Relevance of the Sustainable Rangelands Roundtable Criteria and Indicators for Sustainable Rangeland Management to Conditions in Patagonia (Argentina)

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Abstract—*Patagonia's rangelands are similar to those in western United States in terms of climate, topography, and vegetation physiognomy. However, differences in environmental, economic, and societal values do exist between regions. We assessed the usefulness of C&I (Criteria and Indicators) developed in the United States for other countries, and identified indicators not included in the SRR (Sustainable Rangelands Roundtable) set that would be important for monitoring the sustainability of Patagonia's rangelands. Most of SRR's C&I were relevant to conditions in Patagonia (Argentina). Less than half the indicators were applicable, however, due to the relative paucity of data and validated models. This exercise suggested that a shorter list of essential indicators may be necessary to realistically conduct regional long-term assessments of overall sustainability of rangeland ecosystems in developing countries.*

Introduction

Rangelands of western North America and Patagonia (Argentina) share important physical and productive characteristics. Such similarities should allow a meaningful assessment of the relevance and applicability of the Sustainable Rangeland Roundtable (SRR) monitoring framework to rangelands outside North America. Differences in land use regulations and land tenure regimes between regions, on the other hand, are sufficient to make this comparison an interesting and worth-while endeavor.

The objective of this paper is to assess the relevance and applicability of the criteria and indicators (C&I) proposed by SRR to conditions in Patagonia (Argentina). We will first describe Patagonian rangelands and briefly compare them to rangelands in western North America. We will then give a concise overview of the social, economic, and environmental conditions in Patagonia, followed by an account of current rangeland monitoring efforts in the region. The last and most important section of this paper will deal with the relevance assessment itself. In this section we will summarize the main results and conclusions of this exercise.

Rangelands of Patagonia (Argentina) in Relation to Their North American Counterparts

Rangelands occupy over 90 percent of the land area of Patagonia, a region of cold semi-arid deserts on the southernmost end of the South American continent (Lat 39° to 55° S). In this paper we will focus mainly on Patagonia's grazing lands East of the Andes in southern Argentina (approximately 750 000 km^2).

Most of Patagonia lies in the rain shadow of the Andes. Mean annual precipitation rarely exceeds 250 mm except in the forested foothill ranges where rainfalls can exceed 1,000 mm. (Soriano 1983). Rainfall occurs mainly during winter across most of the region (Paruelo and others 1998). Mean annual temperatures range from 15.9°C in the North to approximately 5.4°C in the far South of Tierra del Fuego (Soriano 1983). Strong persistent westerly winds are one of the most distinctive characteristics of Patagonia's climate; gusts of 100 km/h, or more, are common in spring and summer (Paruelo and others 1998). Over 70 percent of Patagonia's topsoil is coarse-textured, and almost 90 percent of soils in the

region exhibit some degree of degradation, mostly as a consequence of improper land use. Severe desertification affects about a third of Patagonia (Del Valle 1998); some of its most dramatic expressions are the lenguas medanosas (sand dunes) that covered an area of approximately 85 000 km^2 in the early 1970s. Many of these accumulations are about 100 years old, suggesting that the rate of wind-driven erosion processes may have been accelerated by the introduction of domestic livestock in the region (Soriano 1983).

Patagonian rangelands are primarily treeless shrub and grass steppes that give way to dwarf-shrub semi-deserts in the drier areas of the central plateaus (Roig 1998). Vegetation is mostly made up of xerophytic species that have evolved remarkable adaptations to cope with severe water stress conditions (León and others 1998). Blended in the steppe landscapes are riparian areas (*vegas* or *mallines*) associated with rivers and other permanent water sources. Although mallines are a very small proportion of the total land area of Patagonia, they frequently play a key role in livestock production and, in many instances, are the ecosystems most severely affected by improper land management decisions (Golluscio and others 1998).

Patagonian and western North American rangelands exhibit a number of geomorphologic, edaphic, botanical and land use similarities. Both regions share genera of important grasses (*Stipa*, *Festuca*, *Poa*), sedges (*Carex*), and shrubs (*Larrea*, *Prosopis*, *Lycium*, *Atriplex*). Forage production and grazing capacity of areas with similar annual rainfall are analogous. Commercial livestock and sheep grazing enterprises are a fundamental element of rangeland livelihood of both Patagonian and western North American rangelands. Ranch management practices, animal handling skills, and educational background of operators in both regions are also comparable. Furthermore, tensions between multiple rangeland use alternatives, particularly in the case of oil and gas production, have been well documented in both regions.

Rangelands of Patagonia and western North America also exhibit a number of important differences, the most significant of which is possibly associated with land ownership regime. In stark contrast to western North America, almost all of Patagonian rangelands are privately owned and, therefore, grazing use is virtually unregulated. In addition, rangeland science and management tradition is fairly young in most of Patagonia; widespread application of range survey methods to determine grazing capacity of commercial ranches did not begin until the late 1980s. Most of Patagonia's rangelands have been (and still are) grazed by sheep rather than cattle. Wool production-driven grazing management is thought to have greatly contributed to desertification in the region. Surprisingly, invasive noxious weeds are not a widespread problem on Patagonia's rangelands.

Social, Economic, and Environmental Sustainability of Rangelands of Patagonia (Argentina)

Social aspects: Pastoral use history of rangelands in Patagonia is relatively recent; even today there are less than 2.3 inhabitants per square kilometer (INDEC 2001). Colonization of this vast land took place in the late 1880's, after military "desert" campaigns subjugated native peoples and the country offered land for colonization, mainly to Argentine and Chilean "criollos" but also to settlers of European or Middle-Eastern descent, including Spaniards, English, Scottish, Italians, Syrian-Lebanese and Yugoslavians. Native peoples were mainly hunters and gatherers: the Tehuelche in the south did not endure the cultural impact of colonization and are now severely reduced in number, while the Mapuche people, in the north, recovered after an initial descent. Both groups add up to 23 to 50 thousand people, about 1.4 to 3.5 percent of the residents of the region. Early (1880-1900), colonization was actively encouraged by the government and settlers were given access to pastoral leases in large areas of the most productive or readily accessible land. At the turn of the 19th century, poorer settlers took part in the colonization of arid or inaccessible areas. The land was divided geometrically into allotments of about 10 to 20 thousand hectares without considering environmental factors or the balance of range types, water points, or wintering areas within the properties (Barbería 1995). Native Americans remained on the land in small subsistence allotments of about 500 to 2500 hectares or in a few reservations. Freehold rights consolidated land tenure of most of the big "estancias" at the turn of the 20th century, but small allotments remain mostly with informal or traditional occupation, a great number of them unfenced.

Economic Aspects

The sheep industry flourished until 1920, while prices of wool were high and undisturbed grasslands could take heavy grazing pressures. Sheep numbers peaked by 1937, (fig. 1), and remained stable for almost 50 years (Oliva and others 1995, Escobar 1997, Mendez Casariego 2000). In the 1980's, a generalized stock reduction process was triggered by a combination of lower international wool

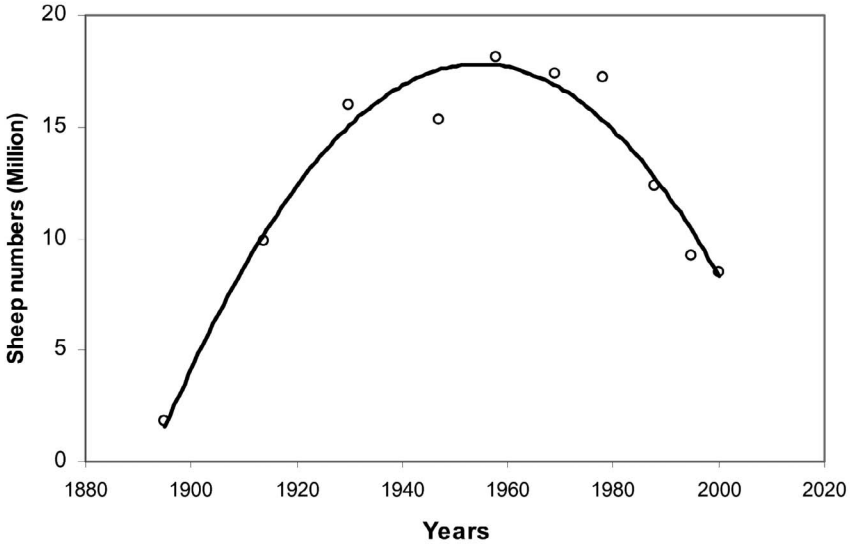

Figure 1. Sheep numbers in Patagonia (From Borelli and Cibils 2004).

and meat prices, loss of productivity due to rangeland degradation, and macroeconomic policies that inflated the value of local currency (Borrelli and others 1997, Mendez Casariego 2000). These factors put most sheep ranching enterprises in a difficult financial position; by the end of the 20th century most ranchers had become heavily indebted and had drastically reduced their work force. This crisis primarily affected mid-sized (20.000 hectares) family-owned ranches in the Central Plateau of Santa Cruz, where about 440 (40 percent of the total) estancias have been abandoned or remain occupied by caretakers with no pastoral activities. Rural population in Santa Cruz fell from 24.500 in 1960 to 13.700 in 1991 (Mendez Casariego 2000). Changes in macroeconomic policies implemented in 2002 have increased the profits of the sheep ranching industry (Teran and Claps 2002), and there is currently a strong predisposition to re-colonize vacant lands.

Environmental Aspects

Heavy grazing-induced degradation processes were described early on by Bailey Willis (1914, as cited in Castro (1983), Morrison (1917), Auer (1951), Soriano (1953), Soriano (1956a, b) and Movia and others (1987). Soil erosion was treated using dune control techniques as early as 1950 (Castro 1983). Nevertheless, the underlying causes of degradation were not addressed, and heavy stocking rates remained in place until the 1980's. Regional evaluation of desertification using satellite imagery began in the early 1990's and showed that severe or very severe desertification had affected approximately 34 percent of Patagonia (Goergen 1995, Del Valle and others 1998).

The Role of Government Administration

According to the Argentine constitution, natural resources, including rangelands, are under the jurisdiction of provincial governments. Sadly, environmental consequences of improper grazing have rarely been addressed by provincial or national government policies due to the fact that most of the land is under freehold tenure and there is no constitutional mandate to monitor the state and management of rangelands. Grazing has therefore, gone unregulated and conservative management has depended mostly on the perceptions and goodwill of landowners. Due to social and political influence of traditional rancher associations, significant amounts of public funds have frequently been directed towards the maintenance and expansion of the sheep industry through subsidies and financial support regardless of the grazing capacity of rangelands. Joint desertification projects sponsored by the Instituto Nacional de Tecnología Agropecuaria (INTA, Argentina) and the Deustche Gesellschaft fur Technische Zusammenarbeit (GTZ, Germany) from 1989 to 2002 helped increase public awareness regarding the threat that desertification posed to the region, and stimulated the design and fairly extensive application of rangeland survey and monitoring techniques. The trend of public fund allocation has changed in recent years since the passing of a Sheep Act in 2002 (Poder_Legislativo_Nacional 2004) that assigns about $7 M yearly to projects that can demonstrate ecological sustainability through certified range evaluation. Rancher associations participate in the distribution of these funds that support the development of a regional-scale monitoring system. A project with

funding currently under consideration by the Global Environment Facility Program of the World Bank (GEF) will address three aspects that the Sheep Act of 2002 does not include, namely: 1) rangeland monitoring; 2) education; and 3) diversity conservation through public and private protected areas. Such recent developments allow moderate optimism regarding a change in long-term government rangeland conservation policies.

Rangeland Monitoring in Patagonia

Rangeland management in Patagonia emerged as a scientific discipline in the 70's as a product of region-wide projects funded by FAO (Food and Agriculture Organization of the United Nations), INTA, and BID (Inter-American Development Bank). During the early 80's researchers began applying traditional range-condition analysis and developing range condition guides for a few sites in the region (Borrelli and others 1984, Borrelli and others 1988, Bonvisutto and others 1993, Nakamatsu and others 1993, Paruelo and others 1993). Considerable effort was later put into transforming range condition guides into state and transition models (Paruelo and others 1993). However, ecological status guides were soon almost totally replaced by practical methods to assess forage availability at the scale of individual pastures in expeditious and cost effective ways.

Two separate approaches were developed to survey grazing capacity of rangelands. The first, known as "Pastoral Value Method" (PVM) (Elissalde and others 2002), calculated cover of all plant species with step transects and transformed cover data into forage availability estimates using coefficients that considered plant species palatability and nutritional value. The second technique known as "Santa Cruz Method" (SCM) (Borrelli and Oliva 1999, Borrelli and others 1999, Borrelli and Oliva 2001), included estimates of shortgrass and forb biomass (by clipping cuadrats) and stubble heights of key shortgrass species. The PVM has been used to determine grazing capacity of shrublands in northern Patagonia whereas dwarf shrublands and tussock grasslands of southern Patagonia (including the island of Tierra del Fuego) have been mostly surveyed using the SCM. Both methods rely on previous site inventories using Landsat TM satellite imagery and on-the-ground GPS sampling to produce ranch maps as base cartography of natural resources is very scarce in most of the Region.

Both the PVM and SCM are now officially recognized by provincial governments in Patagonia. Provincial governments sponsor annual training courses and keep official registries of certified rangeland surveyors. Over 6 percent of rangelands (1.4 million hectares) of southern Patagonia (Santa Cruz and Tierra del Fuego) have been surveyed; approximately 60 percent of the ranches in the most productive areas have been surveyed with the SCM at least once. A somewhat smaller but similarly important area has been surveyed using the PVM in the provinces of Chubut, Río Negro and Neuquén. Because the Sheep Act of 2002 requires producers to submit certified rangeland surveys to qualify for government subsidies and loans, the area of surveyed rangelands is expected to increase steadily in the years to come.

Although the PVM and SCM give valuable rangeland management information, they have not been designed to monitor regional ecological trends through time. The SCM estimates yearly forage biomass at a ranch scale relying on the "take half, use half" rule of thumb for a few key species assuming that this rate of utilization will not have detrimental effects on rangeland condition. The PVM includes an estimate of cover for all plant species in addition to the percent of bare soil, but is usually performed only once in order to obtain an initial forage assessment; subsequently stocking rates are adjusted following rain patterns (Rimoldi and Buono 2001).

The need for an independent method to establish rangeland state and trend at the scale of range types (from 0.4 to 14.3 M ha) and at relevant time scales (decades) has been acknowledged recently, and an INTA-GTZ project has enabled range scientists of Patagonia to discuss an initial methods to monitor vegetation and soil. This monitoring system, known as MARAS (Monitoreo Ambiental de la Región Arida y Semiárida de Patagonia, (Oliva and others 2004) is based on Australia´s WARMS method (Western Australia Monitoring System), and includes point intercept transects or frequency samples to evaluate herbaceous vegetation and Camfield lines to monitor shrubs. Soil surface sampling and shake tests are also performed to monitor topsoil integrity. Monitoring stations will be set up at a rate of 1: 20.000 hectares and will be measured every five years. MARAS has received funding from the Sheep Act of 2002 to train field personnel, install the first monitoring sites, and design a web-based data bank that will be accessed by government agencies and NGOs. In the future, MARAS could supply information to monitor vegetation cover, species composition, forage biomass and soil condition of rangelands in Patagonia. To date, there are no plans in place to incorporate social or economic variables into this monitoring system.

Table 1. Relevance of SRR C&I to conditions in Patagonia.

Criteria	Number of indicators	Indicators important to conditions in Patagonia	Indicators that can be monitored with existing data and models	Indicators that can be reported adequately over time	Indicators that will be monitored in the future
			Soil – based indicators		
1. Conservation and maintenance of soil and water resources of rangelands	5	5	2	2	2
			Water-based indicators		
	5	5	0	0	1
2. Conservation and maintenance of plant and animal resources on rangelands	10	8	4	2	
3. Maintenance of productive capacity on rangelands	6	6	4	4	
4. Maintenance and enhancement of multiple economic and social benefits to current and future generations	28	20	12	12	
5. Legal, institutional, and economic framework for rangeland conservation and sustainable management	10	9	4	4	
Totals	**64**	**53**	**26**	**24**	**3**

Relevance of SRR C&I to Conditions in Patagonia (Argentina)

To asses the relevance of SRR C&I to conditions in Patagonia we followed the overall framework developed by SRR to refine the Sustainable Forest Roundtable's list of C&I. Specifically, we asked: 1) Is this indicator important to conditions in Patagonia?; 2) Can it be monitored with current data and models?; 3) Can it be monitored adequately over time?. In cases where the answer to our second question was "no" we added a fourth question: 4) Is there a feasible plan in place to monitor this indicator in the future?

Most of the SRR criteria were classified as being relevant to conditions in Patagonia (table 1). Only a few indicators, mostly within criterion 2, were classified as not being applicable to Patagonian rangelands. For example, area of land in rangelands is fairly stable and is not threatened by urban growth or agriculture. Therefore, fragmentation of rangeland habitat is possibly not a major concern either. In a small number of other cases, mostly with indicators grouped within criteria 4 and 5, we could not tell whether they applied to social, economic or legal sustainability of rangelands in Patagonia, and therefore excluded them from the list.

Our catalog of 53 relevant indicators was severely reduced when actual monitoring feasibility was considered (table 1). Available data or models could only assess 26 of the 53 relevant indicators for sustainable rangeland management proposed by the SRR (table 2). In most cases, available data and monitoring capabilities would be able to address less than half the indicators classified as potentially relevant. In the case of indicators of productive capacity of rangelands (Criterion 3) almost all indicators could be readily applied. Most disturbingly, however, indicators to monitor water resources of rangelands (Water-based indicators under Criterion 1) were totally absent from our short list.

Relative lack of quality data and scarcity of validated models were the factors that limited the applicability of SRR C&I to Patagonian rangelands the most. Plans to expand and improve rangeland monitoring data collection are limited and can be expected to have a very small impact on our assessment of current conditions.

Table 2. List of relevant indicators that could be monitored in Patagonia.

Criteria	Indicators
1. Conservation and Maintenance of Soil and Water Resources of Rangelands	**Soil –based Indicators:** 4. Area and percent of rangeland with significant change in extent of bare ground 5. Area and percent of rangeland with accelerated soil erosion by water or wind
2. Conservation and Maintenance of Plant and Animal Resources on Rangelands	12. Rangeland area by plant community (*) 15. Density of roads and human structures 17. Extent and condition of riparian systems (*) 18. Area of infestation and presence/absence of invasive and other nonnative plant species of concern (*)
3. Maintenance of Productive Capacity on Rangelands	21. Rangeland aboveground biomass 22. Rangeland annual productivity 23. Percent available rangeland grazed by livestock 24. Number of domestic livestock on rangeland
4. Maintenance and Enhancement of Multiple Economic and Social Benefits to Current and Future Generations	29. Number of visitor days by activity and recreational land class 32. Rate of return on investment for range livestock enterprises 36. Poverty rate (general) 37. Poverty rate (children) 38. Income inequality 41. Federal transfers by categories (individual, infrastructure, agriculture, etc.) 45. Agriculture (ranch/farm) structure 46. Years of education 47. Value produced by agriculture and recreation as a percent of total 48. Employment, unemployment, underemployment, and discouraged workers by industrial sector 49. Land tenure, land use, and ownership patterns by size classes 50. Population pyramid and population change
5. Legal, Institutional, and Economic Framework for Rangeland Conservation and Sustainable Management	56. Institutions and Organizations 59. Professional Education and Technical Assistance. 63. Measuring and Monitoring. 64. Research and Development.

(*) Not all plant communities can be monitored through time with current available technology.
(**) Invasive nonnative plant species are only important locally in certain areas of Patagonia.

Our assessment exercise may be indicative of the kinds of challenges associated with applying the SRR C&I to rangelands in developing countries. Application of rangeland monitoring assessments in developing countries following the framework proposed by SRR may require a shorter bare-bone list of essential criteria and indicators. Our short list of indicators (table 2) could possibly serve as a starting point in that direction. The development of a condensed list of essential indicators could serve as a guide to help land managers and local enforcement authorities in developing countries prioritize the use of scarce funds allocated to monitoring efforts.

There are a few additional indicators not considered in the SRR C&I that would be pertinent and feasible in Patagonia:

1. Wind is the most widespread erosion and degradation agent on grazed rangelands of Patagonia. Because soils are predominantly coarse-textured, some studies suggest that the loss of fine particles (lime) and the increase in heavier particles that cannot be transported by wind (sand) is a good indicator of ongoing erosion processes (Oliva and others 2000). A simple topsoil texture test would allow fairly straightforward monitoring of early degradation processes.
2. Overgrazing can modify structural patterns of the vegetation, subdividing sink areas that are associated with shrubs (in the order of 1-2 meters diameter), and hummocks associated with tussocks (10-30 cm in diameter). These processes are difficult to monitor, although some initial efforts are underway using vertical photography or Camfield lines. Monitoring of vegetation structural patterns may prove to be important to evaluate ecosystem integrity and the risk of unfavorable transitions.
3. From the social point of view the proportion of abandoned ranches, could be a good indicator of the sustainability of the ranching industry.

Conclusions

Most of the C&I for sustainable rangeland management proposed by the SRR are relevant to conditions in Patagonia (Argentina). Less than half the indicators are applicable, however, due to the relative paucity of data and validated models. This exercise suggested that a shorter list of essential indicators might be necessary to realistically conduct regional long-term assessments

of overall sustainability of rangeland ecosystems in developing countries.

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