interact with respect to rangeland EGS. This customized Tier 2 version of ISEEC for LRRP depicts these interactions. The relevant bio-physical condition is the population size of Black-capped Vireos and Golden-cheeked Warblers. The natural capital needed to sustain these endangered species is represented by the amount of habitat at the start of the evaluation period (T_0). For the human subsystem, the relevant condition is the concern over biodiversity loss, in this case decline in the two endangered birds. Interactions with respect to delivery/ use of this ecosystem service are reflected by the heavy solid lines; feedback effects are represented by heavy blue dotted lines; and interactions with respect to extraction of ecosystem goods are represented by the thinner orange dotted lines.

The SRR proposed a consistent set of questions to evaluate each rangeland EGS. While the responses to the questions are important, it is really the evaluation and discussion process that provides the most useful information. The first two questions (Must Haves) are meant to determine if the EGS is rangeland-related and whether it is a good or service that society cares about. The second set of questions (Wants) evaluates the potential goods and services. A rancher, perhaps in consultation with an agency rangeland conservationist or consultant, must interpret answers to these questions and decide how the information can be used in conservation planning and decisions regarding priorities and investments. Answers to these questions, combined with the landowner's goals, will eliminate some options and highlight others for further examination.

Must Haves (Yes / No)

Does the EGS exist on or is derived from from rangelands?
Is the EGS important to rangeland ecosystem processes and/or human well-being?
Both questions must be answered YES to continue.

Wants (High/ Medium/ Low/ NA)

High Importance
Does the EGS provide a basic human need? Is it important to society?
What is the current level of demand for the EGS?
How responsive is the EGS to management?

Moderate Importance
How easily is the EGS measured?
How important is the EGS over local, regional, & national spatial scales?
How important is the EGS over different temporal scales?
How resilient is the EGS?
How much does human activity impact the EGS?
How important are rangelands to this EGS?
How unique is the EGS to rangelands?

Low Importance
For this good, are there no potential substitutes?

Consequences
Is the EGS impacted by local, state or federal regulations?

While the EGS lists in the tables below are not comprehensive, they do represent many of the EGS that could be produced from rangelands to provide economic value to the landowner. We have listed them according to whether they are derived from biological, hydrological/atmospheric, or miscellaneous processes merely as a way to organize the information. These evaluation questions can be used at a variety of other decision-making levels in addition to ranch planning. Questions may need to be adjusted for the scale at which the evaluation is occurring.

Biological Ecosystem Goods & Services	Domestic Livestock for Human Consumption	Other Food for Human Consumption	Forage for Livestock	Fiber	Biofuels	Fishing, Hunting and Viewing Wildlife	Biochemicals	Genetic Material	Other
Must Haves (Yes / No)									
Does the EGS exist on or is derived from rangelands?									
Is the EGS important to ecosystem processes and/or human well-being?									
For each column, both questions must be answered YES to continue.									
Wants (High/ Medium/ Low/ NA)									
High Importance									
Does the EGS provide a basic human need? Is it important to society?									
What is the current level of demand for the EGS?									
How responsive is the EGS to management?									
Moderate Importance									
How easily is the EGS measured?									
How important is the EGS over local, regional, & national spatial scales?									
Local									
Regional									
National									
How important is the EGS over different temporal scales?									
How resilient is the EGS?									
How much does human activity impact the EGS?									
How important are rangelands to this EGS?									
How unique is the EGS to rangelands?									
Low Importance									
For this good, are there no potential substitutes?									
Consequences									
Is the EGS impacted by local, state or federal regulations?									

Hydrological and Atmospheric Ecosystem Goods and Services	Drinking Water	Water for Economic Benefit	Floods for Channel and Riparian Area Rejuvenation	Flood Mitigation	Water bodies for recreation /tourism	Minimizes Contributions of Chemicals and Particulates (PM 10)	Contributes to Clean, Fresh Air	Hydrologic Energy Potential	Solar Energy Potential	Wind Energy Potential	Other
Must Haves (Yes / No)											
Does the EGS exist on or is derived from from rangelands?											
Is the EGS important to ecosystem processes and/or human well-being?											
For each column, both questions must be answered YES to continue.											
Wants (High/ Medium/ Low/ NA)											
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How much does human activity impact the EGS?											
How important are rangelands to this EGS?											
How unique is the EGS to rangelands?											
Low Importance											
For this good, are there no potential substitutes?											
Consequences											
Is the EGS impacted by local, state or federal regulations?											

Miscellaneous Ecosystem Goods and Services	Views and Scenes	Cultural and Spiritual	Historic/ Archeologic	Scientifically Significant Sites	Recreation and Tourism Sites	Ornamental Resources	Ceremonial Resources	Other
Must Haves (Yes / No)								
Does the EGS exist on or is derived from from rangelands?								
Is the EGS important to rangeland ecosystem processes and/or human well-being?								
For each column, both questions must be answered YES to continue.								
Wants (High/ Medium/ Low/ NA)								
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How unique is the EGS to rangelands?								
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For this good, are there no potential substitutes?								
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