Rangelands

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Range Monitoring —The Grazing Response Index

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Rangelands

FEATURE ARTICLES

DEPARTMENTS

COVER

Range monitoring field tour. U.S. Forest Service Photo.

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—to properly take care of the basic rangeland resources of soil, plants and water;

—to develop an understanding of range ecosystems and of the principles applicable to the management of range resources;

—to assist all who work with range resources to keep abreast of new findings and techniques in the science and art of range management;

—to improve the effectiveness of range management or obtain from range resources the products and values necessary for man's welfare;

—to create a public appreciation of the economic and social benefits to be obtained from the range environment;

—to promote professional development of its members.

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Rangelands

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Executive Vice-President's Comments

Of the many topics we like to discuss, survey, evaluate, criticize, and make recommendations on, this magazine is right near the top. Over the history of *Rangelands*, it has been the subject of numerous reviews by special task groups, the Board of Directors, and the membership at large. While the results and recommendations from all this oversight is surprisingly similar each time, the quest goes on. The problems we address fall in two areas; the cost of producing the magazine and how to provide content that is of interest and value to our members.

Rangelands has been around for 25 plus years (I'm sure I will get corrected on that). It was established to meet a need to provide a forum for communicating information on rangeland subjects, as well as SRM activities and business. Much of this had previously been included in *JRM*, but it was felt that printing the less technical information in another publication would help *JRM* maintain its scientific status, while providing another good communication source for the membership.

From the very beginning the cost of producing the magazine has been a subject of debate and discussion within SRM. We have rotated through periods of trying to break even, to minimizing costs, to living with an "absolute maximum", while seeking ways to offset costs through income producing activities. Finally, its been decided that the publication is a major member service funded by dues, and its probably better to work on content for awhile.

What to print in *Rangelands* is a subject every bit as difficult as how to fund it. Our membership is diverse in terms of interest and there will be those satisfied and some dissatisfied with any given issue. The current Board of Directors feels that there are enough members with concerns that it is a good time to review where we want to go as we start a new century. In the past this discussion has covered such areas as what topics were appropriate and desired by the membership, as well as in what style should they be presented. This latter is an interesting challenge. Some folks argue that an article written in scientific style, complete with supporting graphs, charts, and citations is inappropriate and will not be read. Others go the opposite direction and "nitpick" the citations and style and argue that it is not scientific enough. Questions on the citability of a *Rangelands* article come up regularly.

A task group studied *Rangelands* and reported to the Board of Directors in 1994. Part of their report included recommended topics for articles that they felt would broaden the appeal of the magazine. The following is a listing of some of these topics that appear appropriate now as well as 1994. Excellence in range management stories, viewpoint papers from environmental groups, viewpoint papers from commodity groups, increase in wildlife habitat articles, biology of rangeland species, success stories relating to habitat management of threatened species, range management techniques, papers from partners and affiliates, and last was exploring the area of ecosystem management. I am giving you these suggestions from five years ago to stimulate your own recommendations on what you would like to see printed.

When considering the subject of topics of interest you also need to consider who should be writing the articles and what financial arrangement should be made. Some discussion has taken place concerning the possibility of paying stipends for some papers which may be of high interest to members. Also we could consider different alternatives with page charges. Currently, page charges are collected on some papers, while some are waived. The policy has been to charge those authors who have funds available, but to waive charges for authors without resources in order to benefit from their information.

Another topic that has been recommended is the consideration of "focused" issues. This is where all or a significant number of the articles in an issue would pertain to a subject theme such as water, or sustainability. Many publications from other organizations do this and it can be a good source of information on the selected theme.

The final area is the layout and design of the magazine. Some members think its great the way it is others think we could do better. We have been making subtle changes in design this past year and have had some positive feedback.

So, this is where I am going. The Board of Directors has voted to make some changes in *Rangelands*. Some of them can be made in my office, budget items and such. However, membership input is needed to assist our Editor and Editorial Board concerning the type of articles you would like to see, how to get those articles, and any recommendations you might have on layout and design.

On another topic, we are making more changes with our staff at the Denver office. Matt Wirt, who has been our membership manager since last fall has resigned to move to another area. We have promoted Helen Hall, who you were introduced to in a recent issue of *TBN* as our office services manager, to the membership manager position. In doing so we are beginning the task of building this position into a full multi-dimension membership position. In the future Helen will not only be responsible for our member database and subscription programs, but will also deal in the area of recruitment and retention of members. This will be consistent with our needs as well as the way other professional societies are staffed. I feel Helen is up to the task and look forward to her help in providing expanded service in this area.—***Craig Whittekiend***, Executive Vice President

The Grazing Response Index:

A Simple and Effective Method to Evaluate Grazing Impacts

Floyd Reed, Roy Roath and David Bradford

Monitoring is the process of gathering information about plants and the rangeland system response to a grazing regime to make informed adjustments. The intent is to maintain or improve the resource and create a sustained output of animal products, clean water, and wildlife habitat. This means that monitoring must provide information that is useful in making the decisions to be made. Filling file cabinets with data was never the intent of monitoring.

The term **over-grazing** is one that is used rampantly but it is rarely defined. Over-grazing is a process of repeated, selective use of the best, most palatable plants in a grazing environment. This graze and regraze process has profound effects on the individual plants which ultimately changes the plant communities. Thus **over-grazing** is a process of loss of productivity and/or death of a select group of plants that are excessively pressured by grazing animals.

During the 1990's range management began to include length of time and time of year in evaluating the impacts of grazing. Recently the Colorado State University Range Extension Program working hand-in-hand with the Integrated Resource Management Program, developed the Grazing Response Index to help range managers better evaluate the effects of grazing on plants. The Rocky Mountain Region (R2) of the Forest Service has adopted this approach and found it to be effective, simple and easy to communicate.

General Discussion

The Grazing Response Index (GRI) was developed to assess the effects of grazing during the current year, and aid in planning the grazing for the following year. The GRI is based on general assessment of grazing use that occurs during the current growing season. It is necessary to understand plant physiology and plant responses to grazing to use the GRI. The GRI considers three concepts related to plant health in evaluating the impacts of grazing - frequency of defoliation, intensity of defoliation, and opportunity of the plant to grow or regrow.

Cunningham Stomp, Terror Creek. Taken by H.P. Gaylor, November 6, 1940. Site now called Round Corral Park.

Photo retake of Cunningham Stomp, Terror Creek. Site now called Round Corral Park. Photo taken October 1, 1997 by David Bradford.

Frequency

Frequency refers to the number of times forage plants are defoliated during the grazing period. It is dependent on the length of time plants are exposed to grazing animals (grazing period). Seven to 10 days are required for a plant to grow enough to be grazed again during late spring or early summer (Briske, 1986). Therefore, the most selected plants in the grazing area, that are exposed to animal grazing during this growing period are potentially subject to being grazed once for each 7 days of that grazing period. **Remember, overgrazing is the repeated, selective use of the best, most palatable plants**.

This portion of the index is derived from plant clipping research. Plants were clipped at various intensities and frequencies to determine the influence of frequency and intensity of defoliation on plants (Branson, 1956; Mueggler, 1972). Individual tiller defoliation studies (Briske, 1986) indicated that three or more successive defoliations of a plant in one growing season was detrimental to the plant and, if continued, would reduce the plants ability to be productive and/or remain a viable part of the plant community (Ellison, 1960).

West Terror C&H. Photo taken on September 17, 1947 by Carl F. Henderson as part of a range inspection. Henderson described the site "Round Corral Park on West Terror showing active gulley erosion and heavy browsing or snowberry. Complete utilization of bluegrass.

West Terror C&H. Photo retaken on October 1, 1997 by David Bradford. Observed changes are: gullies are healed over; old road to cow camp is noticeable but also revegetating; conifers on hillside have increased; snowberry has increased; willows have come in on main draw; all woody species, oak-brush, cottonwood and spruces are older and taller.

To obtain an estimate of how many times plants were, or will be, defoliated during a grazing period, divide the number of days in the planned grazing period by 7, or up to 10 if growth is slower. Using 7 is more conservative, because it will give the highest probable number of times the plants could be grazed. An index value of **+1** to **-1** is assigned as follows:

Number of Defoliation's	Value
1	+1
2	0
3 or more	-1

A value of **+1** is a general indicator that the plants grazed will respond quite positively to that influence. More importantly if that grazing regime were to continue the plants would continue to be favored by that frequency of defoliation. A **0** value is indicative of the plant's being neutral to the defoliation event - being neither severely depressed or enhanced. A **-1** value is a clear indication that the current frequency of defoliation is excessive and continued grazing at that frequency will have a negative influence on the plant.

Local knowledge of the area is needed to determine how fast plants are growing and whether to use the values of 7–10 days as the divisor in calculating the index.

Intensity

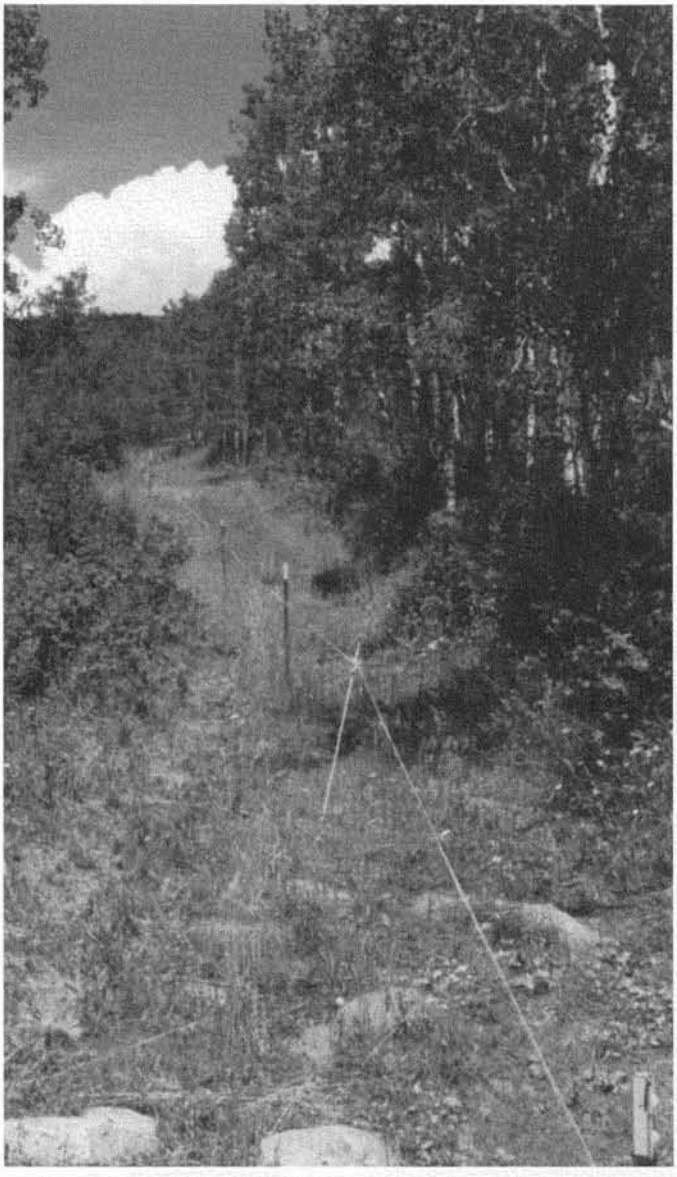
Intensity is a description of the amount of leaf material removed during the grazing period. This is not an estimate of forage utilization. The primary concern is the amount of photosynthetically active material remaining for the plant to recover from defoliation. Generally defoliation of less than 50% of the leaf material allows enough leaf area to meet the plants needs and will not inhibit subsequent plant growth. Intensity for the purposes of the index is described using three levels of defoliation—light, moderate and heavy. These terms are sufficient to handle the description of levels of defoliation for almost every grazing situation.

The intensity of defoliation has long been recognized as an influencing force on plant responses. The effects of defoliation *are more a factor of leaf material remaining after the defoliation* event than a reflection of the amount of material removed (Hyder, 1972). It is clear the plant that has relatively more leaf area surface remaining after defoliation is going to respond better than one that has relatively less.

The GRI uses the following values for describing intensity of grazing:

Level of Defoliation	Percent Utilized	Value
Light	< 40%	+1
Moderate	41-55%	0
Heavy	> 56%	-1

Light use, assigned a **+1**, would be expected to foster positive plant responses because most of the leaf material is still remaining. Moderate use, assigned a 0 value, would be expected to have a neutral effect on the plant, allowing it to maintain itself and its current status in the community. Heavy use, assigned a **-1** value, would inevitably cause the selected plants to decline in vigor; if that level of defoliation were to continue over several years. Use of cages in representative areas is helpful in determining what the level of use was during the grazing



West Terror C&H. Temporary electric fence used to create the east 1/2 low range (right) and west 1/2 low range (left). The right side was grazed June 27–July 16, 1998. Photo by David Bradford.

period. These cages must be moved each year to avoid the effect of long-term deferment and the snow accumulation effect.

Opportunity

Opportunity is the amount of time plants have to grow prior to grazing or to regrow after grazing has taken place. The opportunity of the plant to grow and recover after the grazing period is critical to maintaining the plant. The plant must be able to fully store energy at some time during the active growth period. The inference to grazing management is that the grazing program must either allow plants full growth of leaves before grazing use or allow for full recovery after grazing use for the key plants to maintain themselves. If this is done, even the effects of relatively high frequency use or relatively heavy use can be mitigated.

Opportunity is related to both the time of year and amount of time that grazing occurs (time and timing). Of the three factors in the GRI, opportunity is most strongly correlated to long term health and vigor of the vegetation. The opportunity for plants to grow or regrow is dependent on soil moisture, temperature and leaf area. Since this factor is so important in sustaining healthy plants, the relative rankings are doubled in value.

Opportunity to Grow or Regrow	Value
Full Season	+2
Most of Season	+1
Some Chance	0
Little Chance	-1
No Chance	- 2

Determining opportunity is a judgment call based on appearance of vegetation at the end of the growing season. If the plants look like they were not grazed or just barely grazed, then a value of **+2** is appropriate. If the plants look like they were used, but regrew fairly well , then give a rating of **+1**. Obviously, if the area has the appearance of being heavily used, with no regrowth, assign a **-2** value. If the plants had full opportunity for growth before the grazing period, the index value would be **+2** in this situation as well.

Even though opportunity is based upon appearance of the vegetation at the end of the growing season, there are some general guidelines that can help make the determination. For example a pasture or allotment that is used season-long can be expected to rate **-2** (no chance for growth or regrowth). An allotment with 2 pastures may provide some chance for growth and/or regrowth resulting in a rating of **0** or **-1**. An allotment with multiple pastures that are used at different times of the year, or rested, will usually receive the higher ratings of **+1** and **+2**. The most important aspect in evaluating opportunity is that it is based on field observations on whether the plants had full opportunity to grow or regrow.

Overall Rating - GRI

The values for frequency, intensity and opportunity are additive. The overall rating of the expected response to grazing is the sum of all three values. This result is a numerical value that is either positive, neutral, or negative. As implied a ***positive*** value indicates the management is beneficial to the health, structure and vigor of the plants. Conversely a ***negative*** value indicates that the management is harmful. A ***zero*** (0) rating is neutral. The index is a simple way to incorporate a number of factors into the evaluation of whether a grazing system is providing long-term beneficial, neutral or harmful effects to rangeland plants

The use of the index in making management decisions is the critical link. Without that step this and all other ac-

quisitions of observations are simply data. The power of the GRI is that it is concretely linked with mechanisms that control plant response to grazing. It is also linked with three factors in grazing management that can be managed—**the duration of grazing use, stocking rate and season of use.** *Frequency* is a function **of duration of use**. If the index indicates the plant responses are likely to be negative, changing the duration of the grazing period will alter the plant response. The *intensity* of use is linked with the relative **stocking rate** of the area grazed in the pasture. If the intensity index is high in most pastures on the ranch or the index is consistently high in one or more pastures year after year, the stocking rate is too high. Since *opportunity* is based on plant growth or regrowth, this quite clearly is influenced by **season of the year** and timing more than the other factors. Spring grazed pastures must have enough soil moisture remaining at the end of the grazing period to allow the plants to recover.

Conclusion

Is this type of evaluation useful? We certainly think so. The GRI provides a more comprehensive method to evaluate the effects of current management. It allows managers to evaluate a number of factors in a simple yet effective manner. It provides feedback to managers quickly. The information from the GRI allows managers to make adjustments to grazing without major investments of money and time. Our grazing permittees, environmentalists and members of the general public all like the approach. They appreciate it because it is easy to communicate and it is based on general observations rather than time-consuming, precise measurements.

The GRI is not intended to be the only method for resolving major rangeland conflicts. It should be used for monitoring when resource issues are considered to be of low to mid-level intensity. For situations with significant resource conflicts, other more intensive monitoring strategies should also be utilized. This approach should be coupled with other longer term monitoring methods including range condition and trend as well as photos to allow interpretation of range plant community responses.

The Grazing Response Index is a simple but useful tool. It is helping us on the Grand Mesa, Uncompahgre and Gunnison National Forests. We like it because it is providing feedback on our management and keeping us focused on real impacts of grazing.

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Using the GRI on the West Terror Allotment

David Bradford

The Paonia Ranger District on the Grand Mesa, Uncompahgre and Gunnison National Forests used the GRI in 1998. A number of allotments on the district are managed using holistic management principles or at least using the principles of time-controlled grazing. The West Terror allotment initiated a new management system in 1997. The system was in place by 1998. The management changed from a season-long system to a seven-pasture rotation system. The district incorporated the GRI as one of the monitoring tools—to be completed by the permittees as part of their actual use report. The following is the actual use report for 1998:

West Terror Allotment—GRI for 1998

Unit Name	Livestock Numbers	Date On Unit	Date Off Unit	Frequency	Intensity	Opportunity	Total GRI
Lower Beef	58c/c 322 c/c	16 June 23 June	22 June	-1 *	-1	+1	-1
Upper Beef	380 c/c	24 June	26 June	-1 *	+1	+1	+1
East 1/2 Low	380 c/c	27 June	16 July	0 *	0	+1	+1
West 1/2 Low	380 c/c	17 July	6 August	0 *	0	+1	+1
High Park	380 c/c	7 August	21 August	0	+1	+1	+2
Ellington	380 c/c	22 August	6 September	0	+1	+1	+2
Rock Slides	380 c/c	7 September	24 September	0	0	+2	+2
Low Range	380 c/c	25 September	9 October	-1	+1	+1	+1
Beef Pastures	380 c/c	10 October	15 October	-1	-1	+1	-1

* These units also include significant elk grazing in May and June.

Does this information provide any useful feedback? Yes. The GRI for the West Terror allotment for 1998 shows mostly positive values for total grazing response (TGRI) for each pasture. This indicates that grazing management on the allotment was beneficial. This is not surprising since management is fairly intense. Cattle are maintained as a herd using only one of seven areas at any one time, allowing the plants in the other six areas to grow or regrow. However, the Lower Beef Pasture was given a TGRI rating of -1. This indicates that the grazing in this unit was harmful for the year. Can a change be made to reduce the negative impacts? Sure. The intensity of grazing can be reduced by decreasing the amount of time spent in the unit. In fact, that is what the permittee has suggested for 1999. He would like to reduce the amount of time they spend in the Beef Pastures in the spring to 3 days. This will reduce the time spent grazing in this unit which will reduce the intensity of grazing - resulting in a rating of 0 or +1 for intensity and a TGRI of 0 or +1 for the unit. This translates to a change to beneficial management.

We have found the GRI to be extremely useful on the West Terror allotment and other allotments where we are using it. It displays the effects of current management in a concise and easily understood manner. It is providing rapid feedback on the effects of management and by emphasizing plant responses, it has reduced the value judgments common to utilization monitoring.

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Applied Range Research Needs in the Next Century

Francisco Molinar, Hilton de Souza Gomes, Jerry L. Holechek, Dee Galt, and Leonel Barraza-Pacheco

We consider the lack of applied research to be a serious worldwide problem confronting range managers. In Latin American countries where the authors have had considerable experience, applied range research is almost non-existent. This problem is further compounded by a low level of application of existing range research. We recognize that over one half of the ranchers on public and private rangelands in the USA and many Latin American countries are small operators who often lack motivation to improve land condition or their monetary returns from ranching. This is a major rangeland problem in itself, which may increase as rangelands become more fragmented from human population increases. We will discuss applied range research needs by placing particular emphasis on the southwestern United States and Latin America.

Drought Research

Drought has long been the nemesis of ranchers in the western United States and Mexico. Periodic severity of winter has been an additional climatic risk in the northern United States. Climatic research from the southwestern U.S. indicates that drought is cyclic and somewhat predictable (Betancourt 1996). In the southwestern United States about 3 years out of every 10 are characterized by drought (Holechek 1996). Twenty year periods of below average precipitation tend to alternate with 20 year wet periods. About every 50 to 60 years a 5-7 year period of extended drought can be expected. The predictability of climatic patterns in other parts of the U.S. and the world are less well understood. However, there is some evidence that climatic patterns that are more or less predictable exist in all parts of the world. Research is needed to better understand long term (500–2,000 years) climatic history of the different parts of the world. If this information is effectively transferred to ranchers, it could greatly improve their capability to deal with climatic risk. Better management of climatic risk through stocking rate adjustment, herd composition adjustment, strategic use of range improvements, grazing systems, and insurance programs has considerable capability to improve both rancher and rangeland welfare.

During the recent (1993–1996) drought in Mexico the authors were contacted by many ranchers interested in information on how one or two years of heavy or severe grazing use would impact future forage production and land condition. Our analysis of the literature showed little information is available on this subject other than a

La Necesidad de Investigaciones Aplicadas para el Próximo Siglo

Francisco Molinar, Hilton de Souza-Gomes, Jerry L. Holechek, Dee Galt, and Leonel Barraza-Pacheco

Consideramos que la falta de investigaciones aplicadas es un serio problema que confrontan investigadores en el área de manejo de pastizales a nivel mundial. En paises de América Latina donde los autores han adquirido considerable experiencia, la investigación aplicada es casi inexistente. Este problema se agrava por un bajo nivel de utilización de investigaciones hechas en otros lugares. Reconocemos que alrededor de la mitad de los ganaderos en terrenos públicos y privados en Los Estados Unidos y en varios paises de América Latina son operadores de tamaño pequeños, los cuales con regularidad tienen poca motivación de mejorar las condiciones de sus pastizales y el retorno económico obtenido por la actividad ganadera. Este es por sí mismo un serio problema, el cual podría agravarse si los pastizales continúan fragmentándose debido al incremento de la población humana. En este contexto discutiremos la necesidad de investigaciones aplicadas, poniendo particular énfasis en el suroeste de los Estados Unidos y paises de América Latina.

Investigaciones sobre la Sequía

Las sequía ha sido por mucho tiempo un serio problema para los ganaderos del suroeste de los Estados Unidos y norte de México. Severos inviernos son un riesgo climático adicional. Investigaciones sobre el clima indican que la sequía en la región es cíclica y de alguna manera previsible (Betancourt 1996). En el suroeste de los Estados Unidos y norte de México, alrededor de 3 de cada 10 años son caracterizados por la sequía (Holechek 1996). Períodos de veinte años de precipitación pluvial por debajo de la media normal tienden a alternar con otros veinte años de precipitación sobre la media normal. Asimismo, alrededor de cada 50 a 60 años pueden esperarse períodos de 5 a 7 años de sequía continua. Patrones climáticos en América del Norte y otras partes del mundo son difíciles de interpretar. Sin embargo, existen evidencias para concluir que patrones hasta cierto punto predecibles existen en todas partes del planeta. Por lo tanto, se necesitan mas investigaciones para entender mejor dichos patrones del clima a largo plazo (500 a 2,000 años atrás) en diferentes egiones. Si esta información es transferida correctamente a los ganaderos, podría mejorar significativamente

couple clipping studies (Cook 1971, Trlica et al. 1977). These studies indicate that one or two years of heavy use might have long lasting adverse impacts on vigor and productivity of some forage plants in arid and semi-arid areas. However other range professionals have questioned whether a year or two of heavy use has any lasting impact on plant productivity assuming it is not repeated year after year. We recognize this probably depends on the type of plant and environmental conditions under which it is found, but believe it needs better resolution.

Soil Erosion

Soil erosion is still a problem on U.S. rangelands, but it has been substantially reduced in most regions over the last 15 years (USDA 1997). Throughout Latin America, soil erosion remains a serious threat to rangeland health. During the mid 1990s drought in northern Mexico, large areas of rangeland soils were exposed to wind and water erosion. However, the magnitude of the problem was not quantified and government programs were not put in place to remedy it. Very little information is available on how herbaceous material affects erosion rates and productivity of soils in Latin American countries. The authors believe this problem should receive much more emphasis in Mexico and other Latin American countries.

Grazing Management Research

Stocking Rates

Rangeland damage from heavy grazing still remains a serious problem in most parts of the world, particularly Latin American and African countries. Although some excellent stocking rate studies are available from the grassland and forest rangelands in the United States, information is quite limited for desert areas. Stocking rate studies are virtually non-existent for Latin American countries. This lack of information makes it difficult to implement extension programs that help Latin American ranchers properly stock their rangelands. We believe that long term stocking rate studies such as those from the Great Plains in the USA (Klipple and Costello 1960, Sims et al. 1976) should receive high priority in Latin American range research programs. We consider their demonstration benefits to be as great as their scientific values. Many of the grazing studies in the U.S. reviewed by Holechek et al. (1999) are transferable to portions of Mexico and other Latin American countries. These studies should receive greater application in development of range management programs in Latin America.

su capacidad para tratar con los riesgos climáticos. Un mejor manejo de la sequía a través del ajuste de la carga animal en potreros, la composición del hato, los usos estratégicos del mejoramiento de pastizales, los sistemas de rotación de ganado y programas de implementación de seguros contra riesgos, tienen la capacidad de mejorar el bienestar tanto del ganadero como de los pastizales o terrenos de agostadero.

Durante la reciente sequía en el norte de México (1993–1996), los autores fueron contactados por ganaderos e investioadores interesados en información acerca de cómo uno o dos años de pastoreo severo podrían impactar la producción de forraje y las condiciones generales de los pastizales. Nuestro análisis de literatura muestra que existe poca información sobre el tema. Solo se encontraron un par de estudios (Cook 1971, Trlica et al. 1977). Los resultados indican que uno o dos años de pastoreo severo podrían tener efectos adversos a largo plazo. Efectos que reducen el vigor y la productividad de plantas forrajeras en zonas áridas y semiáridas. Sin embargo, otros profesionales en el área de pastizales, cuestionan los efectos negativos del pastoreo severo durante uno o dos años, asumiendo que esta aseveración no es general, ya que períodos continuos de baja precipitación no se repiten año con año. Reconocemos que esto probablemente dependa del tipo de planta y las condiciones ambientales que la rodean, pero creemos a la vez que se necesitan mas estudios para obtener resoluciones más acertadas.

Erosión de Suelos

La erosión de suelos sigue siendo un problema grave en los Estados Unidos, sin embargo, ésta ha sido reducida en la mayoría de las regiones en los últimos 15 años (USDA 1997). En diversas partes de América Latina, la erosión de suelos continúa siendo un serio problema para la estabilidad de los pastizales. Durante la sequía de mediados de los 90's en el norte de México, extensas áreas fueron expuestas a la erosión por el sobrepastoreo y factores tales como el viento y el agua. Sin embargo, la magnitud del problema no fué cuantificada y los programas de gobierno nunca fueron llevados a cabo para remediar el problema. Poca información existe sobre cómo la cobertura de plantas herbáceas afecta las tazas de erosión y productividad de los suelos en paises de América Latina con extensas zonas de pastizales y cuyas economías dependen en

Grazing Systems

Great interest still exists in the use of rotation grazing schemes to improve grazing capacity and land condition. The Merrill 3 herd/four pasture system has been well proven for south Texas rangelands from vegetation, livestock, wildlife, and financial standpoints (Conner and Taylor 1988, Taylor et al. 1993). In Mexico, Brazil, and several other areas grazed year long but with seasonal precipitation, a modification of the Merrill system is theoretically sound, and has been used by some ranchers. Under this modification, the ranch is divided into 4 pastures and each pasture receives growing season non-use once every 4 years. During the dormant season, stocking rates are adjusted so all pastures will receive near equal use. Replacement heifers and other animals with high nutritional requirements can be placed in the deferred pasture during dormancy. This type of system is fairly simple to operate and practical for many ranchers. At moderate stocking rates (35–40% use), it should theoretically give improvement in sacrifice areas (riparian zones, watering points), increase key forage plants, and improve livestock performance. However, its actual biological and financial effectiveness has not been evaluated.

The Holistic Resource Management approaches of Savory (1988) are being widely applied in Latin America. Although Holistic Resource Management has been experimentally evaluated in the Great Plains of the USA, research is lacking for arid areas of the world such as the Chihuahuan Desert. Savory contends it is these harsh or "brittle" areas where it can provide some of its greatest benefits, while others question its suitability for arid areas. More thorough scientific evaluation is needed for Savory's time control grazing methods and ideas.

Grazing Timing

One of today's bigger controversies in range management centers around the importance of grazing intensity versus grazing timing or frequency (Holechek et a. 1998b). Although existing research generally indicates that grazing intensity is the most critical aspect of grazing management, information is somewhat limited on this subject. Many range managers believe that range plants can withstand higher grazing intensities during dormant periods than active growth. However, this viewpoint is contradicted by studies in Nevada, Arizona, Oregon, and New Mexico (Holechek et al. 1998b). This

gran medida de la producción pecuaria. Los autores consideran que en paises como México, Brasil, Paraguay y Argentina, este problema debería recibir mayor énfasis por parte de investigadores y gobiernos.

Investigaciones en el área de Manejo del Pastoreo

Capacidad de Carga Animal

El daño a los pastizales debido al pastoreo severo continúa siendo un serio problema en la mayoría de las regiones del planeta, particularmente en paises de América Latina y Africa. A pesar de que existen estudios muy completos sobre la capacidad de carga en zonas forestales y praderas húmedas de los Estados Unidos, la información sobre zonas áridas y semiáridas es bastante limitada. Estudios sobre la capacidad de carga animal en América Latina son prácticamente inexistentes. Esta falta de información hace difícil la aplicación de programas de extensión, los cuales ayudarían a productores pecuarios a implementar propiamente las cargas animales en sus ranchos con la finalidad de mantener sus pastizales en buen estado, incluso durante los años de sequía. Los autores creemos que estudios sobre la implementación de capacidades de carga a largo plazo (Kipple y Costello 1960, Sims et al. 1976, y Molinar 1999), deberían recibir alta prioridad en programas de investigación en América Latina. Consideramos que sus resultados tienen gran valor científico en el campo de la investigación práctica aplicada. Asimismo, otros estudios reseñados por Holechek et al. (1999) son transferibles a porciones de México y otros paises latinoamericanos. Todos estos estudios deberían recibir mayores aplicaciones en programas de desarrollo en el campo del manejo y mejoramiento de pastizales en América Latina, particularmente en México, donde recientes sequías asociadas a la mala planeación de los programas de mejoramiento de pastizales y severas crisis económicas, han ocasionado la sobreexplotación de extensas zonas de pastizales (Molinar et al. 1998). Los autores creemos que se necesitan urgentemente estudios sobre el cálculo correcto de carga animal para recuperar áreas de pastizales que continúan bajo pastoreo intenso, particularmente en el norte de México.Estos estudios implican una metodología

controversy has caused some range professionals to reject prescription approaches to grazing management involving set livestock numbers for set time periods. Instead, they advocate flexible grazing systems that strive to continually keep livestock numbers in balance with forage supplies. In our opinion, research is needed that evaluates and compares biological and financial outcomes from both approaches.

Spacing of Watering Points

Applied research is quite limited on the impact of distance to water on livestock performance. This is an important issue since it affects the decision on the number of watering points needed to efficiently operate a ranch. Nearly all of the research available on this subject comes from Australia with the exception of studies in southeastern Oregon by Sneva et al. (1973) and Wyoming (Hart et al. 1989). Research from southeastern Oregon and Australia indicates cattle productivity is reduced if they have to walk over one mile between feed and water. However research on this relationship is lacking for other parts of the world and for different breeds of cattle and sheep.

Livestock Productivity Versus Slope

Several studies have evaluated cattle use of different slope gradients on mountain rangelands (see reviews by Vallentine 1990 and Holechek et al. 1998a). However, with the exception of a few studies from Spain, information is almost totally lacking on how livestock use of different slope categories affects their productivity. This knowledge would be useful in refining stocking adjustments for slope, and in decisions on whether or not to cull animals that make use of only the flatter areas. Because of greater energy expenditure, livestock using rugged terrain may have reduced productivity compared to those using only flat areas. On the other hand, their productivity might be increased over those using flat areas because of access to more and higher quality feed. This, however, remains to be experimentally evaluated.

sencilla cuya eficacia depende de la selección correcta de las areas claves para el muestreo. Las herramientas son solamente la habilidad del investigador y su equipo de trabajo, el establecimiento de transectos o líneas de medición, así como el uso de cálculos matemáticos sencillos, los cuales pueden llevarse a cabo con una calculadora de bolsillo. Ejemplos de cómo calcular la carga animal a niveles de pastoreo moderado en zonas áridas pueden verse de forma explícita en los trabajos llevados a cabo en el sur de Nuevo México por Molinar (1999). Consideramos de suma importancia que los investigadores en el área de manejo de pastizales lleven a cabo esta metodología en el campo y que entrenen al productor sobre los cálculos pertinentes.

Sistemas de Pastoreo

Existe gran interés en el uso de esquemas de rotación de ganado. Su finalidad es el mejorar la capacidad de carga y las condiciones del terreno. El esquema de "Merril" que consta de 3 hatos y 4 potreros, ha funcionado existosamente en el sur de Texas desde el punto de vista del bienestar suelo- vegetatación - rendimiento del ganado, así como la fauna silvestre y el retorno económico (Conner y Taylor 1988, Taylor et al. 1993). En el norte de México, noreste de Brasil y otras regiones donde existe el pastoreo contínuo y precipitaciones pluviales definidas (es decir mayormente durante una estación del año), una modificación del esquema de "Merril"es teóricamente aplicable, e inclusive ha sido utilizada por algunos ganaderos. Bajo esta modificación, el rancho es dividido en cuatro potreros y cada uno de estos recibe un período de descanso durante la etapa de crecimiento cada cuatro años. Se considera la etapa de crecimiento de forraje durante los meses de junio a septiembre. Durante la temporada de dormancia, las tazas de carga animal son ajustadas con la finalidad de que todos los potreros reciban una utilización semejante. Asimismo, durante la temporada de dormancia, las terneras de reemplazo y otros animales con mayores requerimentos nutricionales puden ser aposentados en el potrero sujeto previamente a descanso. Este tipo de rotación de ganado es bastante sencillo de operar y resulta práctico para el ganadero. Si se aplican tazas moderadas de utilización de la parte aérea de las plantas (35–40%), consideramos que podrían

Supplemental Feeding

We believe a better understanding is needed regarding the interaction of stocking rate and supplemental feed needs on range livestock production. Descriptive studies from Arizona and New Mexico indicate that conservative stocking involving 30–35% forage use greatly increases calf crops and calf weight gains over heavier levels. Fewer animals reduce administrative effort (monitoring, record keeping) and labor needs. At the same time supplemental feed needs are drastically reduced or eliminated in most years. This appears to more than compensate for the lower harvest efficiency of conservative stocking in terms of financial returns (Holechek 1992). However actual experimental evaluation is lacking.

Common Use Grazing Research

We believe more research is needed on how dual use by different types of livestock and wildlife impacts rangelands. In New Mexico nearly one-half of the forage is allocated to elk on some Forest Service allotments. Elk seem to prefer areas previously grazed by cattle. Many riparian areas receive heavy use due to repeated elk grazing after moderate use by cattle. There is some evidence that when elk receive over 25–30% of the grazing capacity on an allotment, it becomes quite difficult to avoid damage to riparian and other convenient areas. This, however needs to be studied.

Ranching Economics

We believe there are great voids that remain unfilled in rangeland finance and economics. As an example very little information has been published on the profit potential of diversified ranching operations. One report (Olmstead 1997) indicates that demand is rapidly rising for the western dude ranching experience. Rates per person range between $600 and $2200 for one week. Assuming this is true it seems many ranchers have a potential gold mine. However there could be costs and other problems that make dude ranching far less profitable and more risky than it appears.

We believe research is needed on the range in profitability of ranching operations in different areas. An analysis by Holechek (1992) indicates that New Mexico surveys (Torell and Word 1993) that quantify the actual profitability of the average ranch are not necessarily indicative of potential ranching profitability. This is because ranchers vary greatly in their management skills, and individual ranches differ greatly in their physical and ecological conditions. Under conditions of superior management, enterprise diversification, and high rangeland ecological condition annual returns on investment of 10–15% may be possible for medium to large (250–700 animal unit) western ranches. While the authors believe it probable that most ranches in the western United States are operating well below their profit potential, this needs more thorough examination. The authors believe ranchers are no different than other businessmen. Most

mejorarse significativamente las condiciones en las áreas de sacrificio (áreas alrededor de los bebederos, areas con arroyos o rios). Asimismo, se podría incrementar la producción de plantas forrajeras claves y mejorar el rendimiento del ganado.

Sin embargo, la efectividad biológica y financiera de esta propuesta necesita ser evaluada con mas detalle.

La propuesta de "manejo holístico de los recursos" de Savory (1988) ha sido aplicada extensivamente en América Latina. Si bien esta propuesta ha sido evaluada experimentalmente en las grandes planicies de Estados Unidos, hace falta más investigación acerca de su efectividad en zonas áridas como el Desierto Chihuahuense. Savory afirma que és en estas áreas extremosas, y frágiles donde su propuesta aporta los mayores beneficios. Sin embargo, otros autores cuestionan su efectividad. Por lo tanto, mayores evaluaciones científicas son necesarias para determinar el nivel de eficacia del método de Savory (control de tiempo de pastoreo) en zonas áridas.

Tiempo de Pastoreo

En la actualidad, una de las mayores controversias se centra en la intensidad del pastoreo comparada con el tiempo y la frecuencia del pastoreo (Holechek et al. 1998b). A pesar de que la literatura existente generalmente indica que la intensidad del pastoreo es el aspecto más crítico en el manejo del aposentamiento, la información sobre este tema es limitada. Varios investigadores en el manejo de pastizales consideran que las plantas resisten mayores intensidades de pastoreo durante los períodos de dormancia que durante la etapa de crecimiento. Sin embargo, este punto de vista contradice a los estudios hechos en Nevada, Arizona, Oregon y Nuevo México (Holechek et al. 1998b). La controversia ha ocasionado que algunos profesionales en el área del manejo de pastizales rechacen los métodos prescritos que sugieren la colocación de cargas animales por períodos de tiempo determinados. En cambio, avocan el uso de sistemas de pastoreo flexibles, los cuales mantienen la carga animal en balance con la cantidad de forraje existente. En nuestra opinion, se necesitan investigaciones que evalúen y comparen los resultados biológicos y financieros de ambos métodos.

Espaciamiento entre Bebederos

Las investigaciones sobre el impacto de la distancia que el ganado precisa caminar para beber agua y su efecto en el rendimiento (taza de natalidad, producción de carne) son bastante limitadas. Este es un tema fundamental, ya que afecta las desiciones sobre el número de bebederos o aguajes necesarios para operar el rancho de una manera eficiente. Casi todas las investigaciones sobre el tema provienen de Australia, con excepción de los estudios llevados a cabo en el sureste de Oregon por Sneva et al. (1973) y Wyoming (Hart et al. 1989). Las investigaciones en Australia y el sureste

There is evidence that this has greatly increased property tax levels over what they would be under well planned development.

of them will change how they operate if they can be convinced it will truly increase their profits and/or lower their risk levels.

Urbanization Effects on Rangelands

Large urban areas are developing in several parts of the western United States such as around Denver, Colorado; Albuquerque, New Mexico; Phoenix, Arizona; El Paso, Texas; Boise, Idaho; Salt Lake City, Utah; and Las Vegas, Nevada. This is also happening in rangeland areas in Latin America and Africa. Almost no information is available on the amount of rangeland being lost to urbanization and how this is impacting local economies. However, a recent report indicates around 1.5 million acres of rangeland may have been lost per year to development during the 1990's in the U.S. (USDA 1997). Information is also lacking on how poorly planned urbanization is impacting local tax levels for home owners, farmers, and ranchers. Large zones of low density housing now surround most western USA cities. There is evidence that this has greatly increased property tax levels over what they would be under well planned development. Water tables are being lowered in many localities which may adversely affect rangeland productivity and water availability for livestock. Ranching becomes more difficult when sub-divisions are scattered through grazing lands (Huntsinger and Hopkinson 1996). However, the short and long term impacts of this type of urbanization have not been well quantified, and their future impacts on social welfare are poorly understood. We believe that this aspect of rangeland management needs to be much better studied. Holechek et al. (1998a) considered the loss of space and the resulting social conflicts from urbanization to be some of the most important problems confronting range managers in the 21st century. We believe developmental strategies are needed that strike an optimization among economic development, preservation of open space (rangeland) and equitable taxation.

de Oregon indican que la productividad del ganado se reduce si éste tiene que caminar más de una milla entre las zonas de forraje y el bebedero. Sin embargo, consideramos que hacen falta más investigaciones sobre el tema en otras regiones del mundo, asi como para diferentes razas de ganado bovino y ovino.

Productividad del Ganado vs. la Pendiente del Terreno

Algunos estudios han evaluado la utilización de forraje en regiones montañosas con diferentes gradientes de inclinación de terreno (ver las revisiones de Holechek et al. 1988a y Vallentine 1990). Sin embargo, con la excepción de algunos estudios hechos en España, existe una falta total de información sobre cómo los diferentes gradientes de inclinación afectan el rendimiento y la productividad animal. Los autores consideramos que estos conocimientos podrían ser de gran utilidad en el refinamiento del ajuste de la capacidad de carga de acuerdo a la pendiente del terreno y en desiciones tendientes a deshacerse o no de animales que hagan uso de las areas planas solamente. Debido al mayor gasto de energía, el ganado bovino en terrenos rugosos podría tener menor productividad que al ganado aposentado en áreas planas. Sin embargo, su productividad podria incrementarse debido a la disponibilidad de forraje de mejor calidad y mayor cantidad en zonas de difícil acceso para aquellos animales que utilizan sólo las areas planas. Por lo tanto, consideramos que esto necesita ser evaluado experimentalmente.

Suplemento Alimenticio

Los autores pensamos que se necesita de un mejor entendimiento referente a la interacción entre la carga animal y la necesidad de suplemento alimenticio. Estudios descripitivos provenientes de Arizona y Nuevo México indican que bajo niveles de pastoreo conservador (utilizando del 30 a 35 % del forrage) se incrementan significativamente las tazas de natalidad y el peso de los becerros. Asimismo, un menor número de animales requiere de menores gastos administrativos (monitoreo, mantenimiento de registros y mano de obra). Al mismo tiempo, el costo por suplementos alimenticios podría reducirse o eliminarse en la mayoría de los años. El ahorro en los costos compensaría al productor en caso de existir una baja natalidad dentro de un sistema de pastoreo conservador, esto expresado en términos de retorno económico (Holechek 1992). Sin embargo, esto requiere de más investigaciones.

Range Improvements

Without question the rangeland resource base in the United States and other parts of the world will shrink in the 21st century. This will result from increasing human populations (at least 50% more people in the world by 2050) and rising affluency in developed countries like the USA. Every acre of land will have greatly increased value even if only used for open space, wildlife, and esthetics. Therefore, we believe there will be a major push to increase the productivity of remaining rangeland. Both seeding and vegetation manipulation on degraded rangelands will probably receive more emphasis than in the past 20 years. We believe demand will grow for native plant species that can be used in range seedings. It is also probable fire will receive increased emphasis in vegetation manipulation because it is cheaper and more acceptable to conservation groups than herbicides. There is great need for more cost effective methods for rangeland improvement. In the future these efforts will need to focus more on restoration of native communities, particularly on public lands.

Other Research Needs

Other areas where the authors believe more applied range research is needed include evaluation of game ranching strategies and their economic effectiveness, range use efficiency and productivity of adapted cattle breeds, and response of riparian areas to livestock management strategies. Almost no information is available on plant succession in riparian communities under controlled grazing. However, many researchers have speculated riparian recovery can occur under livestock grazing (Larsen et al. 1998). This needs quantitative documentation. The benefits and drawbacks of herding livestock in mountainous areas to improve distribution needs better evaluation.

Improving Applications of Range Management Technology

We find it somewhat mystifying that the Society for Range Management is confronting a serious drop in membership when knowledge, its most important product, is most needed. In Mexico, the Mexican Society for Range Management, an important source of information not only for the country, but also for other Latin American Countries, is facing the same problem. While the authors do not have all the answers on this subject it does alarm us. It is our experience that ranchers and natural resource conservation groups, alike, seem to lack awareness of range management technology. This has to some extent been confirmed by recent surveys (Brunson and Steel 1994, Rowan et al. 1994).

Uso comun de los Pastizales

Se necesitan más investigaciones referentes al impacto causado por la interacción del ganado y la fauna silvestre en los pastizales. En Nuevo México, aproximadamente la mitad del forrage en terrenos administrados por el Servicio Forestal es asignado al consumo por alces. Esta especie parece preferir áreas anteriormente sujetas al pastoreo de vacunos. Generalmente, las areas en las laderas de rios y arroyos con vegetación de galería reciben pastoreos intensivos por parte del alce, esto después de haber sido utilizadas en forma moderada por el ganado. Existen evidencias para indicar que cuando los alces ocupan del 25 al 30 % de la capacidad de carga del terreno, se torna difícil el evitar el daño a las áreas aledañas a rios y arroyos con vegetación de galería.

Economía de Ranchos Ganaderos

Los autores consideramos que existen grandes vacíos por llenar en el área de las finanzas y la economía de ranchos ganaderos. Por ejemplo, poca informacion ha sido publicada sobre la potencial ganancia al diversificar las operaciones en el rancho ganadero. Un reporte publicado por Olmstead (1997) indica que las demandas por vacacionar en ranchos ganaderos del suroeste de Estados Unidos donde se realicen actividades como montar a caballo y arriar ganado, se han incrementado considerablemente. El costo por persona varía de $600 a $2200 dolares por semana. Asumiendo que esto es cierto, parece que algunos ganaderos tienen una potencial mina de oro. Sin embargo, pudieran existir costos y otros problemas que pudieran hacer este tipo de actividad menos provechosa y con mayores riesgos de lo que aparentemente podria parecer.

Creemos que deben llevarse a cabo más investigaciones referentes a la rentabilidad de diversas operaciones en ranchos ganaderos. Un análisis llevado a cabo por Holechek (1992) menciona que encuestas llevadas a cabo en Nuevo México (Torrel y Word 1993) no necesariamente indican el potencial económico actual de ranchos de tamaño promedio. Esto debido a que las habilidades de manejo por parte del ganadero varian significativamente al igual que las condiciones físicas y ecológicas de los ranchos. Bajo condiciones de manejo apropiado, de diversificación de la empresa y de buenas condiciones ecológicas, pueden esperarse retornos del 10 al15 % anual en ranchos de tamaño medio y grande (250 - 700 unidades animales) en el suroeste de Estados Unidos. Los autores consideramos que probablemente la mayoría de los ganaderos en la región operan por debajo de su potencial económico. Sin embargo, esto requiere de un exámen más profundo. Asimismo, consideramos que el rancho ganadero debe ser considerado como una empresa rentable. La mayoría de los ganaderos podrían mejorar sus formas de operación si pudieran convencerse del potencial económico resultante de la diversificación de funciones. Otro factor importante es la reducción del nivel de riesgos asociados a la producción.

We have been impressed at how well ranchers have responded to applied range management information when it was provided it to them. However, the authors have encountered many ranchers and environmentalists who have never read any of the basic range management textbooks or publications from the Society for Range Management. We consider the challenge of putting range management technology into practical application to be itself a science. This issue needs to be better researched, and improved approaches need to be developed. Because most ranches may be operating well below their profit potential and conflict over rangeland issues is escalating, the authors believe improving society's knowledge of range management should be given a high priority in rangeland research.

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Efectos de la Urbanizacion sobre los Pastizales

Grandes zonas urbanas están siendo desarrolladas en el suroeste de Estados Unidos y norte de México. Zonas aledañas a ciudades como Denver, Colorado; Albuquerque, Nuevo México; Phoenix, Arizona; El Paso, Texas; Juárez, Chihuahua; Cd. de Chihuahua, Chihuahua y Monterrey, Nuevo León son claros ejemplos. Esto también sucede en regiones con pastizales de América del Sur y Africa. Sin embargo, casi no existe información disponible sobre la cantidad de áreas perdidas anualmente debido a la urbanización y su efecto sobre las economías locales. Un reporte reciente indica que sólo en los Estados Unidos, alrededor de 607,500 hectáreas de pastizales podrían perderse al año durante la actual década de los 90's (USDA 1997).

También hace falta información sobre cómo la pobre planeación urbana impacta los niveles de cobro de impuestos tanto para los dueños de casa habitación, como para los agricultores, los ganaderos y otras actividades económicas. .Amplias zonas de baja densidad de casas habitación rodean a la mayoría de las ciudades en los Estados Unidos y México. Esto implica el llevar los servicios básicos a lugares distantes incrementando por lo tanto los costos de instalación. Estos fondos públicos se obtienen directamente del aumento de impuestos locales. Asimismo, existen evidencias para afirmar que esto incrementa también el impuesto a pagar sobre la propiedad. Por otra parte, los mantos freáticos son abatidos en muchas localidades, lo que afecta directamente a la productividad del pastizal y a la disponibilidad de agua para el ganado. La actividad ganadera se vuelve difícil cuando existen subdivisiones a través de los terrenos de agostadero (Hutsinger y Hopkinson 1996). Sin embargo, los efectos de la urbanización a corto y largo plazo no han sido bien cuantificados y sus futuros impactos en el bienestar social son pobremente entendidos. Creemos que este aspecto del manejo de pastizales necesita de sondeos e investigaciones más a fondo. Holechek et al.(1998a) considera que la pérdida de espacios abiertos y los conflictos sociales debido a la urbanización, son algunos de los problemas más serios que confrontan los investigadores en el area del manejo de pastizales en el siglo XXI. Los autores consideramos que se requieren de estrategias de desarrollo que solucionen inmediatamente el problema y a la vez presenten estrategias de optimización entre el desarrollo económico, la preservación de los espacios abiertos (pastizales) y un cobro justo y equitativo de los impuestos.

Mejoramiento de los Pastizales

Sin duda alguna, los pastizales en el continente americano y otras partes del mundo se verán reducidos en el siglo XXI. Esto como resultado del incremento de la población humana (por lo menos 50% más para el año 2050). Cada hectárea de terreno tendrá un incremento

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de valor si se utiliza sólo para espacios abiertos, criaderos de vida silvestre y áreas de recreo. Por lo tanto, creemos que habrán mayores presiones para aumentar la productividad en aquellos pastizales que continuen sin urbanizar. Probablemente la siembra de pastos y la manipulación de la vegetación en zonas con diferentes niveles de degradación ecológica recibirán una mayor atención que en los últimos 20 años. Consideramos que existirá un incremento en la demanda de especies nativas que puedan ser utilizadas en programas de revegetación. También es factible que métodos de manipulación de la vegetación como el uso de" fuegos controlados" adquirirán una mayor importancia, debido a su bajo costo de operación y a la aceptación por parte de los grupos ambientalistas, los cuales se oponen al uso de herbicidas. Creemos que existe una gran necesidad de investigaciones que exploren el costo de los diferentes métodos para el mejoramiento de los pastizales. En el futuro, estos métodos se enfocarán más a la restauración de comunidades nativas, particularmente en zonas degradadas.

Otras Necesidades de Investigación

Los autores creemos que se necesitan más investigaciones tendientes a evaluar el retorno económico proveniente de la caza controlada en ranchos ganaderos; sobre la eficiencia y productividad de razas adaptadas a las condiciones del pastizal, asi como la respuesta ecológica de las tierras húmedas (aledañas a rios y arroyos) a la rotación del ganado. Casi no existe información sobre la sucesión de plantas en tierras húmedas sujetas al pastoreo controlado. Sin embargo, varios investigadores especulan que la recuperación de las tierras húmedas si puede llevarse a cabo bajo estas condiciones (Larson et al. 1994). Sin embargo, ésto requiere de cuantificaciones más detalladas. Por otra parte, se necesitan mayores evaluaciones para cuantificar los beneficios y desventajas del pastoreo en áreas montañosas, con la finalidad de mejorar la distribución de los hatos.

Mejoramiento en la Aplicación de Tecnologías en el Manejo de Pastizales

Los autores consideran desconcertante el hecho de que la membresía de la Sociedad para el Manejo de Pastizales (Society for Range Management) ha decaído considerablemente. Creemos que esta reducción es un hecho crítico, ya que es en la actualidad se necesitan mas conocimientos e investigaciones sobre el manejo y conservación de los pastizales. En México, la Sociedad Mexicana para el Manejo de Pastizales, una importante fuente de información en el pais y América Latina, sufre del mismo problema. Aunque los autores no tenemos todas las posibles respuestas a este fenómeno, consideramos que es alarmante. Asimismo, nuestra experiencia en el campo, indica que tanto algunos ganaderos como grupos conservacionistas, carecen de la información necesaria sobre nuevas tecnologías para el manejo y conservación de los recursos naturales. Esto ha sido confirmado en encuestas recientes (Brunson y Steel 1994, Rowan et al. 1994).

Los autores consideramos como altamente positivo el hecho de que algunos ganaderos respondan adecuadamente cuando se les proveé de información aplicada. Sin embargo, hemos encontrado que otros productores y ambientalistas nunca han leido los textos que tratan sobre los principios básicos, o las publicaciones existentes sobre el manejo de los pastizales. Consideramos como un reto la necesidad de poner la tecnología en un contexto que facilite su entendimiento y facil aplicación. Asimismo, creemos que la ciencia debe enfocarse más a la solución de problemas existentes y tener acceso al entendimiento general. Creemos que el mejorar el conocimiento de la sociedad en la conservación de los recursos naturales debería tener una alta prioridad en el campo de la investigación sobre manejo de pastizales.

Algunos Comentarios Finales

En paises de América Latina como México, Brasil, Paraguay y Argentina, donde los autores hemos llevado a cabo diversos sondeos, los técnicos e investigadores dependen generalmente más en métodos de prescripción. Esto es con la finalidad de obtener algo de producción como objetivo final, sin considerar el verdadero potencial del aumento de la producción pecuaria de una manera sustentable. De acuerdo con nuestro punto de vista, los métodos obsoletos utilizados por gran parte de estos investigadores, deberían ser cambiados por investigaciones científicas y prácticas. Asimismo, hemos visto un cambio gradual en la administración de la investigación por parte de los gobiernos de estos paises. Es decir que la ésta se deja cada vez más a las Universidades y a la iniciativa privada. Creemos que estos son pasos en la dirección correcta ya que los gobiernos deben actuar solo como administradores. Asimismo, es necesario llevar a cabo mas inversiones enaspectos tendientes a mejorar las condiciones de la ganaderia y la agricultura (actividades consideradas como la base de cualquier economía fuerte). Los autores consideramos que ya es tiempo de que en paises como México se le dé una mayor importancia a estas actividades. México y otros de paises América Latina dan mayor relevancia a las operaciones de manufactura (maquiladoras) sin considerar que la concentración de estos capitales atraen a mayores núcleos de población, lo cual requeriría de métodos para eficientar la producción alimenticia.. Desafortunadamente, ésto no se considera prioritario. Si se llevaran a cabo estos métodos, su finalidad sería el proveer de alimento suficiente a la creciente población, proteger al productor nacional y evitar la perdida de divisas por elevadas importaciones de alimentos. Los autores no estamos en contra de la industrialización de estos paises, sin embargo es necesario crear un balance armonizado entre todas las actividades que forman parte de cualquier economia.

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Heavy Winter Grazing Reduces Forage Production: An Observation

Dee Galt, Greg Mendez, Jerry Holechek, and James Joseph

Some range professionals have expressed a viewpoint that grazing timing has more impact on plant welfare than grazing intensity (Sharp et al. 1994, Frost et al. 1994, Burkhardt 1997). Others have challenged this idea, maintaining that intensity is the most critical aspect of grazing management (Pieper and Heitschmidt 1998, Heady and Child 1994, Holechek et al. 1998a,1998b). Controversy also centers around how much adverse impact one year or season of heavy grazing will have on subsequent forage production assuming it is followed by rest or conservative use. Although these issues are of much practical importance to ranchers, little research is available on these subjects (Heady and Child 1994, Holechek et al. 1998a).

During 1997 and 1998 we had an opportunity to test some of these ideas on a short- grass prairie rangeland in south-central New Mexico. The site had two adjacent pastures in good (late seral) ecological condition with a long history (over 10 years) of winter and spring use (mid December to mid May) by cows at conservative stocking levels. Prior to 1997, periodic range surveys showed forage production on the two pastures was nearly equal. In 1997 one pasture was shifted to conservative summer grazing with yearling cattle. On the other pasture cows continued to graze in the winter-spring period with a 50% increase in the stocking rate. Estimated percent use of forage was increased from 40-45% to 60-65%. One year later, in 1998 (July and August), both pastures received non-use. In September 1998 we evaluated vegetation composition and standing crop of forage on each pasture. This allowed us to evaluate how one year of summer cattle grazing at a conservative intensity (about 35-40% use) and one year of winter-spring grazing at a heavy intensity (about 60–65% use) would impact forage production the following growing season.

Site Description

Our two study pastures were located on the eastern edge of the Mescalero Apache Indian Reservation in south-central New Mexico. Both pastures are classified as southern plains shortgrass prairie, with wolftail and blue grama being the primary forage grasses (USDA-Natural Resources Conservation Service). They are adjacent to each other and separated by a common fence (Figure 1). Elevation of the pastures is about 5,500 feet. The pastures are on the eastern edge of the Rocky Mountains and have moderately flat terrain (slopes vary

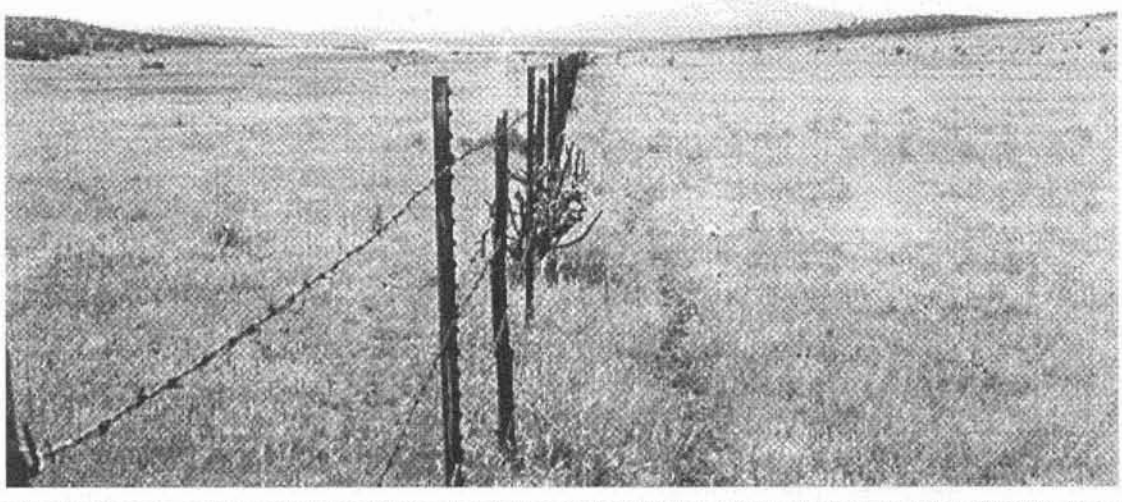

Fig. 1. *These two pastures in south-central New Mexico received moderate winter-spring grazing by cattle until 1997. In summer 1997 the pasture on the right (Deep Lake) was grazed conservatively while in winter-spring 1997-1998 the pasture on the left (Spur) was grazed heavily. In September 1998 (picture) after summer non-use (both pastures) the pasture on right had 50% higher forage standing crop than the pasture on the left.*

from 0 to 9%). Annual precipitation is about 15 inches with over 60% occurring in the summer. July and August are the wettest months, while the December through May period is relatively dry. Growing season precipitation in 1997 was about 20% above average while 1998 precipitation was near average. The last killing frost usually occurs in early April with the first frost in mid-October. Soils on the pastures are primarily moderately deep loams (3 to 6 feet).

Methods

On 4 September 1998 we selected two key areas in each pasture for our vegetation composition and forage standing crop evaluation. A permanent watering point occurs near the center of the fence that divides the two pastures. We located our key areas in each pasture about 0.8 miles east and 0.8 miles west of the watering point along the common fence, and 60 yards inward from the fence. The step point method (Evans and Love 1957) was used to quantify vegetation composition. Two, 100 yard transects were used for cover and standing crop measurements on each key area. Standing crop was estimated by clipping ten, 2.4 foot square quadrats located systematically on each by area (Cook and Stubbendieck 1986). All standing crop estimates were converted to a dry matter basis.

Results and Discussion

Vegetation Composition and Range Condition

Vegetation composition was similar on the two key areas within each pasture (Table 1). Wolftail and blue grama were the primary forage grasses on both pastures. Wolftail is considered a decreaser in response to grazing while blue grama is considered an increaser (Gay and Dwyer 1980). Rangeland ecological condition scores using the quantitative climax approach developed by Dyksterhuis (1949) and guidelines by the USDA-Natural Resources Conservation Service were 57% for the heavily grazed Spur Pasture and 61% for the conservatively grazed Deep Lake Pasture. These scores correspond to good condition or a late seral stage, and indicate that past range management has been sound. Late seral shortgrass rangelands provide a high level of forage for livestock and game animals (elk, pronghorn, mule deer), and have stable soils. Diversity in plant and wildlife species is near maximum.

Table 1. Percent composition by cover (step-point method) on south-central New Mexico rangelands conservatively grazed in summer (Deep Lake Pasture) and heavily grazed in winter-spring (Spur Pasture) on 4 September 1998.

Plant Species	Pasture	
	Spur	Deep Lake
	(% Composition)	
Wolftail	24	30
Blue Grama	22	21
Threeawns	20	4
Vine Mesquite	5	10
Silver Bluestem	2	4
Other Grasses	1	1
Total Grasses	74	70
Silverleaf Nightshade	1	1
Ragweed	6	4
Other Forbs	6	6
Total Forbs	13	11
Fringed Sagewort	8	18
Other Shrubs	5	1
Total Shrubs	13	19

Standing Range Crop

Total standing crop of forage was about 50% higher on the conservatively grazed Deep Lake Pasture compared to the heavily grazed Spur Pasture (Figure 2, Table 2). These differences were greater for perennial grasses than forbs. Prior to 1997, forage production along the fence where our key areas were located was considered to be near equal for the 2 pastures.

Table 2. Standing forage (lbs/acre) on south-central New Mexico rangelands conservatively grazed in summer (Deep Lake Pasture) and heavily grazed in winter-spring (Spur Pasture) on September 4, 1998.

Forage Component	Pasture	
	Spur	Deep Lake
	(lbs/acre)	
Perennial Grasses	352	824
Forbs	256	436
Total Forage	608	1,260

Stubble height of blue grama was evaluated when cattle were removed from each pasture prior to non-use in summer 1998. Blue grama in the conservatively grazed Deep Lake Pasture had a two inch average stubble height compared to 1.25 inches in the heavily grazed Spur Pasture. Recommended minimum stubble height for blue grama after grazing is two inches (Crafts and Glendening 1942). Blue grama stubble height below 1.5 inches indicates heavy grazing, and forage use levels in excess of 60%.

Other Findings on Grazing Intensity Versus Timing

Our observation that grazing intensity is much more critical than grazing timing is consistent with other studies in arid and semi-arid areas. In comprehensive studies of controlled timing of grazing in arid areas on the Santa Rita Range in southcentral Arizona, Martin and Cable (1974) found more perennial grass cover on yearlong than on seasonally grazed pastures. Perennial grass production was closely associated with degree of grazing use, and was highest where grazing intensity

was lowest. In this study, winter-spring grazing with summer rest and summer-fall grazing with winter rest were both inferior to year-long grazing from the standpoint of productivity of desirable perennial grasses. Perennial grass cover and production actually averaged lower on pastures grazed November to April than those grazed May to October.

Heady and Child (1994) reviewed the long term (20 year) results of various grazing management practices applied on 95 different pastures on the Vale Oregon District, Bureau of Land Management. All seasonally grazed pastures started with moderate grazing and had increased forage production during the twenty years. Season of use made little difference. The key factor in range improvement appeared to be the reduction in grazing intensities that were applied when the project was initiated in 1966.

On salt desert rangeland in Utah, one year of heavy defoliation of primary forage plants in winter and spring had long term deleterious effects on their productivity (Cook and Child 1971). After 7 years of non-use plants that had been heavily defoliated still had lower vigor than untreated plants.

Recently the effect of one year of heavy cattle grazing on subsequent forage production was evaluated in the Chihuahuan Desert of south-central New Mexico (Nsinamwa 1993). Timing of grazing in this study occurred during the summer. For several years prior to application of the moderate and heavy grazing treatments all experimental areas had been conservatively grazed. In the year following grazing treatments, forage production was reduced about 25% on heavily (60% use) compared to moderately (40% use) grazed areas. Both years of study had well above average growing season precipitation. This study showed that one year of heavy grazing, even under favorable precipitation conditions, can reduce subsequent forage production.

During the recent drought in New Mexico (1994–1996) we had considerable opportunity to observe forage production on similar rangelands with different grazing intensities. We noticed that areas receiving heavy grazing during the drought typically produced lower amounts of forage when the drought broke in 1997 than pastures where some degree of forage residue was maintained. Generally, recovery of forage plants after drought appeared closely related to standing crop levels maintained throughout the dry period. Hughes (1982, 1990) found that desert grasses were quite slow to recover from occasional years of heavy utilization regardless of season of use. We strongly agree with his recommendation that grazing use be kept within safe limits (no more than 50%) regardless of year or season.

Management Implications

The forage production data collected in September 1998 indicate that one year of heavy use on shortgrass rangeland in New Mexico during dormancy (winter and spring) can reduce forage production the following growing season as much as 50% compared to conservative or

a)

b)

Fig. 2. *Standing forage crop on Deep Lake Pasture (a) and Spur Pasture (b) after summer non-use in September 1998. The Deep Lake pasture was conservatively grazed while the Spur Pasture was heavily grazed in 1997-1998.*

moderate use. Conservative use during the growing season appears to have much less impact on subsequent forage production than heavy use during dormancy.

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Impacts of Federal Land Livestock Reductions on Nevada's Economy

ROB PEARCE, DON HENDERSON, TOM HARRIS, AND TIM TETZ

If you want to start a heated discussion, bring up the topic of public land grazing. Such public land conversations are often emotionalized and are often not based on fact. People's views can be extremely polarized. A sensitive topic related to this subject is the reduction of livestock numbers. Views on public land grazing vary; there are those who wish to see livestock removed from public lands; there are others whose livelihoods depend on livestock grazing on public lands. However, there is no doubt that livestock numbers on Nevada's public land have been reduced over the last thirty years.

Many rural communities in the Western United States depend on a healthy agricultural economic base to prosper. Livestock operations, primarily sheep and beef cattle, are a major contributing agriculture enterprise in western states like Nevada. Numerous livestock producers rely on public land grazing for continued successful ranching operations. The rural communities have strong ties to the livestock industry. This helps to provide economic stability and a fulfilling rural lifestyle to many families.

Federal land management agencies' (Bureau of land Management (BLM), US Forest Service (USFS), and National Parks) policy decisions over the past several decades have resulted in a consistent downward trend in the amount of authorized public land grazing in Nevada. Livestock producers are well aware of how previous, and on-going, grazing reductions have influenced their individual operations. However, little information is available to identify cumulative economic effects resulting from this trend to the local communities, rural counties, or throughout the State. The general public typically are unaware of how livestock reductions on public lands impact livestock producers, and associated rural economies.

Six Nevada counties (Eureka, Humboldt, Lander, Lincoln, Nye, and White Pine) and three Nevada State Grazing Boards (N-2, N-4, and N-6) initiated research to evaluate the impacts of reducing public land grazing in their respective areas. Resource Concepts, Incorporated (RCI) of Carson City, Nevada in cooperation with the University of Nevada, Reno, Applied Economics and Statistics Department conducted the research (Resource Concepts, Inc. 1998a, 1998b, and 1997). This article summarizes Nevada public land livestock reductions and the resulting economic impacts to the above regions (Figure 1).

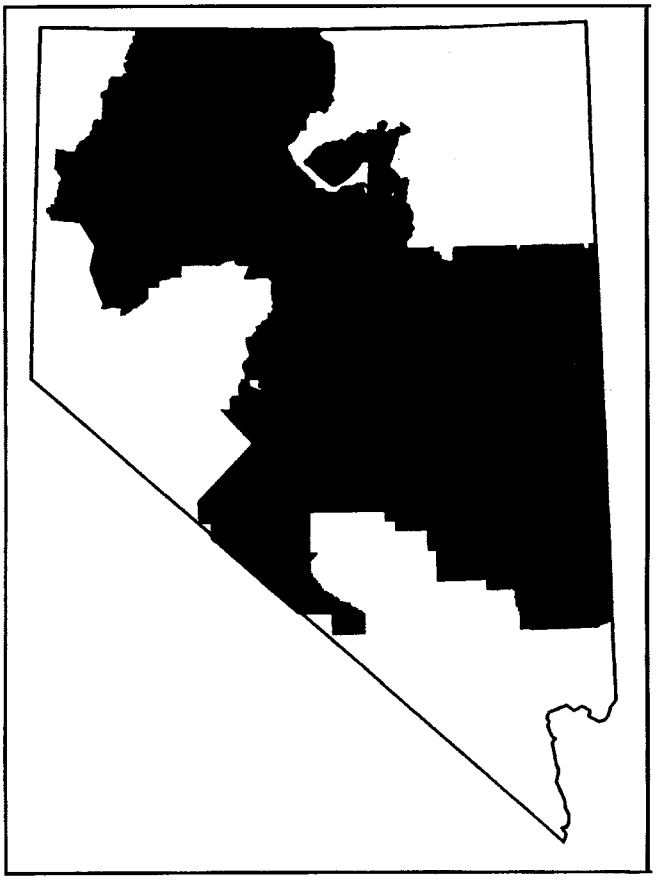

Figure 1. *Map showing the portion of Nevada covered in the grazing analyis*

Methods

Conversion of Animal-Unit-Months

The various land management agencies in Nevada use different units to designate grazing intensities. All grazing records were converted to a common unit, animal-unit-months (AUM).

Bureau of Land Management Data Collection

The BLM's National Applied Resource Center in Denver, Colorado provided a digital copy of the Grazing Authorization and Billing System (GABS) database for every Nevada BLM allotment. Grazing permit information was collected and combined at the allotment level to create the Nevada Grazing Statistics database.

This database was expanded to include the active and suspended grazing for each permittee as of 1980. This

reflected all the adjudicated (period during 1950s–1960s when the size and extent of grazing permits were established) and post adjudication actions that had occurred prior to that year. Through a series of meetings and conversations with BLM staff the updated database was corrected to include decisions and changes that had occurred since 1994 (Resource Concepts, Inc., 1994). Maps provided by the BLM Nevada State Office were used as a primary source of graphically delineating allotment boundaries

U.S. Forest Service Data Collection

The USFS Ranger Districts' staff provided grazing permit information for the period of record from 1980 to 1997. The existing permit information was combined with the regional USFS Range Management Information System (RAMIS) database. Through a series of meetings and conversations with USFS staff the Nevada Grazing Statistics database was updated. Maps provided by the Ranger District Offices were the primary source of graphically delineating USFS grazing unit boundaries.

National Park Service

Unlike most other National Parks, grazing is permitted within the Great Basin National Park. The Park was contacted in 1998 and provided information for allotments under their management.

Economic Analysis

Potential estimated economic impacts to rural Nevada resulting from livestock reductions, were calculated using the Micro IMPLAN model developed by the U.S. Forest Service. The model estimates sector and regional impacts of alternative forest management scenarios (Alward et al., 1989). The IMPLAN model has been revised by the University of Minnesota to accommodate other impacts, such as grazing reductions. Secondary data were integrated into the model using the Regional Purchase Coefficient Procedure developed by Stevens et al. (1983). Primary data were collected and put into the input-output models for impact assessment (Stoddard et al., 1995a, 1995b).

The input-output model relates how sectors of the economy interact to one another. The modeling procedure uses output multipliers to demonstrate the effect a change within one sector has on total economy. Alternate scenarios are considered to evaluate the changes in economic activity, household income, and total employment.

Direct economic impacts to the livestock sector from past livestock reductions were based on total reductions valued at 1990 gross market value. The 1990 adjusted IMPLAN model then quantified the livestock reductions economic impacts to the region. Industries such as range livestock, crops, construction, manufacturing, transportation, communication, utilities, and trade and services were included in the IMPLAN model. Assumptions for the economic analysis include:

Permitted grazing within the studied Nevada USFS Ranger Districts decreased by 33,266 AUMs between 1980 and 1997. Grazing on specified BLM lands decreased by 309,184 AUMs for the same period. Under National Park management there was a 135 AUM reduction.

The gross market value of livestock per AUM is constant and equal to $21 per AUM. This is the typical value estimated for a 1990 cow-calf enterprise in Elko County, Nevada (Torrell and Myer 1990), and for southern Idaho by Smathers et al. (1990).

No substitution between input variables was allowed. A constant, proportionate share of production factors was assumed.

All cattle sold were exported from the State at the time of sale.

Grazing permits have a market value which is eliminated without compensation whenever allowable grazing reductions are made. The current market value of Nevada grazing permits averaged $37 per AUM for BLM permits and $42 per AUM for USFS permits (U.S. Department of Interior 1993).

Results

There was a reduction in licensed livestock grazing of 342,585 animal-unit-months (AUMs) on Nevada's public lands between 1980 and 1997. Among the BLM, USFS, and Great Basin National Park there were 1,760,408 AUMs in 1980, 1,480,886 in 1995, and 1,417,823 AUMs in 1997. This reduction is estimated to result in a total annual monetary loss of $12.3 million in the affected economies, including rural communities. The economic loss to the agriculture sector is about $7.2 million (Resource Concepts, Inc. 1997, 1998a, 1998b).

The following three sections summarize specific economic impacts to the northwestern, central, and eastern regions of Nevada. Animal Unit Month (AUM) changes in Nevada by region are summarized in Table 1.

Northwestern Nevada Impacts

Economic analysis of the impact of the BLM and Forest Service livestock grazing reductions to the livestock sector shows a potential annual loss of $2,051,364 within the Northwestern Region. When other economic sectors are included in the analysis, then the estimate of the negative impact to the region is $3,697,460 annually. The estimated market value of impacted ranches in the area decreased by $3,632,038 between 1980 and 1997. These economic impacts affect both the county and state tax bases.

Eastern Nevada Impacts

The impact of the BLM, USFS, and Great Basin National Park livestock grazing reductions to the livestock sector shows a potential annual loss of $1,853,733 to local economies within the Eastern Region. When other economic sectors are included in the analysis, the

Table 1. Livestock Reductions on Federal Lands by Region in Nevada

	Northwestern Nevada Reductions		Eastern Nevada Reductions			Central Nevada Reductions	
Year	BLM	Forest Service	BLM	Forest Service	Great Basin National Park	BLM	Forest Service
1980-97 Percent decrease	23	6	15	22	NA	21	39
1980-97 AUMs decrease	94,138	3,546	88,237	9,128	137	126,773	20,592

impact to the region is a negative $3,040,122 annually. The estimated market value of impacted ranches has decreased by $3,266,101 between 1980 and 1997 affecting both the county and state tax bases.

Central Nevada Impacts

The livestock grazing reductions to the livestock sector within the central Nevada Region shows a potential annual loss of $3,094,665. With a total negative impact to the region of $5,199,037 annually. Once more, these economic impacts affect both the county and state tax bases.

Summary

The livestock sector contributes significantly toward the economic well being of Nevada's rural lifestyle. Livestock operations provide a stable long-term economic base for many agriculture based communities. Public land grazing is a vital component of Nevada's rural communities, counties, and the entire state.

The public typically view a reduction in livestock numbers for a Federal land grazing permittee as an isolated incident with few repercussions. However, there are many other individuals and sectors that feel the economic impacts. This is especially true when evaluating statewide public land livestock reductions.

Cumulative impacts from reductions in public land grazing demonstrate serious negative consequences to rural communities, counties, and to the grazing permittees. The estimated potential annual loss to rural economies resulting from livestock reductions on public lands, in northwestern, eastern, and central Nevada since 1980 is $12.3 million

Efforts are underway in Nevada to develop a statewide impact analysis of livestock grazing reductions on public lands. Evaluation of other public land states would likely demonstrate many similar impacts. This information is important for legislators, state government, and other policy makers responsible to the citizens of Nevada and the West.

If the lifestyle of rural Nevada residents is to continue, it is important for the public to understand the contribution livestock production provides to rural economies. The loss of livestock grazing in rural Nevada will significantly reduce the opportunities for rural residents. It is imperative to seek critical scientific review and timely oversight of the methodology applied to carry out grazing reductions, and to evaluate the necessity and propriety of livestock reductions on public lands in Nevada, and elsewhere in the West.

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Sustaining the People's Lands:

Recommendations for Stewardship of the National Forests and Grasslands into the Next Century

K. Norman Johnson, James Agee, Robert Beschta, Virginia Dale, Linda Hardesty, James Long, Larry Nielsen, Barry Noon, Roger Sedjo, Margaret Shannon, Ronald Trosper, Charles Wilkinson, and Julia Wondolleck

The Committee's Assignment:

In December 1997, the Secretary of Agriculture, Dan Glickman, convened an interdisciplinary Committee of 13 Scientists to review and evaluate the Forest Service's land and resource management planning process. The Committee was asked to:

- Recommend how to best accomplish sound resource planning within the established framework of environmental laws and within the statutory mission of Forest Service.
- Provide technical advice on the land and resource management planning and provide material for the Forest Service to consider in revising planning regulations.
- Recommend improvements in Forest Service coordination with other federal land management or resource protection agencies, state and local government agencies, and tribal governments.
- Suggest a planning framework under current law and policy that could last a generation.

The Committee's Approach:

The Committee met in cities around the country where it heard from Forest Service employees, representatives of tribes, state and local governments, related federal natural-resource agencies, and members of the public. The Committee used many of the approaches and improvements to planning undertaken across the country.

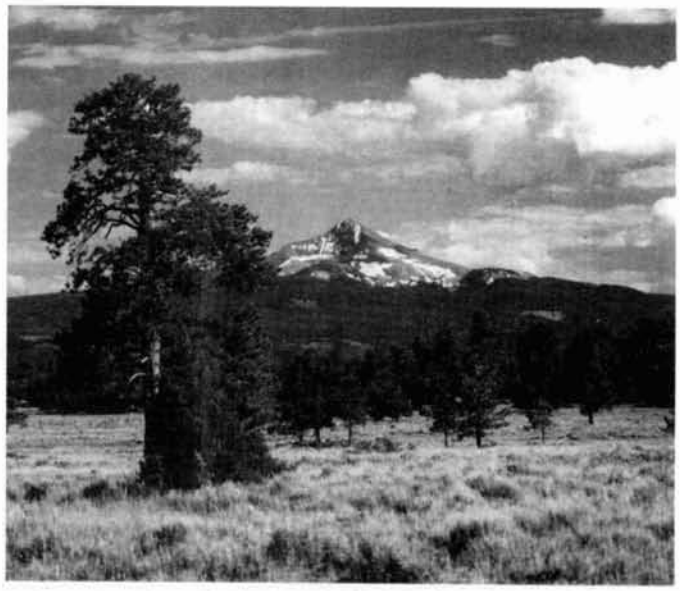
Following is a Summary of the Committees Recommendations:

1) Make Sustainability the Overarching Objective of National Forest Stewardship

The national forests and and grasslands constitute an extraordinary national legacy created by people of vision and preserved for future generations by diligent and far-sighted public servants and citizens. They are "the people's lands," emblems of our democratic traditions. These lands provide many and diverse benefits to the American people. Such benefits include: clean air and water, productive soils, biological diversity, goods and services, employment opportunities, community benefits, recreation, and naturalness. They also provide intangible qualities such as beauty, inspiration, and wonder.

The Committee believes that sustainability in all of its facets—ecological, economic, and social—should be the guiding star for stewardship of the national forests and grasslands.

Looking back across the century, a suite of laws, starting with the Organic Act of 1897, call for federal agencies to pursue sustainability. Thus, for the past 100 years, we, as a nation, have been attempting to define what we mean by "sustainability," in part through our grand experiment in public land ownership. In the process, we have broadened our focus from that of sustaining commodity outputs to that of sustaining ecological processes and a wide variety of goods, services, conditions, and values. The concept of sustainability is old; its interpretation and redefinition in this report should be viewed as a continuation of the attempt by Gifford Pinchot and others to articulate the meaning of "conservation" and "conservative use" of the precious lands and waters known as the national forests and grasslands.



Uncompahgre National Forest.

2) Ecological Sustainability: A Necessary Foundation for Stewardship

The Committee recommends that ecological sustainability provide a foundation upon which the management of national forests and grasslands can contribute to economic and social sustainability.

The Committee believes that conserving habitat for native species and the productivity of ecological systems remains the surest path to maintaining ecological sustainability. To accomplish this, the Committee suggests a three-pronged strategy:

- Maintain the viability of selected "focal" species and their habitat needs;
- Maintain conditions necessary for ecological integrity, i.e., the characteristic composition, structure, and processes of the ecosystems; and
- Monitor the effectiveness of this approach in conserving native species and ecological productivity.

The Committee has drafted regulatory language to help the Secretary understand how this strategy might be converted from concept to application.

With the Committee's recommendations, choices in management still exist about the level of risk.

3) Economic and Social Sustainability: Contributing to the Wellbeing of People Today and Tomorrow

Conservation and management of the national forests and grasslands can promote sustainability by providing for a wide variety of uses, values, products, and services and by enhancing society's capability to make sustainable choices. To accomplish this goal, the Forest Service should:

- Assess the contributions of national forests and grasslands to society.
- Recognize the interdependence of forests and grasslands with economies and communities.
- Recognize the rights of American Indian Tribes.
- Search for strategies and actions that provide for human use in ways that contribute to long-term sustainability.

4) Consider the Larger Landscapes in which the National Forests and Grasslands are Located to Understand their Role in Achieving Sustainability

Recognize the special role that national forests and grasslands play in regional landscapes.

Recognize national and global implications of managing national forests and grasslands.

5) Build Stewardship Capacity and Use a Collaborative Approach to Planning

Assess resource conditions and trends as joint public-scientific inquiries that build both a knowledge base for planning and institutions and relationships to carry out stewardship.

Work with other public and private organizations, and engage communities and citizens in envisioning and working toward a sustainable future on the national forests and grasslands.

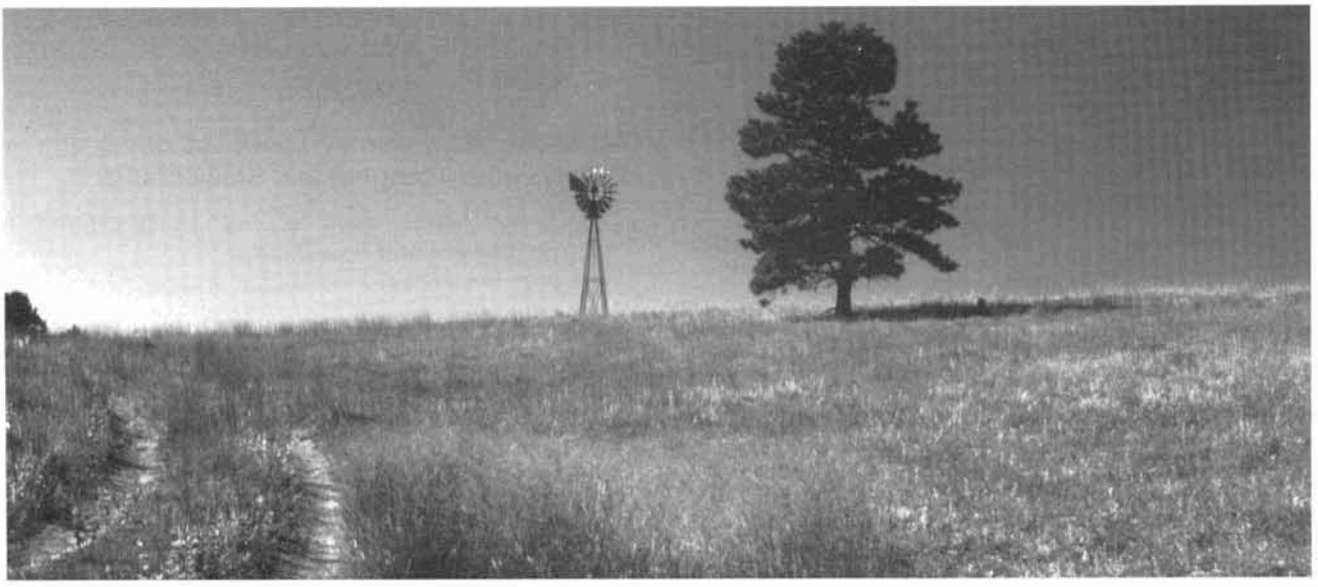
Establish collaborative relationships that provide opportunities and incentives for people to work together and contribute to forest planning in meaningful and useful ways.

Address all federal lands within the area and work, to the degree feasible, with all affected federal agencies.

Use the NEPA review process as an opportunity to coordinate across agencies and responsibilities.

Make plans understandable to the American people.

U.S. Forest Service Photo



Nebraska National Forest.

6) Make Decisions at the Spatial Scale of the Issue or Problem (Fit Decisions to the Problems)

Develop overall guidance on sustainability for bioregions.

Undertake strategic planning of large landscapes within regions for attaining long-term goals and conduct project-level planning for small landscapes.

Recognize that we need to learn systematically about successful and unsuccessful approaches to planning and set up experiments and pilots across the country to try different approaches.

7) Use the Integrated Land and Resource Plan as an Accumulation of Planning Decisions at All Levels and as an Administrative Vehicle for Plan Implementation

Make these "loose-leaf" plans dynamic and evolving, reflecting the outcomes of adaptive management.

Support local-management flexibility with independent field review.

Keep decisions close to the planning area.

Identify the suitability of land for resource management as an outcome of planning.

Use principles of efficiency and analysis in planning, plans, and management and to help determine the suitability of land for timber production.

8) Make "Desired Future Conditions" and The Outcomes Associated with Them the Central Reference Points for Planning

Establish pathways to the desired future conditions and outcomes in large landscape plans that can guide small landscape decisions.

Create incentives within the Forest Service that reward undertaking activities and achieving the conditions needed through time to move to the desired future.

9) Make Effective Use of Scientific and Technical Analysis and Review

Involve the scientific community in developing strategies for maintaining ecological, economic, and social sustainability.

Establish a national science and technology advisory board.

Involve the scientific community in designing procedures for monitoring and adaptive management.

Establish independent reviews on the use of technical and scientific information in planning.

10) Integrate Budget Realities into Planning

Set long-term goals considering likely budgets and acknowledge that actual budgets affect the rate of progress to the goals.

Consider putting more national forest goods and services, such as recreation, on a paying basis to help provide a stable-funding source.

11) Special Guidance on Watersheds and Timber Supply: Traditional Focuses of the Forest Service in Achieving Sustainability

Given the continuing attention to these two important resources, the Committee has developed general recommendations in response to language in the National Forest Management Act and other laws:

Develop a strategy for conserving and restoring watersheds:

- Provide conditions for the viability of native riparian and aquatic species.
- Maintain and restore watershed integrity; that is, maintaining and restoring the natural composition, structure, and processes of the watershed, including their flow regimes.

- Recognize watersheds in assessment and planning.
- Develop an overall strategy for setting priorities for restoration and use.
- Energize the people of the watershed to help provide stewardship.
- Monitor watershed conditions over time as part of adaptive management.

Recognize the role of timber harvest in achieving sustainability.

Recognize the need for predictable timber supplies and how adherence to sustainability increases long-term predictability.

Focus on desired conditions and the actions needed to produce these conditions, including timber harvest, in planning, budgeting, and monitoring.

Past planning, which often focused on timber harvest and the allowable cuts, tended to polarize people and groups. Planning that focuses on desired future conditions and outcomes, and the activities to achieve them, on the other hand, gives the Forest Service its best chance to unify people on the management of the national forests.

Budgeting by amount and type of actions needed, rather than volume of harvest, will ensure that the needed treatments occur.

12) Recognize External Influences on Collaborative Planning and Stewardship

The Forest Service must deal with many external influences on planning and stewardship.

Consider developing a consistent approach across federal agencies for addressing protests and appeals.

Recognize that differences exist in legal responsibilities and missions across federal agencies and that some friction is inevitable, but that a coordinated planning approach should smooth some difficulties.

Recognize that actions by Congress and the administration can undercut plans and render collaborative planning ineffective.

The complete report is available on the Forest Service website, http//www.fs.fed.us/news/science

K. Norman Johnson (e-mail: johnsonn@usc.orst.edu), forest management and policy, is professor, College of Forestry, Oregon State University, Corvallis, and was chair of the Committee of Scientists. Other members of the committee were James Agee (forest ecology), University of Washington, Seattle; Robert Beschta (forest hydrology), Oregon State University, Corvallis; Virgina Dale (landscape ecology), Oak Ridge National laboratory, Oak Ridge, Tennessee; Linda Hardesty (range ecology and management), Washington State University, Pullman; James Long (silviculture), Utah State University, Logan; Larry Nielsen (fisheries and public administration), Pennsylvania State University, University Park; Barry Noon (animal ecology), Colorado State University, Fort Collins; Roger Sedjo (natural resource economics and policy), Resources for the Future, Washington, DC; Margaret Shannon (sociology and organizational theory), Buffalo School of Law, Buffalo, New York; Ronald Trosper (forest economics and Native American studies), Northern Arizona University, Flagstaff; Charles Wilkinson (natural resource law), University of Colorado, Boulder; Julia Wondolleck (public participation and dispute resolution), University of Michigan, Ann Arbor.

Our Forgotten Rangelands

J. CRAIG WHITTEKIEND

Range resources played only a small role in the first round of national forest plans, the Society for Range Management believes, and the Committee of Scientists' proposal for identifying lands suitable for values other than timber production is still vague. But the committee's strong appeal for a collaborative approach to planning, the opportunity for involvement at multiple levels, and the emphasis on local input will help ensure that range managers can become involved. If they can't, controversy resulting from the past lack of direction for rangelands may continue.

The range management profession has followed the land and resource management planning process on the national forests with great interest since its inception in the early 1980s. We have also had a number of concerns with the way the current process affects rangeland ecosystems and issues. Because of these concerns the Society for Range Management made comments available to the Committee of Scientists for use in developing their recommendations to the Secretary of Agriculture.

The current approach to forest planning, as represented in the first round of plans, has proven cumbersome, time consuming, and expensive. Although some of this may have been unavoidable because the process was being developed along with the first plans, our fear has been that revisions and the new plans would continue on this same path. One problem with the current approach has been that the separation of planning from management and implementation has funneled both funding and personnel into planning—at the expense of other management activities.

Our recommendation was to look at planning as a continuous process in which revisions would be completed incrementally as landscape assessments were completed. In this approach, planning would be part of the continuing work process rather than an expensive special project. The Committee of Scientists' proposal for a multi-level approach linked to funding, implementation, and monitoring would package the job of resource management into one continuous flow, rather than set up planning and field programs in competition with one another for people and dollars.

Another concern has been the misunderstanding about the use of guidelines in place of objectives in efforts to implement present plans. This happens when plan prescriptions do not clearly articulate the desired condition that the guideline was designed to achieve. A planning process should lead to the development of clear objectives or desired conditions. Guidelines would then be used as monitoring tools for management practices designed to move toward the desired conditions. Obviously the committee recognized the importance of a clearly stated desired condition at each planning level, and that concept is among the recommendations.

The subject of suitability has been difficult in planning for rangeland ecosystems. The current regulations are directed at developing criteria and mapping areas suitable for timber harvest but are not particularly clear on suitability as range. This has led to litigation on some national forests in recent years. Under the current concept, forest plans should identify areas capable of and suitable for grazing, but the terms have been misused and misunderstood. *Capability analysis* is the identification of areas with physical characteristics conducive to livestock grazing: that is, areas that produce adequate forage and are accessible to livestock. *Suitability analysis* is the identification of areas already determined to be capable, where grazing is found appropriate considering economics, environmental consequences, rangeland conditions, and other uses or value of the area.

The committee has commented on the determination of suitability for various resource management practices as an activity that would take place at the large-landscape planning level. Again, the determination of lands suitable for timber production is covered, but determinations for other resource use are still vague. Since this question has been an issue subject to appeal and litigation in the past, it should be clarified more directly in future regulations.

The current approach to fish and wildlife planning is based on the selection of management indicator species, the presumption being that population changes will be indicative of both the effects of management activities and overall ecosystem health. The use of this approach has been controversial, and its scientific basis has been questioned in some instances. As an alternative we have recommended that planning focus on habitat, in terms of composition, type, structure, and quality required to meet the needs of species. The committee's recommendation of selecting "focal species" as indicators of ecosystem health, even though used in tandem with the assessment of ecosystem composition, structure, and process, seems to be similar to the current approach and may have some of the same weaknesses.

In many instances range re-

Rio Grande National Forest.

sources and issues were not sufficiently addressed in the first round of forest plans. In fact, the rangeland community was not a significant participant. This situation needs to be corrected in future efforts. The committee's strong recommendation of a collaborative approach to planning, the opportunity for involvement at two-levels, and the emphasis on local input and management will go far to involve the necessary interests in the future. However, the recommended planning process is rather general when it comes to specific resource uses. Such terms as ecosystem, landscape, and species are inclusive of rangelands, but *range* is not to be found in the proposed planning framework. My concern is that controversy resulting from a lack of direction for rangelands in past efforts may continue in the future unless there is more specific direction in future regulations.

It is encouraging that the committee is recommending the collaborative approach to planning. This is a concept that the Society for Range Management has supported for many years. Collaboration by its definition will create the cooperative environment necessary to ensure that all parties have opportunity to participate. We continue to sponsor workshops in coordinated resource management, which we feel is an effective and successful collaborative process. One caution, however, is that some participative projects can actually create new levels of bureaucracy, which may have negative effects on planning and implementation. I have seen this happen with some advisory committees.

The planning approach recommended by the Committee of Scientists includes most if not all of the elements needed to move national forest planning to a more effective level. Most people would support the idea of managing for sustainable ecosystems, but nevertheless it is not going to be easy to get general public approval. There are two words that in the course of my career I have learned to avoid when I explain resource programs to many groups: "ecosystem" (the e-word) and "sustainability." What these terms mean to many is "limitation" and "regulation."

As the Committee of Scientists has stated, planning and management must proceed in the face of legitimate but often divergent interests. I hope the future will bring an increased understanding of these concepts by all interests and that resource management will take place in a less controversial environment.

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Sustaining the Peoples' Lands: Implications for Rangeland Management

Linda H. Hardesty

As a member of the committee that authored this report, I appreciate the opportunity to respond to Craig Whittekiend's comments on behalf of the SRM, and to briefly highlight some aspects of the 193-page report for SRM members.

The most critical point I need to make is that rangelands were not overlooked in the committee's deliberations and recommendations, but are integrated throughout in the sense that all the resources of the National Forest System are intended to be managed as components of ecosystems rather than as distinct resources or programs. Other resources (minerals, wilderness etc...) are similarly spared prescriptive management attention. The resources specifically addressed in the report are limited to those that the National Forest Management Act (NFMA) required be addressed to this degree (such as timber production suitability). The scientific foundation for resource management expands daily, but regulations are only formulated periodically, hence our emphasis on the goals of management rather the management practices employed in pursuit of those goals.

Integrated resource management stands on a definition of sustainability as the state of the ecosystem being managed rather than specified levels of resource outputs. This is consistent with the direction of progress in scientific understanding in the years since the passage of NFMA. Economic and social aspects of sustainability are fundamental to the committee's approach. We do not recommend, nor intend to imply that there will be no resource outputs, only that outputs are consistent with progress towards a desired future condition that contributes to future ecosystem integrity and productivity.

The key to implementation of this approach is focus on a detailed and realistic desired future condition (DFC) for specific management areas. Often we still lack the means for establishing progress in this direction over time, especially when confounded by natural variability in many of the parameters used to describe DFC. This is the rationale for our emphasis on collaboration between scientists and managers, and on adaptive management and other types of learning processes. Monitoring management actions and resource conditions is essential for completing the feedback loops this system requires.

Other recommendations include expanded flexibility in defining the planning and decision unit: for example part of a particular National Forest, or an aggregation of several Forests or Grasslands, with the emphasis on logical resource boundaries rather than traditional administrative unit boundaries. Concurrent coordinated planning with adjacent land managers and all interested publics is strongly advocated. The goal is to accurately view the Forest Service System in the context of the larger landscape. Local management discretion is encouraged and the participatory aspects of planning and management are emphasized in a manner consistent with the use of Coordinated Resource Management. As Craig notes, these processes can be difficult and the report addresses this extensively as "building stewardship capacity".

If our vision is realized, future land and resource management plans will be concise, specific and continually evolving. Planning and management will be indistinguishable, enjoy wide public support and ensure accountable agency action. Ultimately, more agency and public energy would be invested in stewardship and enjoyment of public resources than in wrangling over their future.

A separate committee is currently drafting proposed revised regulations for implementation of NFMA. I would encourage you to offer your comment on these proposed regulations as they become available. As Craig reminds us, there remain important, range management issues for the agency to address, most outside the scope of NFMA, and I would encourage the agency and SRM to work towards their resolution. Perhaps the committee's work will provide a useful frame for these efforts.

Many SRM members assisted the committee through their thoughtful analyses, comments and suggestions. Some gave their time to meet with us. We are grateful to you all for your help and for your continuing concern for the future of our resources.

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Simulation Models and Management of Rangeland Ecosystems: Past, Present, and Future

Edited and compiled by Clayton L. Hanson, J. Ross Wight, Charles W. Slaughter, Fred B. Pierson, and Ken Spaeth

Rangeland ecosystems on public and private lands are subject to increasing pressures to meet multiple-use objectives, while managers, management techniques and plans on those same lands are subject to heightened public scrutiny. The most significant problem facing natural resource planners is that no uniform set of management guidelines fits all community types, pastures or units of land. Plant communities and associated environmental factors are multivariate in nature and interactions between plants, soils and environment are complex. Resource managers are faced with synthesizing an overwhelming amount of scientific information relative to ecology, soils, hydrology and range management principles. Innovative management tools, including simulation models and decision support systems, are needed to meet the multi-faceted challenges of rangeland ecosystems.

Models are abstractions of the real world or representations of the relationships under consideration. Simulation models have become important tools in the management of cultivated lands. However, simulation models have not been widely employed in the management of rangelands. Rangeland ecosystem process modeling has advanced to a level of sophistication, applicability and utility. The question remains whether such models are now viable management tools which could or should be more widely employed by land managers and agencies.

At the 50th Annual Meeting of the Society for Range Management, a symposium held in February, 1997 in Rapid City, S.D., addressed the use of simulation models in natural resource planning and management. This paper summarizes the symposium and provides a current reference for natural resources modeling activities associated with rangeland ecosystem management. Individual authors can be contacted for more detailed information.

Symposium Titles and Authors

ELM (Ecosystem Level Model): The beginning. Robert Woodmansee. Dept. Rangeland Ecosystem Science, Colorado State University, Fort Collins, Colo 80523

SPUR2 (Simulation of Production and Utilization of Rangelands): Its development and application. Jon Hanson. USDA-ARS, Great Plains Systems Research Center, Fort Collins, Colo 80522

SPUR-91 (Simulation of Production and Utilization of Rangelands): Its development and application. Tom Thurow. Dept. Rangeland Ecology and Management, Texas A&M University, College Station, Tex 77843

SPUR2.4 (Simulation of Production and Utilization of Rangelands): Its development and application. Richard Teague and Joelyn K. Foy. Dept. Texas Agricultural Experiment Station, The Texas A&M University System, Vernon, Tex 76385

RAPPS (RAngeland Plant ProfileS): Its development and application. Phillip L. Sims, Derek W. Bailey, Michiel B. Coughenour and James A. Bradford. USDA-ARS, Range and Pasture Research, Woodward, Okla 73801

WEPP (Water Erosion Prediction Project): Its development and application on rangelands. Mark Weltz. USDA-ARS, Southwest Watershed Research Center, Tucson, Ariz 85719

GEM (Generation of Weather Elements for Multiple Applications): Its application in the management of rangelands. Clayton L. Hanson and Greg Johnson. USDA-ARS, Northwest Watershed Research Center, Boise, Ida 83712

SHAW (Simulation of Heat And Water): Its application in the management of rangelands. Fred Pierson and Gerald Flerchinger. USDA-ARS, Northwest Watershed Research Center, Boise, Ida 83712

RANGETEK: Its development and application. Ross Wight. USDA-ARS, Northwest Watershed Research Center, Boise, Ida 83712

Use of simulation models in decision support systems. Jerry Stuth, Richard Conner and Wayne Hamilton. Dept. Rangeland Ecology and Management, Texas A&M University, College Station, Tex 77843

Factors that affect the adoption and use of simulation models as decision support tools. Ara Gardner. Dept. of Forest Resources, University of Idaho, Moscow, Ida 83843, and Ross Wight. USDA-ARS, Northwest Watershed Research Center, Boise, Ida 83712

Simulation models and rangeland management: The future. Will Blackburn. USDA-ARS, Northern Plains Area, Fort Collins, Colo 80525

Simulation models and rangeland health: Problems and Solutions. Ken Spaeth, USDA-NRCS, Northwest Watershed Research Center, Boise, Ida 83712, Fee Busby, USDA-NRCS, Little Rock, Ark 72201, Pat Shaver, USDA-NRCS, Corvallis, Ore 97331, Rhett Johnson, USDA-NRCS, Fort Worth, Tex 76115 and Dennis Thompson, USDA-NRCS, Washington, DC 20250

Synthesis and reflections. Herman S. Mayeux. USDA-ARS, Beltsville, Md 20705

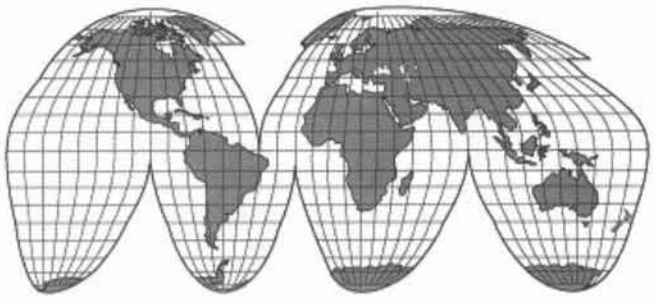
Rangeland Resource Models

Early modeling efforts began in 1965 with the development of ecosystem models via the International Biological Program (IBP). The IBP Grassland Biome study was "an experiment in big biology"dedicated to improve understanding of the structure and function of ecosystems. Through this effort, the Ecosystem Level Model (ELM) was developed. It was comprised of five basic components: 1) abiotic variables driven by temperature, water and carbon dioxide, 2) nutrients focused on nitrogen and phosphorus, 3) producers, 4) consumers, and 5) decomposers. ELM reasonably represented the biomass dynamics of IBP perennial grassland sites and their response to management alternatives.

The ELM effort provided important lessons to the future of ecosystem modeling: 1) modeling efforts require careful and detailed organization, 2) models require full documentation to facilitate future modification and user support, 3) models organize information and, if clearly described and explained, they are excellent communication devices, and 4) models both rely on and can guide field research because they integrate knowledge, guide the investigation of poorly understood mechanisms, and test hypotheses. The ELM provided a conceptual framework for much of the modeling progress over the last 25 years.

In 1987, the Simulation of Production and Utilization of Rangelands (SPUR) model was released as a general grassland simulation model composed of four basic components: hydrology, plant growth, animals (domestic and wildlife), and economics. The hydrology component in SPUR calculates a soil water balance, upland surface runoff volumes, peakflow, snowmelt, upland sediment yield, channel streamflow and sediment yield. In the plant component of SPUR, carbon and nitrogen are cycled through several compartments including standing live, standing dead, live roots, dead roots, seeds, litter and soil organic matter. The model simulates both competition between plant species and the impact of grazing on vegetation. The animal component of SPUR calculates domestic livestock physiology and forage harvesting by wildlife for all classes of animals including forage preference, palatability and utilization. Wildlife species, including insects, were considered as fixed consumers and were given first access to the available forage. SPUR was primarily designed to be used as a research and development tool.

The SPUR2 model is an enhancement of SPUR with modifications to the plant, animal, plant/animal interface and wildlife components. Modifications to the plant component include an improved method for calculating daily photosynthesis, and the ability to simulate plant response to elevated carbon dioxide. The animal component was enhanced by improving the energy dynamics for steers, the inclusion of a genetic-based cow/calf model, and the ability to design and test grazing systems. A new plant/animal interface was developed that incorporates the bite-count method of foraging. The wildlife component was improved by the addition of a grasshopper component. The SPUR2 model has been used to describe the impact of global warming and climate change on U.S. rangelands and the responses of arid and semiarid watersheds to increasing levels of carbon dioxide.



The SPUR2 model has been used to describe the impact of global warming and climate change on U.S. rangelands and the responses of arid and semiarid watersheds to increasing levels of carbon dioxide.

The SPUR-91 model was a revision of the original SPUR model. The SPUR model worked well on the short-grass prairie, but did not represent sites with multiple growing seasons and both warm and cool season plant species. The modifications made to SPUR were therefore directed primarily at improving hydrology-plant intercommunication. Soil evaporation was linked to amount of vegetation cover which improved evapotranspiration predictions for low or no cover conditions, while permitting the original evapotranspiration model to remain unchanged for greater vegetative cover conditions. Plant growth was modified to provide accurate rates of plant dieback during seasonal dry periods, and generation of multi-modal growth curves. Better representation of the location of plant roots within the soil profile provided: 1) better timing of plant growth, 2) more accurate estimates of production for individual plant species, and 3) stability in long-term relative species composition.

The SPUR-91 model has potential for aiding in the assessment of various management practices on rangelands. Currently, however, the model is more reliably used to predict general trends rather than absolute values of management responses. At present, the model is not designed to simulate the growth processes of non-herbaceous vegetation. There are no algorithms for light attenuation, nor for woody growth or respiration of woody tissue. The modifications incorporated into SPUR-91 have improved the intercommunication between the hydrology, soils and plant components.

The SPUR2.4 version integrated all previous versions of SPUR and added a three-component soil organic carbon and nitrogen submodel which had been identified as a weak component in SPUR. The SPUR2.4 version improved both within- and between-season plant growth and long-term persistence of the key species.

The changes made to SPUR in creating SPUR-91, SPUR 2 and SPUR2.4 have improved the accuracy of the model. The model is now able to do more than just predict general trends of management responses. There is now potential for incorporating the assessment of various management strategies and practices in limited areas.

The ERHYM-II model is an enhanced version of the Ekalaka Rangeland Hydrology and Yield Model (ERHYM) which is a modification of an earlier crop yield model. It is a climate/water-balance model which provides daily simulation of soil water evaporation, transpiration, runoff and soil water routing for individual range sites. The model can utilize real-time climate data to simulate ongoing processes, or it can utilize long-term weather records or stochastically generated weather records to simulate runoff and herbage production (at peak standing crop) under a range of climatic conditions and management practices.

To address the need for readily-available climate data for any location, a stochastic climate simulation model has been developed which delivers accurate time series of daily or higher temporal resolution weather data.

Rangeland Plant Profiles (RAPPS) is a perennial, cool-season and warm-season, grass model that simulates for a single, average plant, and by extension for a monoculture, the following five plant functions: 1) phenology, 2) morphology, 3) chemical balance, 4) growth, and 5) tissue loss. The model calculates biomass production per unit area by plant part, digestibility, forage quality, plant dimensions, plant morphology and timing of phenological events. The construction of RAPPS in a modular format allows individual researchers to focus on modules appropriate to their research interests.

The Simultaneous Heat and Water (SHAW) model simulates the movement of water and heat through a vertical profile of vegetation, snow, soil surface residue and soil. The model looks at the plant-soil system as a series of layers starting from the top of the plant canopy and extending down through the soil to a depth specified by the user. Simulated processes include the influence of soil freezing and thawing, evaporation, transpiration, infiltration and surface runoff. The SHAW model provides hourly or daily predictions of temperature, water potential, ice and solutes at any specified point throughout the soil profile. The model simultaneously simulates the influence of several plant species and dead plant material on soil water and temperature conditions. After the required weather data are furnished to the model, it then predicts how much heat and water will move between layers or will be lost out the bottom of the soil profile or back into the atmosphere. The SHAW model is a very detailed process-based model; however, as a stand-alone management tool, it currently has limited use because it does not directly address management applications. The model must be coupled with other models or decision support tools to become useful for addressing practical rangeland management scenarios.

Water Erosion Prediction Project (WEPP) is a process-based model developed to replace the Universal Soil Loss Equation (USLE) for erosion prediction. It operates on a daily time step, allowing for the incorporation of temporal changes in soil infiltration, management practices, above- and below-ground biomass, litter biomass, plant height and canopy cover. The model is designed for use on a wide spectrum of grazing lands including rangelands, pastures, woodlands and alpine meadows. The WEPP model is intended to apply to all situations where soil erosion by water occurs, including that resulting from rainfall, snowmelt, irrigation and ephemeral gullies.

The hillslope version of WEPP can be conceptually divided into seven conceptual components: climate, topography, soils, hydrology, erosion, management, and plant growth and decomposition. A hillslope can be subdivided into 10 overland flow planes that represent different soil types, vegetation communities or management activities. The grazing option allows for 10 rotations of livestock within a year on each overland flow plane.

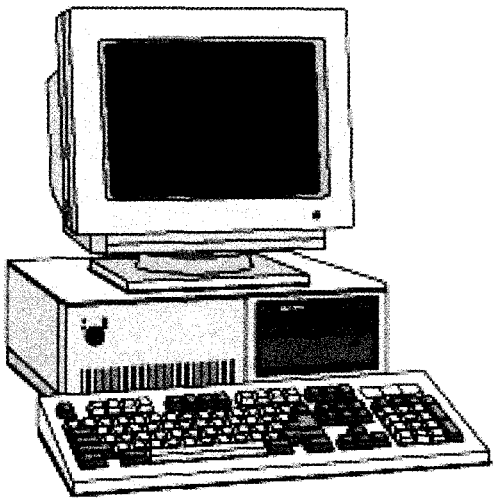
The watershed version of WEPP estimates soil loss and deposition from one or more hillslopes within a watershed. It computes sediment delivery from small watersheds and computes sediment transport, deposition and detachment in small channels and impoundments within the watershed. This includes erosion in ephemeral gullies and channels, but not "classical" gullies. The WEPP watershed model is limited to field-size areas, estimated to be approximately 800 acres for rangelands. To realize the full potential of WEPP as a management tool, requires improvements in the estimation procedures used to represent vegetation, soil, and management-induced temporal and spatial variability.

To address the need for readily-available climate data for any location, a stochastic climate simulation model has been developed which delivers accurate time series of daily or higher temporal resolution weather data. This model, Generation of weather Elements for Multiple applications (GEM), retains the basic internal structure of previous climate models, but has several significant improvements. The GEM model allows a user to select a location and request a simulated weather sequence for that location for as many months or years as needed. At present, GEM delivers a daily time series of maximum

and minimum temperature, precipitation amount and solar radiation for any location, even in regions where no long-term climatic data exists.

Decision-Aid Software for Making Management Decisions

Contemporary ecosystem management, in which the land is viewed in a more holistic way, requires public land managers and consultants to be able to develop, justify and defend decisions with the assistance of computer systems. Computer software specifically designed



to aid in the decision-making process can enhance the ability of managers to view the greatest range of options and decide among them with greater confidence and insight. Decision-aid software includes: simulation models, databases, visualization systems and expert systems.

Because decision-aid software systems have not been extensively used by natural resource managers, a study was conducted to determine how significant certain perceived software characteristics are in affecting the potential user's intention to adopt these systems. Interviews were conducted with USDI-Bureau of Land Management, USDA-Forest Service, USDA-Natural Resources Conservation Service (NRCS) and Idaho Department of Agriculture managers. Each respondent that filled out the written questionnaire had tried at least one decision-aid software. Respondents commented on timber growth and yield simulation models, timber projection models, grazing land management decision-support-system models, pest and pathogen disturbance models and water quality models. Quantitatively, the variable "Compatibility" was the only variable that described how the respondents thought about the use of decision-support systems. Compatibility is the degree to which the user felt using the software was consistent with their past experiences, values, needs and job goals. The strongest qualitative predictor of adoption was "Participatory Design" which is how much the user of software is involved in the actual design of the software. Thirty out of 35 responses indicated that the end user should participate at a high level in an early stage of software development to create better, more usable software tools. This idea was summed by one respondent who stated that, "models don't get used at the ground level if field-level managers are not involved somehow."

To match software to end users' values, past history, needs and job goals, software developers must understand how end users think, how they do their jobs, and how they make decisions. For example, many respondents commented that they felt that software modelers/developers thought that the more calculations and/or more functions their models could perform, the better; actually field-level managers wanted only one or a few of these functions performed to really assist them in their decision-making process. Here, the first respondent hit a chord when she said, "Developers don't live in our environment where we make decisions on the ground; I don't think they have a clue how we make integrated decisions."

A summary of this study suggests that, even though respondents may have found that using the software was complex or frustrating, they still felt that if a decision-aid provided what they needed in their jobs and in their decision-making scenarios, it was a good tool. These findings send the strong message to software developers; that if software tools are going to be used in the decision-making process by natural resources managers, participation in development by the end user, and a thorough understanding of end user values, goals and needs, are crucial.

Examples of Decision-Aid Software

Decision support systems (DSS) are decision-aid software that are designed to represent complexity of a particular decision environment in an understandable manner. Grazing Lands Applications (GLA) is a comprehensive ranch-level planning system for nationwide application. The GLA was implemented in NRCS field offices across the U.S. in 1991 and represents the first comprehensive DSS ever developed and deployed for application on grazing lands.

The GLA maintains a database structure that allows information to be used for local problems. The DSS is designed to allow storage and retrieval of client-independent and client-dependent databases that support planning activities for assessment of forage supply, demand by animals and forage balance, nutritional status of grazing animals, economic feasibility of investments and grazing strategies for a given property. Client-dependent analysis involves creation of forage inventories, herd definition/profiling, grazing schedule/balance and combined long-term stocking responses. The GLA is essentially a forage budgeting framework relying on externally

computed information, professional judgement of anticipated responses of vegetation and landholder interviews. Additional decision support tools include a module for long-term investment analysis linked to the combined stocking response.

Multiple Species Stocking Calculator (MSSC) was developed to address more complex planning issues. It utilizes a complex diet selection model with a limited input interface to determine stocking rates of multiple species of livestock in the presence of wild ungulate populations. The MSSC is a preference-based stocking system which shifts planning to understanding the diet-selection process and establishment of desired levels of utilization on target plant species. Plant species within the GLA plants database have to accommodate one of five major selection classes, depending upon the animal species of interest for each quarter in the year. The success of MSSC depends largely on the user's ability to properly characterize the forage on offer to the animals, assign an animal unit equivalent (AUE) value, understand the average population density of the wild herbivores, and feel comfortable with the assignment of the preference classes for plant-animal species.

The Nutritional Balance Analyzer (NUTBAL) was developed to meet GLA users' requests for a nutritional management module which allows more accurate assignment of animal-unit equivalent values throughout the production year. The NUTBAL provides representation of breedtypes and environmental conditions in a manner such that users are not forced to input information that is difficult to acquire. The use of NUTBAL has dramatically risen as its capabilities have been improved and a new fecal profiling service has become more widely used by professionals.

The Grazinglands Alternative Analysis Tool (GAAT) DSS was developed to overcome the problem of dynamic shifts in grazinglands enterprises (animal and non-animal) over longer planning horizons. The GAAT incorporates a dynamic economics model to assess net present value and internal rate of returns from an investment stream applied to a specified land unit. The GAAT accommodates analysis of a wide variety of animal and non-animal enterprises, either individually or in combination. It allows changes in any specific category of annual operating costs and/or product prices throughout the planning period. The GAAT accommodates breeding herd replacement from purchased or retained young animals. The GAAT can accommodate changes throughout the planning period in the proportion of available forage and/or feedstuffs allocated to each enterprise. The GAAT provides planners and consultants the capability to analyze complex situations where economic response must be tempered in ecological and biological reality.

The RANGETEK is decision-aid software designed for use at the field level. It makes extensive use of user-friendly menus, help screens, and expert system technology to organize input and output information and estimates values for input variables and parameters. The RANGETEK provides for the daily simulation of soil and plant evaporation and water routing through the profile. Minimum plant and soil parameters include dates of growth initiation and peak standing crop, average site herbage yield, and soil texture by horizon. The RANGETEK is intended for two main applications: 1) real-time simulation of daily soil and plant evaporation and soil water content, and 2) forecasting annual herbage production. Real-time simulations are used to monitor soil water and compute actual transpiration/potential transpiration ratios as indicators of current growing conditions. The calculated actual transpiration/potential transpiration ratios are used as yield indices to predict peak standing crop yields and to forecast herbage yields based on soil water content at the beginning of a growing season.

Phytomass Growth Model (PHYGROW) was developed to capture critical concepts from a wide array of models addressing hydrology, plant growth, diet selection, animal production and human decision making. The user can define plant communities with an unlimited number of species or functional groups of species. A module in PHYGROW allows the user to simulate various levels of risk in human decision making as it relates to destock/restock decisions. Currently, PHYGROW is being used primarily for policy analysis and drought monitoring systems.

Discussion and Conclusions

Changing societal demands for environmentally sustainable management practices and the growing trend to meet these demands through increased regulation requires improved prediction technology. While traditional rangeland research has led to the development of improved vegetation management practices, it has done little to enhance predictive capabilities of complex ecosystem processes. Rangeland plant communities are

Rangeland research has led to the development of improved vegetation management practices.

very unique and "rule of thumb" notions and "one equation fits all" approaches which depict linear attributes to be used ubiquitously for all rangeland plant community types do not result in models with much utility and robustness.

Natural resource planners and managers have encountered problems with the use of simulation models. Some models do not meet the needs of resource planners because considerable customization is needed to get information that is useful in the planning process. Input parameters are often ambiguous and not intuitive to the user. For example, the primary reasons for the lack of use of simulation models by the NRCS are complexity of software, availability of data, lack of validation for many rangeland communities, and models that incorporate the Universal Soil Loss Equation (USLE) and the Hydrologic Curve Number (HCN) are limited in scope for use on rangelands.

Natural resource planners and managers must account for interactions among soils, water, air, plants and animals. Rangeland simulation models can integrate these components of the rangeland ecosystem to facilitate evaluation of alternative management scenarios. Management alternatives can be evaluated in terms of how they affect hydrology, the plant community and soil stability. Rangeland simulation models, in theory, offer land management agencies planning assistance that is based on a high degree of science and technology. In order to successfully utilize this technology, the resource planner needs to know about many of the attributes in the rangeland plant community: plant community composition, soil information, climate, hydrology, and ecological attributes related to succession and plant composition. As rangeland simulation models evolve, potential applications for them may include evaluation of plant composition shifts, effects of grazing management strategies, and fire on plant communities and subsequent hydrologic trends.

Selection of simulation models to address problems on rangeland is difficult, given the potentially wide range of study objectives, data constraints, and spatial and temporal scales of application. Development of a Modular Modeling System for rangelands is needed. Modules and algorithms must be developed to specifically represent rangeland processes. The future of simulation models for rangeland management exists in our ability to selectively couple appropriate modules from a library of modules to create an optimal model for a desired application.

The development of viable simulation models is a long-term process. Decades, rather than months or years, may be needed to accomplish the comprehensive development, testing, validation, data collection, refinements and user simplifications necessary to make a model a viable, off-the-shelf management tool. This requires long-term commitment by individuals and organizations. It means commitment to collect basic data and to test, validate and maintain the model.

The process of model development, in and of itself, is valuable in studying ecosystem processes and how they function and interact. Simulation models can provide useful management information throughout their development, with the kinds and amount of information provided being consistent with their stage of development. While the application of simulation models may seem intuitive, more effort is needed on development of formalized procedures for using models as decision support tools; GLA is one example.

The transfer and acceptance of science-based technology to rangeland resource managers has been difficult. Success will depend on a team approach between model developers and model users and the commitment by both to stay the course. Such teamwork will result in the development of technologies for using these models as decision support tools.

Simulation models, used independently and as components of computerized decision support systems, will play an increasingly important role as decision support tools in the management of rangeland ecosystems. Through their ability to simulate plant community dynamics, runoff and erosion, they will also find application in dealing with trend analyses and rangeland health issues. The complexity and litigious nature of today's natural resource management problems require such tools.

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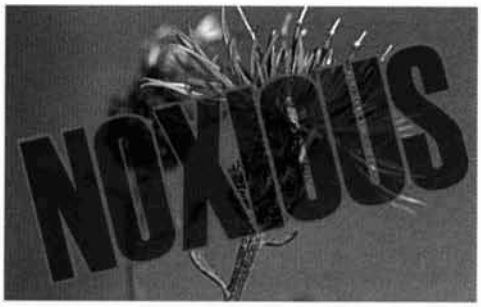

HOW TO GET ON THE LIST

Listing and delisting exotic plants as noxious

Roger L. Sheley and Jane M. Krueger

Exotic, invasive weeds, such as spotted knapweed, pose a serious ecological and environmental threat to the natural resources of the western United States. These weeds displace native plant communities (including endangered species), alter the functioning of the ecosystem, reduce forage for livestock and wildlife, and lower diversity. In some cases, noxious weeds increase soil surface runoff and sedimentation into streams. As a response, many states have enacted laws to protect their natural resources from invasion by exotic weeds. The Montana County Noxious Weed Law was established in 1948 to protect Montana from destructive weeds. This act, amended in 1991, has established a set of criteria for the control and management of noxious weeds in Montana. Noxious weeds are defined by this act as being any exotic plant species which may render land unfit for agriculture, forestry, livestock, wildlife, or other beneficial uses, or that may harm native plant communities. Plants can be designated as statewide noxious weeds by rule of the Montana Department of Agriculture (MDA). It is imperative that federal, state, and county agencies develop processes and criteria for deeming exotic plants as "noxious". Many states and counties are struggling to develop efficient and expedient processes and criteria.

The purpose of this paper is to present the process and criteria for listing and delisting exotic plants as noxious weeds in Montana. Perhaps Montana's process and criteria for listing and delisting exotic plants can provide a guideline for others attempting to identify and designate weeds as "noxious."

The Process

In Montana, there are three primary methods for initiating the listing or delisting of exotic plants as noxious. The Montana Department of Agriculture can initiate the process based on their internal information; any individual, group, or association can petition the MDA; and an organized committee with the responsibility to identify potential noxious plants can initiate the process (Fig.1). The process is initiated by written request to the MDA.

Some situations may call for more immediate action. A proposed emergency declaration can also be requested for rapid processing. A temporary emergency declaration can

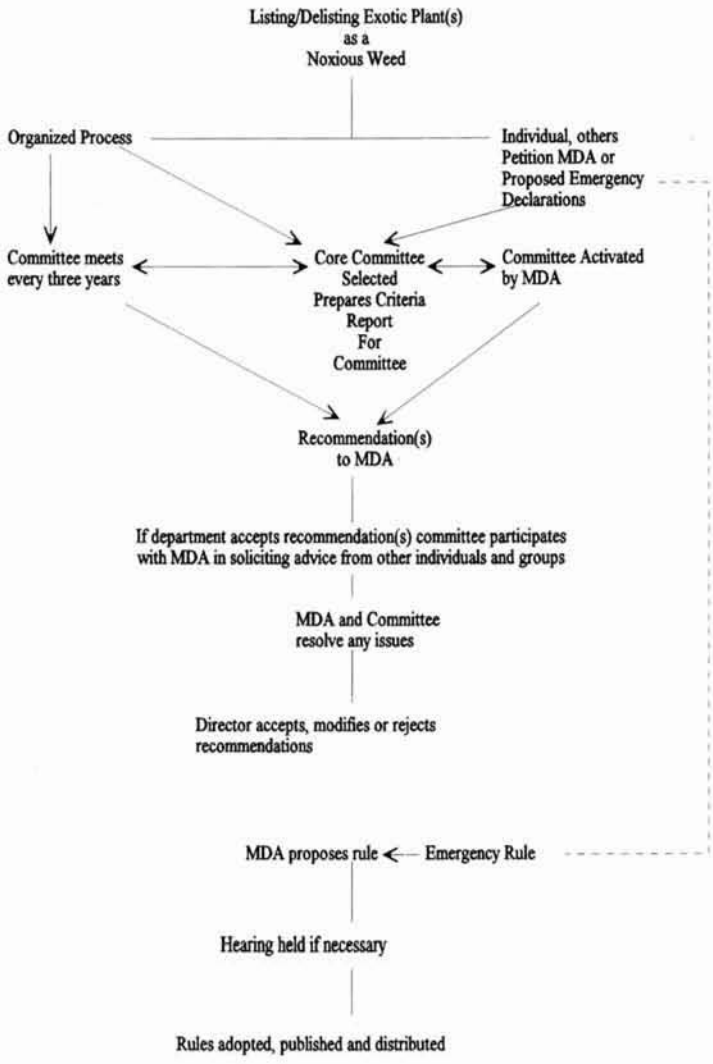

Fig. 1. *The process for listing and delisting exotic plants as noxious weeds in Montana.*

be made by MDA. An emergency declaration may be important where a new weed infestation is serious and is in a nearby state. Squarrose knapweed is a serious problem in many states. Discovering an initial infestation in adjacent states would justify an emergency declaration as a noxious weed. Once the MDA receives a petition, two committees are created and activated. The first, larger committee comprises representatives from weed districts, the weed control association, various (5–7) agricultural groups, state and federal agencies, university weed specialists, environmental groups, a representative from MDA, and others who might be impacted by declaring an exotic weed as noxious. Weed specialists comprise the second committee. Their job is to evaluate and assess a weed's potential as noxious based upon predetermined criteria (Figure 2).

Once this committee has prepared a specific report for each proposed noxious weed, the information is evaluat-

Name of Plant: Saltcedar (*Tamarix ramosissima, T. chinensis,* or *T. gallica.*)

Date: 11–16–97

1. Is the plant pre–adapted to Montana's climate
   - 80 Yes (80 pts
   - ___ Probably yes (40 pts)
   - ___ Probably no (–40 pts)
   - ___ No (–80 pts)

2. Based on MAPS, what is the percentage of Montana's area that is expected to have suitable climate for this weed (1 pt for each percentage)
   - ___ (Not able to attain this information)

3. How many neighboring States/Provinces list the weed as noxious?
   - ___ Oregon (6 pts)
   - 8 Washington (8)
   - ___ Idaho (10 pts)
   - ___ Wyoming (10 pts)
   - ___ South Dakota (10 pts)
   - ___ North Dakota (10 pts)
   - ___ Southern Alberta (10 pts)
   - ___ Southern Saskatchewan (10 pts)
   - ___ British Columbia (10 pts)
   - ___ None

4. How many acres does the weed infest in each State/Province?

	Acres	Points
___ Oregon		
2 Washington	0–100	1
10 Idaho	100–1000	2
___ Wyoming	1000–5000	4
___ South Dakota	5000–10,000	6
___ North Dakota	10,000–50,000	8
___ Southern Alberta	50,000–over	10
___ Southern Saskatchewan		
___ British Columbia		

5. How many acres does the weed infest in counties/portion of provinces immediately adjacent to Montana?

Not available acres

Acres	Points
0–100	5
100–1000	10
1000–5000	20
5000–10,000	40
10,000–50,000	60
50,000-over	80

6. How many counties in Montana have listed the weed as noxious (2 pts for each listed county)?

15 Number of counties 30 points

(Rosebud planning to put on county list in spring 1998)

7. How many total acres does the weed infest in Montana?

10 points

Acres	Points
0–100	5
100–1000	10
1000–5000	20
5000–10000	40
10,000–50,000	60
50,000–over	80

8. Which environmental types has the weed invaded? (10 pts for each environmental type)
   - ___ Forest/grassland (>20" ppt)
   - ___ Forest/grassland (<20" ppt)
   - ___ Sagebrush/grassland (western Montana
   - ___ Sagebrush/grassland (eastern Montana)
   - ___ Grassland (west)
   - ___ Grassland (east)
   - 10 Riparian/wetland
   - ___ Improved pasture
   - ___ Cropland
   - ___ Roadsides/right-of-ways right-of-ways
   - ___ Aquatic

9. Which of the potential negative impacts are associated with this weed?
   - 10 Loss of forage production (10)
   - 10 Loss of native plants (10)
   - 10 Loss of biodiversity (10)
   - 10 Loss of wildlife habitat (10)
   - 10 Increase soil erosion (10)
   - 10 Reduced recreational value (10)
   - ___ Poisonous to any animal (10)
   - ___ Causes human health concern (10)
   - 10 Loss of cropland (10)
   - ___ None (0)

(Note: Saltcedar increases sediment deposition)

10. Which of the potential impacts are associated with this weed?
    - –5 Pollen for honey bees (–5)
    - ___ Pollen food item source (–10)
    - ___ Potential medical uses (–10)
    - ___ Grazing value (–10)
    - ___ Other (–10)

11. How often has the weed been included in a national or international weed list? (5 pts for each listing)
    - 15 Points

12. What is the current rate of expansion of the weed?
    - ___ Decline (–5)
    - ___ Stable (10)
    - ___ Slow/moderate (20)
    - 40 Fast (40)
    - ___ Exponential (60)

13. Which of the following characterizes the plant?
    - 10 Very high seed production (10)
    - ___ Long-lived seed bark (10) (over 3 years)
    - 10 Simultaneous asexual & sexual reproduction (10)
    - 10 Adapted to disturbance (10)
    - 10 Rapid growth rate (10)
    - ___ Early and continous growth throughout the season (10)

TOTAL POINTS 290

Please attach biological information on this plant.

Fig. 2. *The criteria for listing and delisting exotic plants as noxious weeds in Montana.*

ed by the larger committee. The larger committee finalizes the report by providing practical information about the impacts of declaring the weed as noxious. Once all the information is compiled, the larger committee provides a recommendation to MDA. If the recommendation is accepted, the committee participates with MDA in soliciting advice from other individuals and groups and in resolving their concerns. The director then accepts, modifies, or rejects the committee recommendations, and rules are proposed. If necessary, a public hearing will be held. Rules are adopted, published, and distributed.

The Criteria

Listing or delisting an exotic plant as noxious is based on three criteria. The first criteria is a relative ranking based on suitability of climate, current distribution, acreage of infestation, number of counties present, potential habitat types susceptible to invasion, potential negative and/or positive impacts, number of national and international listings, and a few biological characteristics. Points are allocated to responses of 13 questions. Figure 2 shows the criteria questions, points allocated for each response and an example using saltcedar as the plant petitioned for consideration as noxious. There is no magic number of points after which the weed is considered noxious. The numerical score is simply used to provide some insight into the overall potential invasion and impact of the plant.

The second criteria summarizes the biological characteristics of the plant. This is a brief description of special characteristics important to understanding the potential invasion and impacts of the plant not addressed by the ranking system. Any special considerations should be stressed in the biological summary. Some special situations, such as invades riparian areas only, may lead to low numerical scoring because of the low number of acres potentially infested. Low scoring may underestimate the invasiveness and ecological and economic impacts of the weed.

The final criteria for listing or delisting an exotic plant as a noxious weed is how the rule impacts various agencies, companies, groups, or individuals in the state. For example, listing a common garden ornamental, such as purple loosestrife or yellow toadflax, as a noxious weed may significantly impact nursery sales. In another case, listing a common weed in crop seed as noxious may alter the legal status and salability of the crop seeds.

Conclusion

As weeds continue to invade western rangeland, it is critical that processes and criteria are developed to determine those weeds that pose a serious threat to the ecology and economy. These processes must include assessment of the invasiveness and impacts of exotic plants based on biological characteristics and past history of invasion. Sociological impacts of the weed and its declaration as noxious must be considered as well. This requires a social process and the development of criteria based on the plant's biology. We have attempted to provide an example process and criteria for listing or delisting a weed as noxious.

The author wishes to recognize the Montana Department of Agriculture for providing leadership in developing the process and criteria for listing and delisting exotic plants as noxious weeds in Montana. In addition, special appreciation is given to the process and criteria committee members. A special thank you is given to Gary Gingery, Montana Department of Agriculture.

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Letters to the Editor

Dear Editor:

In his farewell address as President of SRM (*Rangelands* 21:23-24), Lamar Smith forcefully and effectively dismissed the logical fallacies of "biocentric" philosophy and "ecosystem health." I am concerned, however, that some resource managers will confuse his call for "human-value-centered" management to mean that the success of management can be gauged by its commodity output. Sustainable management requires attention to numerous components of a system. Surely one of the profound teachings of 20th century environmental history has been that manipulation of ecosystems can have surprising and widespread undesirable consequences not intended by the managers. Examples abound, including the damage to the Northwest salmon fishery by logging practices, damage to Chesapeake Bay and the Everglades by farming runoffs, and of course the ozone hole, acid rain and global warming. Range managers who try to maximize beef production will kill plants, lose soil, cause gullies.

I think it is a mistake for range people to feel antagonism towards conservation biology. President Smith implied that the scientific discipline of conservation biology rests on the biocentric philosophy and is therefore invalid. Instead, I think it rests on the knowledge that human ecosystem manipulation has resulted in an ongoing mass extinction unrivaled since the asteroid impact at the KT boundary. Such a situation satisfies none by the most short-sighted and selfish human values. Conservation biologists study species and ecosystems at risk, to find management strategies that may allow them to survive. From a global perspective range management is thus an important part of conservation biology, that part which seeks to satisfy human needs by using rangeland ecosystems without doing damage to them. How to define, measure and minimize damage are open questions, demanding both scientific understanding of the consequences of management actions and public ethical debate about how much is enough, what other life forms do we care about, how many people do we try to feed.

Humanity has become a significant geological and evolutionary agent. Land managers are in the forefront of those who will shape the future planet. I hope we will do so with broad minds, humility and compassion.

Peter Sundt
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Dear Editor:

I am writing in response to an article by Lamar Smith that appeared in the March 1999 issue of the *JRM* and again in the April 1999 issue of *Rangelands*. As past President of SRM, Smith first outlined some items that will move SRM forward under a new strategy initiated by John Buckhouse, and then followed up with his views on management.

While I agree with the pro-management message that Lamar Smith espouses, I disagree with him that "much of conservation biology rests on Biocentrism". To the contrary, pick up any issue of *Conservation Biology*, and the term "sustainable use" appears over and over as a solution when opposing economic and natural resource decisions collide. It may be true that the philosophies of certain individuals associated with conservation biology differ markedly from the percepts on which SRM was founded. Nevertheless, a key goal of the Society for Conservation Biology is "to encourage communication and collaboration between conservation biology and other disciplines that study and advise on conservation and natural resources issues".

To equate Biocentrism with conservation biology is misleading to those of us who work with diverse landowners and managers to accomplish long term conservation in a private land state. Lamar Smith states in his article, "we hope to attract new members interested in rangelands, but who are not range professionals." I couldn't agree more. Maybe we should ask ourselves why our membership is shrinking while groups like the Society for Conservation Biology are expanding. The answer may lie in the fact that their membership attracts a diversity of professionals interested in conservation issues in general. Conservation biology was founded on the idea that a team approach to natural resource issues is much more effective than single disciplines alone.

Today, conservation biologists include range managers working with herpetologists, wildlife biologists working with botanists, economists working with entomologists, etc., etc. Together, they are able to propose an inclusive set of solutions to increasingly complex ecological problems. These solutions are then offered to the ultimate decision makers: private landowners and leaders at the local, state and national levels.

Matt Wagner
Chair, Information and Education Committee
Texas Section Society for Range Management

Sneek a Peek at the upcoming issue of *Journal of Range Management*

Goat's Locomation Energy Expenditure Under Range Grazing Conditions: Seasonal Variation

M. Lachica, R. Somlo, F.G. Barroso, J. Boza and C. Prieto

The physical energy expenditure of grazing goats may affect productive performance and may be influenced by season variation in grazing activities. Calorimetric techniques in conjunction with direct observations were used to quantify locomotion energy expenditure of goats in open range. Grazing and walking accounted for 52 and 42% of the goats daily range activity, expectively, with significant changes in daily energy expenditure due to locomotion of the animals at pasture in different seasons. The energy cost of locomotion represented a substantial contribution to the energy expenditure of goats on range which must be considered in the calculation of requirements.

Intake of Cattle Offered Normal and Lodged Tall Fescue Swards

Charles T. Dougherty and Paul L. Cornelius

Grazing behavior of livestock may be altered when swards are lodged by trampling, wind or rain. We evaluated the effects of lodging on the ingestive behavior of Angus cows grazing artificially lodged tall fescue swards. Although grazing cattle preferred normal to lodged swards or to partially defoliated swards, they were able to maintain intake on lodged swards by compensating components of ingestive behavior. It was concluded that lodging was a normal condition of swards that was unlikely to cause a significant decline in daily herbage intake but would likely alter spatial grazing behavior.

Conditioned Aversion to Minimize *Ferula communis* Intake by Orphaned Lambs

Serge Y. Landau, Ezra Ben-Moshe, Anat Egber, Alan Shlosberg, Michel Bellaiche and Avi Perevolotsky

Anticoagulant constituents in *Ferula communis* can cause up to 5% mortality in sheep grazing infested areas. The intake of F. communis in an artificially infested field by weaned, "orphaned", ewe lambs, that had been submitted or not to conditioned aversion procedures to the toxic plant, using LiCl, was assessed. The rate of F. communis disappearance was greater when grazed by unaverted than averted lambs. Intake by unaverted lambs was at dangerous levels whereas conditioned aversion reduced the intake of orphaned lambs to safe amounts of the poisonous plant.

Deer Damage to Alfalfa and Mixtures with Timothy or Orchardgrass

Marvin H. Hall and Robert C. Stout

White-tailed deer cause considerable damage to forage crops in Pennsylvania. A study at 2 sites measured losses in yield and economic return caused by deer feeding on pure and mixed stands of perennial forage crops. Deer reduced annual yield of pure alfalfa by an average of 54%, while yields of pure orchardgrass were reduced by only 7%, resulting in an average economic loss of $198 and $59 per hectare, respectively. The forage species or mixtures that farmers plant may play an important role in minimizing deer damage on their farms.

Assessing grazing impacts by remote sensing in hyper-arid environments

David Saltz, Heike Schmidt, Mary Rowen, Arnon Karnieli, David Ward and Iris Schmidt

Vegetation indices that are derived from remote sensing techniques have not been evaluated in hyper-arid environments. Satellite images of an erosion cirque in the Negev desert were used to evaluate changes in plant cover and community structure in grazed and ungrazed areas, dry and wet seasons, and in above- and below-average rainfall years. Ground measurements showed changes in plant community structure following grazing by Asiatic wild asses, but there was no correlation with vegetation indices from the satellite images. Satellite imagery detected changes in plant cover over time but is not a reliable indicator of grazing impacts in hyper-arid environments.

Coyote Depredation Control: An Interface between Biology and Management

Frederick F. Knowlton, Eric M. Gese, and Michael M. Jaeger

Coyote depredation on domestic sheep remains a serious management problem for many livestock producers. A synthesis of known coyote biology, behavior, and management strategies suggests that there is no single method for reducing damage to livestock by coyotes. Successful depredation management requires a variety of techniques used in an integrated program.

Spotted Knapweed, Forbs, and Grass Response to 2,4-D and N-fertilizer

James s. Jacobs and Roger L. Sheley

Long-term spotted knapweed control strategies using non-residual herbicides are important for riparian areas and to reduce impacts on non-target forbs. We combined 2,4-D and nitrogen on 2 field sites in western Montana to control spotted knapweed and increase grass competitiveness. Two years after application 1 quart 2,4-D plus 150 pounds N per acre applied in the spotted knapweed bolt or bud stage provided 75% control without affecting other forbs and increased grass density. We believe that where there is a healthy and diverse plant community, spotted knapweed can be controlled using 2,-D without killing non-target forbs.

Early-summer Grazing Effects on Defoliation and Tiller Demography of Prairie Sandreed

Andrew P. Cullan, Patrick E. Reece, and Walter H. Schacht

Most grazing systems used on semi-arid rangelands are not designed for specific plant species. Cattle use of prairie sandreed was measured in June or July for 2 years in 18 pastures under light, moderate, or heavy stocking rates in Nebraska. Percent of prairie sandreed tillers grazed can be monitored to determine average utilization of this highly preferred grass in pastures under any grazing system. The potential for overuse of prairie sandreed decreases as turn-out date is delayed and concentration of cattle declines.

The Role of Drought in Range Management

Thomas L. Thurow and Charles A. Taylor, Jr.

Drought is an ambiguous term, subject to expectation and the weight of emphasis on meteorological, agricultural, hydrological, and socio-economic dimensions. We discuss some of the muddled views and lagged responses toward drought that poses a threat to sustainable management of rangelands. The wait-and-see attitude that characterizes many rangeland decisions in the face of drought has a high long-term cost, especially if accelerated soil erosion occurs. Rather than blaming management problems on climate, the challenge is to intensify the research focus on crafting and implementing management and policy tools designed to integrate the economic and ecological aspects of drought.

Livestock Response to Multispecies and Deferred-Rotation Grazing on Forested Rangeland

Kenneth C. Olson, Randall D. Wiedmeier, James E. Bowns and Rex L. Hurst

Concurrent grazing with more than 1 animal species is hypothesized to improve animal performance, but the effect of multispecies and deferred-rotation grazing on livestock performance on high-elevation summer rangeland has not been measured. Cow-calf and ewe-lamb performance under multispecies versus single species grazing and deferred-rotation versus continuous stocking was evaluated in a 10-year grazing trial. Calves gained faster alone while lambs gained faster when mixed, and calves gained faster under continuous stocking. Multispecies or sheep grazing were more appropriate than cattle for this environment, while deferred-rotation was most appropriate for sheep and continuous stocking most appropriate for cattle.

Drought and Grazing: I. Effects on Quantity of Forage Produced

R.K. Heitschmidt, M.R. HaferKamp, M.G. Karl and A.L. Hild

Grazing regimes during and following drought may alter post-drought recovery patterns. Non-weighing lysimeters under an automated rain-out shelter were used to examine interactions of drought and grazing regimes on herbage growth dynamics and aboveground production in a northern mixed grass rangeland. The effects of the imposed late spring to late summer drought and associated grazing treatments were minimal relative to soil water dynamics and herbage production. Absence of any major drought/grazing effects was related largely to timing of the imposed drought in that most annual growth in this cool-season dominated grassland is completed by early summer.

Land Use Change Effects on Breeding Bird Community Composition

Jon C. Boren, David M. Engle, Michael W. Palmer, Ronald E. Masters and Tania Criner

Avian community dynamics in environments changing from wildland to suburban is not clear. Land uses, vegetation cover types, and landscape patterns associated with avian community composition were evaluated in a hardwood forest-tallgrass prairie ecotone with 2 levels of human population density. Avian community composition in the low density zone was related to the area of deciduous forest and area treated with fire and herbicides, while in the high density zone, avian composition was related to the area of deciduous forest, native grassland and roads. Attention should be focused on preserving biological diversity of rural ecosystems by maintaining native plant communities.

Influence of Environmental Factors and Sheep Grazing on an Andean Grassland

Peter B. Adler and Juan Manuel Morales

Chronic overgrazing in the central Andes alters vegetation and may cause erosion and loss of productivity. The relative influence of environmental factors and sheep grazing on vegetation was evaluated in a remote site in northwestern Argentina. Grazing had a slightly greater influence on vegetation than environmental factors, particularly wet season grazing which dramatically reduced total cover, forage volume, species diversity and soil organic matter compared to sites grazed only in the dry season. Our results suggest that protecting pastures during the summer rainy season may be an important complement to traditional management efforts of reducing stocking rates.

Prescribed Fire Effects on Biological Control of Leafy Spurge

David P. Fellows and Wesley E. Newton

Little is known concerning effects of fire on the persistence and dynamics of the flea beetle, *Aphthona nigriscutis*, used to control leafy spurge in grassland wildlife habitat. Small plot studies were conducted to evaluate effects of burning on established colonies and effects of prerelease burning on colony establishment. Results demonstrated that prerelease burning facilitates colony growth in suitable habitat, and suggest that established colonies are not harmed, and in fact may benefit, from properly-timed burning. We recommend that managers coordinated their burning and biological control programs to achieve maximum benefit from *A. nigriscutis*.

Imbibition Temperature Affects Seeding Vigor In Crops and Shrubs

D. Terrance Booth and Yuguang Bai

Imbibition at cold temperatures reduces seedling vigor of some plant species but is beneficial to others. Three rangeland shrubs and 8 agronomic plant species were used to develop general relationships among imbibition temperature and seed water uptake, dry weight loss, and seedling vigor measured as post-germination growth. The relationship between imbibition temperature and seedling vigor was related to the physiology of water uptake and seed respiration. Optimum imbibition temperatures should be defined by species and incorporated into seed-testing guidelines.

Bison Use of Fire Managed Remnant Prairies

Mario E. Biondini, Allen A. Steuter, and Robert G. Hamilton

There have been few studies on the ecology of bison grazing in large mixed and tallgrass prairies managed with fire. We identified fire and range site effects on bison distribution patterns on fire managed prairie remnants in the Oklahoma tallgrass and Nebraska mixed prairie ecosystems. There was an interaction between fire and range site, with bison selecting burned areas for 1–3 years during the growing season, while avoiding old burns and unburned areas. With proper stocking rate and prescribed burning, bison grazing results in a dynamic spatial and temporal plant community, reducing the need of costly cross-fencing.

Western Juniper Expansion on Adjacent Disturbed and Near-Relict Areas

Peter T. Soule and Paul A. Knapp

Western juniper expansion has both ecological and management implications. A study on 3 sites in central Oregon documented the rates of juniper density and cover increase during the past 4 decades and addressed how land-use histories may have affected the expansion. Altered fire regimes and domestic livestock grazing may have contributed to expansion on 2 disturbed sites, but these mechanisms can not explain the expansion on a near-relict mesa. Explanation of western juniper expansion on semiarid rangelands must also include fire history, biological inertia, climate, domestic grazing, and atmospheric CO_2 enrichment.

Leaf Area, Visual Obstruction, and Standing Crop Relationships on Sandhills Rangelands

Jerry D. Volesky, Walter H. Schacht, and Patrick E. Reece

Standing crop or above-ground herbage biomass is an important quantitative variable needed in grazing studies and in characterizing plant communities. Our study examined the potential use of leaf area index (LAI) and visual obstruction (VO) measurements in a double-sampling format for estimating total above-ground standing crop. The LAI and standing crop relationship was generally stronger than that of VO and standing crop, but the most successful LAI procedure was considered marginally effective (R^2 = 0.59) in predicting standing crop. With replicated pastures, LAI and VO measurement procedures can be used to efficiently detect the relative effects of stocking rate treatments.

Total Nonstructural Carbohydrate Trends in Chinese Tallow

Warren C. Conway, Loren M. Smith, Ronald E. Sosebee and James F. Bergan

Chinese tallow is a naturalized plant throughout much of southern U.S. and continues to invade a variety of habitats. We related root total nonstructural carbohydrate (TNC) levels and phenological development over an annual cycle to determine optimal timing for better control treatments. Tallow root TNC concentrations were highest during leaf fall and lowest during leaf development and seed formation. Effective tallow control may be achieved if foliar applied herbicides are delivered during the period of seed maturation until leaf fall.

Diversity of the Herbaceous Layer in Mixed Bushveld

Werner G. Dörgeloh

Knowledge of the diversity of the herbaceous layer is necessary to develop proper management practices. Species composition, diversity and density, and grass density were measured with a small-quadrat method and compared along plant communities. The high diversity of the herbaceous layer in the Nylsvley Nature Reserve is influenced by environmental factors and is a reflection of previous low animal stocking densities and a rotational burning regime. Results of the diversity of the herbaceous layer may serve as a benchmark for comparing range diversity over time and space within this vegetation type.

Browsing the Literature

JEFF MOSLEY

This section reviews new publications available about the art and science of rangeland management. Personal copies of these publications can be obtained by contacting the respective publisher or senior author (addresses shown in parentheses). Suggestions are welcomed and encouraged for items to include in the future issues of *Rangelands.*

Grazing Management

Ranching for conservation and profit: Producer experiences. B. Kowalenko and Z. Abouguendia, editors. 1999. (Grazing and Pasture Technology Program, Box 4752, Regina, SK S4P 3Y4, Canada). Twenty-three successful Saskatchewan ranches are highlighted in this 57-page color bulletin.

Rotational vs. continuous intensive stocking management of bahiagrass pasture for cows and calves. M.J. Williams and A.C. Hammond. 1999. Aronomy Journal 91:11-16. (Subtropical Agr. Research Station, 22271 Chinsegut Hill Rd., Brooksville, FL 34601). Livestock performance did not differ between rotational and continuous grazing.

Hydrology

Stream and riparian area management: A home study course for managers. G. Surber and B. Ehrhart. 1998. (Extension Publications, 118 Culbertson Hall, Montana State Univ., Bozeman, MT 59717). Home study course includes written lessons in a workbook, 12 supplemental publications, and 4 accompanying videos. Workbook and supplemental materials can be purchased by Montana residents for $15 and the entire package (workbook, supplements, and videos) is $70. Out of state residents can purchase written materials for $25, and the entire package is $80.

Survey of livestock influences on stream and riparian ecosystems in the western United States. A.J. Belsky, A. Matzke, and S. Uselman. 1999. Journal of Soil and Water Conservation 54:419-431. (Oregon Natural Desert Association, 732 SW 3rd Ave., Suite 407, Portland, OR 97204). Concludes that livestock grazing continues to degrade riparian ecosystems in the West.

Temporal and spatial trends in streamwater nitrate concentrations in the San Bernadino Mountains, southern California. M.E. Fenn and M.A. Poth. 1999. Journal of Environmental Quality 28:822-836. (Pacific Southwest Research Station, 4955 Canyon Crest Dr., Riverside, CA 92507). Reports streamwater nitrate concentrations from forest and chaparral watersheds.

The effects of bison crossings on the macroinvertebrate community in a tallgrass prairie stream. K.M. Fritz and W.K. Dodds. 1999. American Midland Naturalist 141:253-265. (Division of Biology, Kansas State Univ., Manhattan, KS 66506). Distribution and diversity of macroinvertebrates in a stream was altered by bison.

Improvements

Perennial pepperweed (Lep*idium latifolium*). J. Krueger and R. Sheley. 1999. MontGuide 9906. (Extension Publications, 118 Culbertson Hall, Montana State Univ., Bozeman, MT 59717). Describes the identification, biology, and control of perennial pepperweed, an introduced weed that is spreading rapidly along river systems in the western United States.

Prescribed fire management of Karner blue butterfly habitat at Indiana Dunes National Lakeshore. J.R. Kwilosz and R.L. Knutson. 1999. Natural Areas Journal 19:98-108. (Indiana Dunes National Lakeshore, 1100 N. Mineral Springs Rd., Porter, IN 46304). Prescribed fire is successfully used to restore and maintain habitat for the endangered Karner blue butterfly and its sole larval host plant, wild lupine.

Thinning of Emory oak coppice: Effects on growth, yield, and harvesting cycles. R. Touchan and P.F. Ffolliott. 1999. Southwestern Naturalist 44:1-5. (Tree Ring Research Lab, Univ. of Arizona, Tucson, AZ 85721). Proper timing of thinning treatments may enable more frequent fuelwood harvests.

Plant/Animal Interactions

Rarity of oak saplings in savannas and woodlands of the eastern Edwards Plateau, Texas. F.L. Russell and N.L. Fowler. 1999. Southwestern Naturalist 44:31-41. (Dept. Of Botany, Univ. of Texas, Austin, TX 78713). Browsing by white-tailed deer appears to be severely limiting the recruitment of oak trees.

Small mammals, ectomycorrhizae, and conifer succession in beaver meadows. J. Terwilliger and J. Pastor. 1999. Oikos 85:83-94. (Vermillion Community College, Ely, MN 55731). Lack of ectomycorrhizal fungi in meadow soils likely limits conifer invasion. Voles, via their feces, distribute ectomycorrhizal fungi spores into meadows which promotes conifer seedling establishment.

Plant Ecology

Ashe juniper (*Juniperus ashei:* Cupressaceae) canopy and litter effects on understory vegetation in a juniper-oak savanna. L.Y. Yager and F.E. Smeins. 1999. Southwestern Naturalist 44:6-16. (Natural Resource Conservation Program, Univ. of Florida, P.O. Box 3634, Milton, FL 32572). Grass seedling establishment in Ashe juniper litter was affected more by physical features of the litter than by allelopathy.

Demography of *Bouteloua gracilis* in a mixed prairie: Analysis of genets and individuals. J. Fair, W.K. Lauenroth, and D.P. Coffin. 1999. Journal of Ecology 87:233-243. (W.K. Lauenroth, Dept. of Rangeland Ecosystem Sci., Colorado State Univ., Fort Collins, CO 80523). A blue grama plant community was relatively stable over a period of 38 years. Openings created by plant or tiller mortality were recolonized by recruitment.

Harvest management of switchgrass for biomass feedstock and forage production. M.A. Sanderson, J.C. Read, and R.L. Reed. 1999. Agronomy Journal 91:5-10. (Pasture Systems & Watershed Mgmt. Research Lab, Curtin Rd., University Park, PA 16802). In northern Texas, yield of Alamo switchgrass was maximized by a single harvest in mid-September.

Tillering responses to red:far-red light ratio during different phenological stages in *Eragrostis curvula*. C. Wan and R.E. Sosebee. 1998. Environmental and Experimental Botany 40:247-254. (Dept. of Range, Wildlife and Fisheries Mgmt., Texas Tech Univ., Lubbock, TX 79409). In grass plants with open canopies, plant organs receive light with higher red:far-red light ratios. Higher red:far-red light ratios promote plant growth, but favor inflorescence development over tillering.

Reclamation

Arbuscular mycorrhizae promote establishment of prairie species in a tallgrass prairie restoration. M.R. Smith, I. Charvat, and R.L. Jacobson. 1998. Canadian Journal of Botany 76:1947-1954. (Dept. of Plant Biology, Univ. of Minnesota, 1445 Gortner Ave., St. Paul, MN 55108). Inoculation with arbuscular mycorrhizae increased the aboveground cover of seeded native grasses.

Socioeconomics

Is the conversion of land from agricultural production to a bioreserve boon or bane for economic development? The Cache River Bioreserve as a case study. R.J. Beck, S.E. Kraft, and J.H. Burde. 1999. Journal of Soil and Water Conservation 54:394-401. (Dept. of Agribusiness Econ., Southern Illinois Univ., Carbondale, IL 62901). ...total economic activity is expected to increase as a result of the land-use shift from agricultural production to environmental preservation.

Land degradation is not a necessary outcome of communal pastoralism in arid Namibia. D. Ward, B.T. Ngairorue, J. Kathena, R. Samuels, and Y. Ofran. 1998. Journal of Arid Environments 40:357-371. (Ben Gurion Univ. Negev, Jacob Blanstein Institute for Desert Research, Mitrani Center for Desert Ecology, IL-84990 Sede Boqer, Israel). "...in spite of far higher stocking densities on the communal areas and the absence of an overall grazing strategy, we found no evidence of the 'tragedy of the commons"

Soils

Response of the shortgrass steppe to changes in rainfall seasonality. H.E. Epstein, I.C. Burke, and W.K. Lauenroth. 1999. Ecosystems 2:139-150. (Dept. of Environmental Sci., Univ. of Virginia, Charlottesville, VA 22903). Relative amounts of C-3 and C-4 plants in shortgrass steppe influence soil carbon and nitrogen levels.

Soil compaction under grazing of annual and perennial forages. E. Mapfumo, D.S. Chanasyk, M.A. Naeth, and V.S. Baron. 1999. Canadian Journal of Soil Science 79:191-199. (Dept. of Renewable Resources, Univ. of Alberta, Edmonton, AB T6G 2H1, Canada). In meadow bromegrass pasture, soil compaction was not significant under heavy, moderate, or light stocking rates.

Temporal variations in nitrous oxide fluxes from urine-affected grassland. D.L. Williams, P. Ineson, and P.A. Coward. 1999. Soil Biology & Biochemistry 31:779-788. (Institute of Terrestrial Ecology, Univ. of Wales, Deiniol Rd., Bangor LL57 2UP, Gwynedd, Wales). Over 42 days, 7% of the applied urinary nitrogen was lost to the atmosphere as nitrous oxide.

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The Life Member List which was published in the June issue of *Rangelands* had some members omitted and some sustaining members not recognized. We hopefully have recognized all of our life and life sustaining members. If not please call the production department at 303-355-7070.