studies describe a variety of water sources and range condition relationships that fall in different places along a continuum. At one end of the continuum are the virgin grasslands; at the other end are the abandoned and eroded plains and slopes, alive only to dust devils. While the results of both studies caution against opening up new grazing areas without sufficient forethought to water source placement and use, this is not their major policy implication. Instead, both studies indicate that the real range management challenge is the planning of water and range development for those areas that continue, to varying degrees, to be intensively grazed between the ends of this continuum.

Simple range recommendations, such as small capacity water sources or privately held ones as opposed to large capacity or communal water supplies, may be appropriate for the few new grazing areas. They are not suitable for the bulk of those cases that lie in the middle of the continuum which these studies describe. It is the middle group of cases where herd and water source management are at times indistinguishable and where the requirements of herd management almost solely set the context in which water is to be used and access regulated. Thus, an overgrazed area might still be suitable for a goat browse project. An overgrazed area might still have some viable cattle watering locations which can be closed during the wet season for subsequent dry season use. In today's Africa, discussion of new drinking water locations for many already heavily used grazing lands must start with *what* is to be the continuing use of the rangelands, *when* are the water and forage needed, and *for how long* are they needed *where*. ●

The Challenge of Integrated Brush Management in Semiarid Tropics

Linda Howell Hardesty

Shrubs and other woody plants cover more than half the earth's surface. Often they are important forage plants. In some cases they are unpalatable, noxious, or otherwise compete with more desirable plants. Undesirable woody plants, called brush, are often targets for removal from the community.

Early in the development of range management, brush eradication programs were advocated. Since the probability of completely killing any species is quite low, emphasis moved to control rather than eradication. During the 1960's the concept of management of woody plants to minimize the adverse effects of brush and enhance the positive values of shrubs developed. Brush management was a logical outgrowth of the recognition of the beneficial qualities of woody plants and the growth of system science. Today, this concept is tagged Integrated Brush Management.

The arid and semiarid tropics are ideal laboratories to test the theories of integrated brush management. They feature a rich flora, long growing season, various browsing animals, and a tradition of intentional burning to manipulate vegetation.

Northeast Brazil is typical. The climate is semiarid with only a short rainy season. The caatinga vegetation is composed of 15-30 woody species of varying forage value. Both native and cleared caatinga are grazed by cattle, sheep, goats, donkeys, and horses.

The woody vegetation periodically is cut often followed by burning and grazing of regrowth. Although no systematic brush management is practiced, my work there as part of the Small Ruminant Collaborative Research Support Program

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Edge of a recent clearing illustrates the density of mature, intact caatinga in northeast Brazil.

has helped me develop an approach to improved brush management that should apply widely in the arid and semi-arid tropics.

My suggestions are based on my experience and the results of a survey of 220 papers on brush management throughout the dry shrublands of North and South America, Africa, Australia, and India[1]. Because emphasis has been almost entirely on elimination of brush, this is actually a survey of brush control literature. The results strongly suggest that control of brush is rarely achieved in these regions and a new approach is needed.

Not all available techniques were reviewed. The use of herbicides, fertilizers, and sophisticated machinery was not included in the review. This is not to say that these techniques are not valuable, but their use may not be justified until we have a better understanding of these regions, and the potential of less risky, less expensive technologies has been thoroughly explored. These techniques include manual treatments, controlled burning, and selective grazing.

Typical hand-clearing operation using brush hook and axe.

Variations and combinations of these three methods have been the traditional approach to brush management throughout the world.

Manual Control

Manual control is the oldest, simplest, and most universally used method. This includes topcutting, grubbing out stumps, and girdling. Advantages include minimal needs for equipment or technical training, adaptability to almost any site, either rugged or sensitive, and most important: a high degree of selectivity. Treatment can be directed at a single species, size class, or growth form. Disadvantages include resprouting after treatment, slow application, the limited area which can be treated in a period of time, and the cost and availability of labor, although this varies substantially with the locale and the acceptability of the work.

[1]For a detailed discussion of semi-arid, tropical, and tropical brush management by region and a complete bibliography, see Howell, L.A., 1982. A review of tropical and subtropical brush management techniques with special reference to the northeast Brazil. M.S. Thesis. Utah State University.

Cutting is the most frequently used method both to eliminate undesirable growth and to stimulate browse production. Grubbing and girdling are more effective for control but are rarely practical on a broad scale. Manual treatments are often combined with other techniques, for example, to prepare fuels for controlled burning, clear regrowth, or provide access for browsing animals.

In Northeast Brazil woody plants are cut by hand and the wood suitable for fence posts and fuel is removed. Sometimes these clear-cut areas are cultivated. In other instances the woody plants are removed to stimulate herbaceous forage growth.

The timing of woody plant removal appears to be related to the value of wood products as well as the desire to produce forage. This dual use is consistent with the concept of integrated brush management.

Controlled Burning

Burning undesirable vegetation is an ancient practice. Fire is lauded for creating and maintaining grasslands and blamed for causing shrub invasions or rangeland deterioration. The result of a burn is determined by the interaction of the fire tolerance of the vegetation and the intensity of the fire. Both of these vary seasonally and annually making an intimate knowledge of the particular ecosystem and fire behavior essential. Because of the number of variables involved, it is risky to generalize about the effects of fire. This may partially explain the lack of consensus on its value as a brush control tool. Selecting the season to burn and manipulating the condition and distribution of fuels are all possibilities for increasing the effectiveness of controlled burning. Like manual treatment, fire is often used as part of an integrated brush management program to clear debris, encourage sprouting of browse species, eliminate thickets, etc.

In the caatinga, like many tropical areas, slash is often piled before burning, causing extreme variation within the burned area. The primary objectives appear to be clearing for cultivation, improving animal access, and killing fire sensitive species which are often left uncut.

Selective Browsing

Controlled browsing can be an effective brush management tool. Managing browsing is complicated since the forage selected by a species or individual changes with the season and forage availability. When understood, these differences can be exploited to improve both animal and range condition.

In general, camels and goats browse more than sheep, cattle, horses or donkeys. Sheep often select more herbs than the others. Likewise, the selectivity of wild herbivores varies. Preferences for classes of plants may not be as important as preferences for individual species. For example, one forb species may always be preferred to any shrub, even when the diet is primarily browse. Differing dietary habits may make mixed grazing both more economical and more effective for managing brush and maximizing animal production.

Stocking rate has a critical effect on results. Two general approaches are used: moderate, longer-term stocking has rarely been effective for brush control; high stocking rates

Stumps resprout rapidly. Middleground is four-month-old regrowth. Foreground was similar before goat grazing.

for short periods are usually reported to be more successful. Economics are an important consideration when animal production declines at the stocking rates needed to cause significant vegetation changes. Another problem is that desirable species may suffer overuse during grazing treatments.

Browsing can rarely reduce mature brush but is effective against regrowth and young plants. Again, grazing treatments are most effective when used in combination with other techniques.

In the Northeast of Brazil all classes of livestock graze cleared sites with preference given to cattle, sheep, horses, and donkeys, who are less productive in uncleared caatinga than goats. Grazing animals are not generally considered a

Slash burning has little impact outside brush piles. Unburned regrowth is one month old.

range manipulation tool. Similar conditions for integrative brush management exist in many tropical areas. *What is missing are firm objectives and a methodical approach.*

Conclusions

My work reveals a surprising lack of agreement on the appropriateness or effectiveness of any single brush control method but does identify many of the variables influencing a plant or community response to manipulation. These include the species, size, age, and condition of the plant in relation to soils, topography, climate, and the other biotic elements of the community, the time and type of treatment, and any prior, concurrent, or short-term future manipulations. We cannot always predict the effect of these factors, but we can investigate them, allow for them, or, when possible, control them.

The importance of cultural, temporal, and economic factors cannot be overemphasized. A biologically successful technique has no value if it does not ultimately improve or stabilize animal production, if it is not economical in the existing management system, or if it is unacceptable to producers or the public in general.

The effect of the techniques reviewed on the target vegetation ranged from complete elimination of some species to invasion by even less desirable species. The best that can be expected is partial or temporary change in the vegetation.

Combined treatments were almost always more successful than any single method. Manipulation of one species has indirect effects on the entire community. Elimination of one troublesome species may create the opportunity for invasion by others. All of these techniques have the potential to damage the entire ecosystem.

This is a pretty meager collection of generalizations considering the time, effort, and money that have been invested in brush management research and practice. As a body, the results are not coherent or cumulative, nor do they provide much insight into ecological realities. Lacking systematic experimentation, it is difficult to decide when conflicting results are due to differences in ecosystems, in the application of a particular treatment, or in the interpretation of results. The lesson lies not in the conclusions we have, but in those which are missing. And more critical than the facts that are missing is the approach used in their pursuit. *The problem is not due to a lack of skill or effort on the part of the researchers, but to the tremendous number of variables involved in brush management work.* This, often coupled with the absence of basic knowledge of the ecosystems involved, and a tendency to want to experiment with razzle-dazzle techniques tends to perpetuate the situation by focusing attention on the end of a process, rather than allowing the process to proceed step by step.

Integrated brush management, an alternative approach based on the idea of maximizing the contribution of existing vegetation while working to minimize its less desirable features, appears to be a process-oriented technique with promise in Northeast Brazil. I believe it could be applied widely in the tropics.

This approach requires specific management objectives, a basic understanding of the local ecosystem and perspective on the region in general. In developed countries, much of this information is available, but in less studied regions basic information may be lacking.

Admittedly, it is frustrating to be confined to broad analysis and the accumulation of basic data rather than immediately applying new techniques, but if the overall objective is to advance our knowledge of shrublands, improve range condition and productivity, and enhance the quality of human life in the arid and semiarid tropical regions, we must concentrate our efforts on understanding the entire system. The general process I propose is outlined below.

The first step is to identify the value of the plant species present, even if based only on observations, approximations and local history. This includes the forage value for all important livestock and wildlife species throughout the year, both green and dry, young and old growth. There may also be timber, fuelwood, post, thatch, tannin, or charcoal values. Often native plants are traditional sources of fiber, oils, remedies, and foodstuffs. Also consider ecological status such as competitive relations, mode of reproduction, ability to persist on the site, role in successional patterns and in providing soil stability and cycling nutrients.

The next step is to review traditional management practices, becoming familiar with the overall agricultural system, including grazing and harvesting of native vegetation and management constraints such as land tenure patterns and how they fit into regional and farm production strategies. Find out what techniques are used to manipulate woody vegetation: how and when and why are these selected over others which appear to be available? Identify the specific objectives of these traditional methods including the need to eliminate or cultivate particular species, build forage reserves, etc. Also what have been the results, good and bad of these treatments? Survey known history areas and compare with relicts.

This information will help clarify current management objectives and problems within the entire management system, at the regional, industry, and producer level. Do specific brush management objectives appear within the framework of these broader objectives?

At this point specific management objectives and information needs will become apparent and can be analyzed. This final step is where range research programs usually begin. This phase involves collecting the basic biological, physiological, and ecological information needed to answer questions presented by species management objectives. For example, if one objective is to increase the density of a given species, the question might be, what is currently limiting its distribution? How does it reproduce, etc.? This is the foundation allowing development and testing of techniques to accomplish specific objectives.

These last two steps can be combined, using experimental treatments to deduce basic information about a particular species. For example, if it seems that seasonal rest will permit seedlings to reach a browse resistant stage but the most effective phenological period for rest for that community is unknown, seasonal trials can be conducted. The results should provide information on phenology as well as the effects of treatment. With this approach, even projects unsuccessful in terms of their management objectives can contribute basic information, improving the chances of

future success. Experimental treatment based on a growing understanding of the target species and its environment allows us to accumulate knowledge. This stepwise approach can be more effective, more economical and lead us more surely to an understanding of arid and semi-arid tropical shrublands and their potential contribution to the welfare of their inhabitants.

Our work in Brazil demonstrates this approach to integrated brush management. Other scientists have surveyed production systems and producer needs, described range sites, determined sheep and goat diets on cleared and uncleared caatinga, and estimated plant productivity. I am determining the sprouting potential of woody plants under different cutting and browsing regimes. All of these are separate studies that will add to the scientific literature. But the real payoff will come when we can put all the studies together to meet the needs of land managers for integrated brush management programs.

About the Author: Linda earned a BS degree in wildlife and fisheries at the University of Idaho in 1973. She did graduate work there in veterinary science and then worked for the Idaho State Department of Fish and Game and later worked for the State Department of Lands as a ranger manager. During that time she was very active in the Idaho Section, SRM. She received the Rangeman of the Year Award from the Idaho Section for her work with ranchers in range development.

She earned a master's degree in range science in 1980 from Utah State University. At present (1983) she is working on a Ph.D. in range management as a research associate with Utah State University on the USAID/SR-CRSP range research project in northeast Brazil.

Performance of Icelandic Horses in Northwestern Alaska

William B. Collins and John Brooks III

Horses played a significant role in exploration and settlement of Alaska during gold rush days. However, with the increase of mechanized transportation, horses became less important and generally too expensive to keep for purposes other than recreation. Some would argue that horses are also too expensive to keep for recreational purposes. In 1982 a different breed of horse—one which appears well adapted to living off the range in summer and winter with little supplementation—was introduced to the state. The following is a brief description of that breed, its history, its requirements, potential uses, and special adaptations which make it more satisfactory than its predecessors as a work or pleasure horse in northwestern Alaska.

The Breed

About 1000 years ago, settlers from Scandinavian countries and the British Isles began arriving on the volcanic island of Iceland. These Viking farmers had crossed the North Atlantic in open boats, bringing with them all they thought essential for pioneering in their new, often harsh, environment. Perhaps the most enduring of their precious cargo was horses. Their horse was relatively small (13-15 hands and 850-900 lb), typical of European horses at that time. During the next 1000 years, "Icelandic" horses were to remain isolated from other horse populations. This was made possible as the Althing (the oldest parliament in the world) passed a law in 930 forbidding the importation of horses to maintain breed purity. Some scholars have suggested that the establishment and long existence of the Althing depended on horses to enable Icelandic chieftains to gather together from across the rugged country. From the time of settlement until the beginning of the 20th century, Icelandic horses represented the sole means of transportation for people and goods. Had there been a network of roads and bridges, perhaps a larger horse would have been bred to pull wagons and carriages. As it was, Icelandic horses were well suited to cross-country travel and could be kept year-round on open range.

People outside Iceland have become increasingly aware of the self-sufficiency, stamina, fecundity and longevity of the Icelandic horse. This animal has become well known for being the only remaining European breed to retain five distinct gaits, the most notable of which is the Tolt, or running walk (The Tolt disappeared from Europe as larger horses were bred for the purpose of carrying mail-clad soldiers and pulling wagons and carriages.) The horse is ideal for the Icelandic sport of "trekking," in which the horse is ridden cross-country 20-40 miles/day over several consecutive days, resting and grazing at night. The breed has a variety of colors as it was bred only in accordance with strict standards on quality of gaits. In addition, extremely severe winters

Authors' Note: As of March, 1984, there were only eight Iceland ponies in Alaska. Prospects for more are good for use as pack animals, sport hunting, fishing, and pleasure riding.