Prescribed Grazing - A Tool for Weed Management

There is growing interest in the potential of carefully controlled livestock grazing to manage invasive plants on pastures, rangelands, and forests. Scientific studies and on-the-ground experiences have clearly demonstrated that livestock are a promising tool in the battle against weeds. Prescribed grazing is an effective technique, rivaling traditional chemical and mechanical control methods, for the management of deleterious invasive plants including leafy spurge, spotted knapweed, yellow starthistle, cheatgrass, salt cedar, and kudzu. Furthermore, prescribed grazing is viewed as an "environmentally friendly" alternative to traditional methods because it leaves no chemical residue, can be removed whenever necessary, and often improves land health and biodiversity. Prescribed grazing can also be integrated with herbicides, fire, or traditional biocontrol methods to improve the efficacy and longevity of weed control treatments. There is an ever-increasing body of research and experience that demonstrates the utility of managed grazing for weed control, yet prescription grazing remains a highly underutilized technique. Obstacles to its adoption include ignorance of land managers about its potential application, lack of information related to animal production systems designed for vegetation management, and limited familiarity with developing grazing prescriptions and drafting contracts for vegetation management. Information on how to accomplish prescription grazing for weed control is currently available in a few scientific articles, book chapters, and symposia. There is considerable need to foster discussion on the potential value or obstacles for use of livestock grazing to accomplish weed management goals.

✦ Prescribed Herbivory: An Emerging Biocontrol Tool for Managing Invasive Species

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✦ Engaging Livestock in Weed Management - A Western Perspective

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Prescribed Herbivory:
An Emerging Biocontrol Tool for Managing Invasive Species

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Although humans have battled for millennia plants that grow where they are not desired, weed control as a science and a multi-billion dollar business is an invention of the 20th century. In the past 50 years, chemical control methods developed into the dominating tool for the suppression of weeds in agricultural fields and rangelands. After 50 years and billions of dollars spent in herbicide applications, more than 40 million ha of agricultural (including range) lands of the US are invaded. The infested area continues to expand at a rate of about 14% per year. Decision makers and stakeholders are beginning to fear that this is a losing battle and additional control methods are being sought.

Cost and risk associated with the application of pesticides were among the factors motivating the development of Integrated Pest Management, an approach to optimize effectiveness of pesticide applications by combining several control tools with careful threshold and effectiveness analysis. Biological control agents (insects, microbes or fungi) play a role in IPM schemes. These traditional biocontrol agents are symbolic for the dominating view of invasive weeds – the single species approach. Biocontrol agents are developed with the overarching emphasis on host species specificity. This of course is not always achieved. More importantly, however, the emphasis on host specificity, while obviously based on good management principles, may in a way also reflect difficulties in accepting invasive weeds as an ecosystem problem. Only if viewed in relation to plant community dynamics and factors impinging upon succession can the causes of weed invasion be understood. Without understanding causes of invasion, prevention is not possible. Once established, invasive weeds are typically bound to stay, and weed management assumes the character of regulation, often effectively eliminating hopes for eradication.

One of the currently most active research areas in rangeland ecology is the study of plant community response to disturbance. Dissatisfaction with established (linear) models of succession motivated much of this work, which has a strong focus on the development of theoretical models predicting plant community responses to fire and grazing. Especially the so-called State and Transition Model should appeal to weed ecologists. This approach considers events or processes leading to the establishment of plant community states with probabilities of change potentially differing by orders of magnitude for different directions on the successional scale. Moreover, succession is not viewed as necessarily bidirectional in this model. Intuitively, this property should accommodate many observations made in plant communities under invasion pressure from non-native species. Inasmuch as rangeland ecology is indeed successful in finding better prediction models for plant community succession, a unique opportunity exists for weed science to strengthen an ecosystem perspective in research on invasibility of plant communities and sustainability of control programs.
Interest in the application of prescribed herbivory for weed management is exploding, largely driven by considerations of cost and environmental risk of herbicide applications. However, one of the strongest arguments leveled against this management approach is the perception that domestic herbivory is the driving force in weed establishment in rangelands. This may have been true for certain species, such as Bromus tectorum, but unequivocal data establishing a general causality for domestic herbivory as the main factor in weed invasion is very scant at best. Further, domestic herbivory is viewed either as non-selective, or as exerting selective pressure against desired species. However, current research is beginning to lay the foundation for herbivory management strategies capable of being (a) selective against undesired species, and (b) selective in favor of desired species. Thus, understanding prescribed herbivory (and prescribed fire, for that matter) as planned disturbances and studying their effects on plant communities has the potential to significantly contribute to better understanding of ecosystem level processes underpinning weed invasion.

Prescribed herbivory requires a management protocol. Research supporting the development of a practical management protocol has led to the description of the following knowledge gaps:

1. Effects of plants on animals: Many if not most invasive weeds contain plant secondary compounds at different levels with potentially adverse or deleterious effects. Considerable between-species and within-species variation seems to exist in the behavioral and metabolic capacity of herbivores to mitigate impact of PSC's. Research in this area is at an infant stage, and knowledge about strategic nutritional and non-nutritional supplementation options for domestic biocontrol herbivores to maintain health and intake is very rudimentary.

2. Relevance of animal product derived from domestic biocontrol herbivores in regards to food safety. Animals may accumulate potentially toxic PSC's or their metabolites in muscle, or excrete it in milk. Virtually nothing is known in this area, although many domestic biocontrol herbivores are already used to control-graze several Centaurea species containing very troublesome PSC's.

3. Effects of animals on plant communities. Domestic biocontrol herbivores are selective grazers and browsers. The widespread notion of the contrary must be overcome, ideally with research data illustrating the selectivity of domestic herbivores. Nutrient content, physical properties and PSC content of plants change considerably during their life cycle. Herbivores adjust to these changes by taking advantage of the fact that in no plant community all plants have perfectly aligned growth curves and life cycles. In other words, timing and intensity of herbivory can be used to fine-tune and steer selectivity. In particular goats are exquisitely selective and thus ideally positioned to become rather highly specific biocontrol agents. Research in this area mandates interdisciplinary work – this task cannot be mastered without animal biologists and community ecologists working together.

4. Secondary effects of prescribed herbivory at the landscape and community level. Domestic herbivores do not only impact the biological dimension of plant communities and landscape, they also have physical impact. Soil compaction, drainage effects, nutrient contribution, effects on plant community structure influencing wildlife habitat properties, and increased mobilization of sediment must be monitored and regulated in adaptive management schemes. It is noteworthy, however, to consider the fire fuel conundrum: often, the use of herbivores for fuel reduction is rejected on the grounds of potential impact on sediment release affecting endangered fish species along the Pacific Coast. Yet, there is hardly any more violent release of sediment into watersheds than that occurring after catastrophic wildfires in the Pacific Coast ranges. It appears that those in charge of setting management policies have not been supported by appropriate analyses.

5. Effects of domestic biocontrol herbivores on wildlife populations. In addition to the indirect effects of habitat modification, direct effects such as disease transmission and even hybridization have been cited as arguments against prescribed herbivory. Yet, evidence is very scant, as it is in the reverse case of wildlife acting as disease agent reservoir for domestic herbivores. The infamous case of the Yellowstone Basin bison herd is an illustrative example.

As a conclusion, it appears that very profitable opportunities exist for collaborative research on prescribed herbivory for weed management. Invasive weeds have been billed for many years as a runaway ecological problem of very substantial proportions, and in many cases, this is unfortunately correct. With herbicide applications becoming ever more problematic, and traditional biocontrol methods not in a position to even slow down rate of invasion, alternatives must be researched. Accordingly, there should be no room for continued construction of disciplinary barriers and further cultivation of professional bias. Rather, collaborative work involving weed ecologists, rangeland ecologists and animal scientists should move into the foreground.

Engaging Livestock in Weed Management - A Western Perspective

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Invasion by exotic species is one of the most significant ecological threats of our modern era rivaling even highly warned and researched concerns such as ozone depletion, global warming, and loss of biodiversity. In Western North America, noxious weeds, such as downy brome (*Bromus tectorum*), spotted knapweed (*Centaurea maculosa*), leafy spurge (*Ephorbia esula*), yellow starthistle (*Centaurea solstitialis*), and rush skeletonweed (*Chondrilla juncea*), pose significant threats to livestock production and the ecological integrity of rangeland communities. Weed invasion into rangeland communities most often results in reduced biodiversity, increased soil erosion, degradation of wildlife habitat, and reduced carrying capacity for livestock.

The cure for these weedy rangeland aliments is often illusive and expensive. The challenges of controlling invasive plants on rangelands include vast roadless areas that limit access for weed control and lands of low economic value making chemical and cultural control impractical. These challenges limit the feasibility of chemical and mechanical treatments and favor use of biological control. Insects and microbes for biocontrol can be quite effective but they are difficult, expensive, and time consuming to develop. An under-exploited and readily available agent for weed control is domestic livestock. I suggest that the challenges of rangeland weed management may be overcome with the careful sharpening of an old tool; *livestock grazing.*

The effectiveness of prescription grazing by sheep and goats has been clearly demonstrated for the management of leafy spurge, which aggressively competes with native plants on over 3 million acres of rangeland in the Northern Great Plains. Because cattle avoid grazing leafy spurge, the forage value of rangeland and pastureland can be decimated as leafy spurge invades and forms near monocultures. Fortunately, sheep and goats readily graze leafy spurge, finding it a nutritious and desirable forage and selecting it before resorting to eating grasses. Sheep and goats are highly effective tools for reducing the dominance of leafy spurge and are a readily applied technique in many areas of Montana and North Dakota. Using sheep to control leafy spurge can cost as little as 60 cents per acre, compared to a cost of $35 per acre to spray herbicides from a helicopter. Currently, Montana weed trust fund dollars compensate sheep producers $1 a head per month for grazing services to control leafy spurge on over 28,000 acres.

Spotted knapweed is considered one of the most troublesome rangeland weeds in the northern United States and Canada. Spotted knapweed is an aggressively spreading weed currently occupying more than 7.5 million acres of western rangelands costing the livestock industry more than $42 million a year in lost forage and additional weed control expenses. Herbicides, insects, pathogens, and fires have not effectively contained the spread of this noxious weed. Sheep readily graze spotted knapweed, consequently reducing reproductive output of spotted knapweed and abundance.

There is growing interest in livestock grazing to reduce fire fuel loads in response to continued urban development at wildland interfaces and the extensive and destructive fires of 2000. Strategically applied sheep and goat grazing has reduced the risk and extent of wildfire in many settings. The most successful programs to reduce fuel loads are in California where goats and sheep are commonly employed to graze the highly flammable shrubs of the chaparral region. Intensive grazing at the urban interface can create effective fire breaks as was accomplished near Carson City, Nevada, in a program cleverly named “Only Ewes Can Prevent Wildfire.” A fenced corridor around the city was grazed by ewes resulting in removal of 71 to 83% of fine fuels. A survey of nearby homeowners revealed that over 90% supported the project and preferred the sheep to traditional chemical or mechanical methods of creating fuel breaks. In the Great Basin, extensive wildfires often burn through areas dominated by cheatgrass. Intense sheep grazing of cheatgrass-dominated sites, for as little as 2 years, can effectively suppress or even eliminate cheatgrass stands.

Though prescribed grazing is used minimally for fuel management on federal forest rangeland, success has been demonstrated by several trial projects and opportunities for prescribed grazing are expected to expand. Federal funds for hazardous fuel reduction, exceeding $350 million annually, could be used to secure the services of sheep and goat operators.

Removal of undesirable vegetation can be accomplished by prescription grazing for management of power line easements, irrigation canals, roadsides, forest plantations, and orchards. Animal impact can also be harnessed to sow seeds for ecological restoration of degraded lands. Sheep and goats have been used to improve wildlife habitat by removing weeds, reducing fire frequency, and changing plant composition. All of these grazing applications have potential ecological and production values that create economic incentives for prescription grazing enterprises.

There is an ever-increasing body of research and experience that demonstrates the utility of small ruminants for vegetation management, yet prescription grazing remains a highly underutilized technique. Obstacles to its adoption include ignorance of land managers about potential application, lack of information related to animal production systems designed for vegetation management, and limited familiarity with developing grazing prescriptions and drafting contracts for vegetation management. Information on how to accomplish prescription grazing for vegetation management is currently available in a few scientific articles, book chapters, and symposia. Several projects are currently underway to identify obstacles and provide information this emerging weed management technology – *Prescribed Grazing*.

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Solving Vegetation Management with Goats – An Eastern Perspective

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Much of hill-land pasture in the Appalachian region of North Carolina is infested by brushy vegetation including multiflora rose (Rosa multiflora Thunb.). Multiflora rose was imported in 1886 from Japan by the USDA for use in erosion control and as a rootstock for some varieties of ornamental roses. According to a 1977 survey by the North Carolina Department of Agriculture, multiflora rose had infested 58,514 ha of pastureland and an additional 18,480 ha of non-pastureland in 53 mountain and western counties. Since then, invasion of productive land by multiflora rose has increased, and in cases of heavy infestation, access to pasture and recreational areas has been severely restricted. Multiflora rose seeds are widely dispersed by birds, rodents and water, and may remain viable in the soil for up to 20 years. Controlling multiflora rose usually involves mechanical cutting and the use of herbicides. Nevertheless, increased restrictions for herbicide use and elevated costs of other control methods requires an effective integrated management program for years after controlling the original plants.

Field studies were initiated in an abandoned, overgrown orchard (8.4 ha) left untouched for 15 years. In study 1, brush goats were grazed alone (30 mature does/ha) or with cattle (17 mature does/ha with 2 to 3 growing steers/ha) for 4 grazing seasons on 3 replicated pastures. Grazing occurred for 45 to 60 days from May to July and for another 24 to 35 days in September and October. The grazing/browsing periods were dependent upon having at least 5 to 10 cm of available forage to graze within each paddock. At the time study 2 started, the orchard had not been grazed for two years and multiflora rose and other brush had increased. Animals were rotationally grazed on 3 replicated pastures throughout the grazing season over a 4-year period, at a stocking rate of either 1.7 steers/ha or 1.7 steers/ha + 3.4 goats/ha. Managed defoliation resulted in a substantial increase in herbaceous vegetative cover and grass species in plots grazed by livestock. Inclusion of goats practically eliminated multiflora rose bushes whereas cattle provided only modest control. Conversely, black locust (Robinia pseudoacacia) trees, brambles (Rubus spp.), poison ivy (Toxicodendron radicans) and honeysuckle (Locifera japonica) vines were practically eliminated in all grazed pastures. Integrating goats in cattle grazing systems in the Appalachian region is a useful and environmentally-friendly tool to control invading woody species and forbs, and shifting botanical composition toward desirable forage species while increasing profit per unit of land through the production of an additional saleable commodity. The inclusion of one to two goats per head of beef cattle in mountain grazing systems is now recommended to interested farmers by the NC Cooperative Extension Service.

Over 500,000 ha of forest in the Southeastern region of the country is invaded by kudzu (Pueraria montana). Kudzu, a native vine from Japan and China, was introduced by the USDA in early 1900s for erosion control. Kudzu is one of the most aggressive legume vine growing in the Southeastern United States. Herbicides have been used to control kudzu, but these chemicals are expensive and repeated applications are usually required. In addition, environmental concerns associated with the repeated use of chemicals cannot be over emphasized. A two-year field study conducted on Centennial Campus at NCSU demonstrated that repeated defoliation (avg 5 times per growing season) at a stocking rate of 100 goats/ha resulted in the elimination of kudzu after only two years. These results also indicate that goats offer an environmentally-benign and viable alternative to achieve management and elimination of this unwanted plant while providing additional income to goat producers.

Because of their opportunistic and versatile grazing/browsing behavior, the foraging habits of goats have important environmental implications in many other situations. For instance, browsing goats in hardwood forests and other timber land areas can potentially provide buffer zones around rural communities and newly-established development projects as viable protection against forest fires during periods of summer drought.

Integrating Prescribed Grazing into Vegetation Management Programs

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The strategies and methods for vegetation management available to the land manager can be as diverse as the invasive plants they are managing. To be effective, long-term management of invasive plants must adopt an integrated approach of carefully planned and well-implemented activities.

The framework for integrated vegetation management is based on the stated short and long-term land management goals. The most effective and sustainable weed management programs are those which are founded on sound land management goals, as determined by a collaborative of interested and committed people, from resource managers, to ranchers and recreationists. The first step of integrated management takes place in the meeting room, where thoughtful discussion outlines the intended use of the land, defines the vegetation management objectives, identifies the invasive plant(s) to be managed, lists the resources available to achieve the goal, and outlines a plan to monitor and evaluate the progress of the management program. The control of invasive plants, within the context of vegetation management, serves to protect or restore plant communities, increase availability of forage for livestock production, improve wildlife habitat, and improve water quality and recreation opportunities.

Prescribed livestock grazing can be integrated with other conventional weed control strategies, including herbicides, biological control insects, reseeding and competition, hand pulling, and prescribed burning. Prescribed grazing particularly provides an additional strategy for vegetation management in remote areas where other options can sometimes be limiting. How multiple strategies are combined depend on which strategies are to be used, the species of weed, the existing plant community, and the type of ecosystem. Integrated programs usually extend over a few to several years.

Several weed management programs have successfully integrated prescribed grazing. In controlling leafy spurge in Idaho, it was shown that goat grazing reduced the canopy cover of the spurge, and after 2 years increased the activity of the leaf- and root-feeding biocontrol beetles. The combined herbivory from goats and beetles produced a synergistic effect for controlling leafy spurge. In Idaho, prescribed grazing was shown to be compatible with yellow starthistle seed-feeding biocontrol insects. In Montana, researchers have used sheep and herbicides to control Dalmatian toadflax and spotted knapweed, with sheep grazing the weeds and herbicides being applied to control regrowth following grazing. Competitive vegetation is another benefit to prescribed grazing – competition normally imposed by the invasive plants is removed with grazing, often enabling native and desirable vegetation the opportunity to re-establish and flourish. In Idaho, the state Department of Lands is using goats and prescribed fire to check the spread of undesirable shrubs in valuable tree plantations.

Researchers and practitioners are continuing to investigate this emerging technology. Land management agencies such as the Bureau of Land Management and the Forest Service recognize the benefit of prescribed grazing and are working with cooperative programs to incorporate this vegetation management tool into their land management programs. These efforts will continue to define how prescribed grazing, as a tool, can be integrated to maximize our weed management opportunities and achieve our vegetation management goals.