By Gary Frasier

Frasier's Philosophy

Rangeland weeds and pests, the theme of this issue, are an ongoing concern to many people. Everyone who has tried to garden, farm, or managed a piece of land has encountered them. I have several old photos taken in the early 1900s of the Frasier homestead in southwestern Nebraska showing the farm buildings, animals, and family. The remarkable thing is that the photos also show a good crop of cockle burrs and sunflowers. Years after the photos were taken, I remember that as a youngster growing up not too far from the old homestead, my father every evening during the summer would spend an hour or so pulling cockle burr plants. Cockle burrs and sunflowers still grow on the land today. Though maybe not as numerous in present times as in the past, they are still there despite all the effort to eradicate them. The best that can be done is to keep them down to a mere nuisance level.

We have all heard about the locusts that invaded the crops of the early settlers. They were a pest. A few years ago I was trying to grow a small garden. Just as everything was going good, we had an invasion of grasshoppers. They devastated the plants. My neighbor said, "This isn't bad. Several years ago the grasshoppers were so numerous that they ate the screens off the windows and the paint off the wood siding of the house." Just because grasshoppers are not a problem this year does not meant that they are gone for good.

Rangeland pests can come in all sizes. There are several large bull elk wandering around my neighborhood. To a hunter, they are a desirable species. They are a pest to my place. To a rancher, prairie dogs can be a pest. To the black-footed ferret, the prairie dog is a desirable item on the rangeland. It all depends on your perspective.

There are many pests of the rangelands. Some are present today. Some occurred in the past. Some pests of the past may return. We will never completely eliminate pests. We must learn to live with them. As one of the papers in this issue points out, a weed is a plant out of place. A pest in one place may be a desirable feature in another setting. There may even be some places where grasshoppers and locusts are desirable. ◆

Important Poisonous Plants on Rangelands

Management strategies based on toxin level in the plant, animal susceptibility, and grazing behavior can reduce the risk of poisoning.

By Lynn F. James, Dale R. Gardner, Stephen T. Lee, Kip E. Panter, James A. Pfister, Michael H. Ralphs, and Brian L. Stegelmeier

Introduction

All plants have secondary compounds, some of which can be toxic to livestock if consumed in sufficient quantities. A few plants accumulate toxins at high levels and yet are relatively palatable to livestock. These pose a high risk of poisoning. Most native range communities contain a few toxic plant species that create risks to grazing livestock.

Historically, poisonous plants have caused significant problems for the livestock industry on rangelands and to a lesser degree on pastures. The estimated livestock loss from deaths and abortions exceeds $340 million in the 17 western states.[1] In addition, these plants cause weight loss, unthrifty animals, and altered management strategies.

USDA-Agricultural Research Poisonous Plant Laboratory, Logan, Utah.

The USDA became concerned about livestock poisoning in 1894 when V.K. Chestnut was hired to investigate plant poisonings on western rangelands. Formal research on poisonous plants began in 1905 when C. D. Marsh was sent to Hugo, Colorado, to establish a research station to study locoweed poisoning. This research continued in various departments and locations in the West and is now a component of the USDA Agriculture Research Service at Logan, Utah.

The mission of the Poisonous Plant Lab is to solve poisonous plant problems: identify plants that are toxic to livestock; identify, isolate, and quantify the toxin and determine its mechanism of action; determine how the toxin is metabolized and cleared from the body; develop diagnostic and prognostic procedures; ascertain the conditions when livestock graze these plants and are poisoned; and develop management strategies to reduce the risk of poisoning. A truly integrated team of scientists work cooperatively on all aspects of poisoning: veterinary medicine, pathology, toxicology, reproductive physiology, natural products and synthetic chemistry, animal nutrition and behavior, range management, and ecology. Knowledge generated from research is used to develop recommendations and management strategies to reduce or eliminate livestock poisoning. Examples of some of the important poisonous plants are listed here.

Halogeton.

Halogeton

Halogeton (*Halogeton glomeratus*) is an invasive alien noxious weed from Russia that was first collected in Wells, Nevada, in 1934. Within 4 decades, it rapidly spread throughout the cold desert and infested over 11.2 million acres in the Great Basin, Snake River Plains, Colorado Plateau, and Red Desert of Wyoming. Catastrophic livestock losses occurred in the 1940s and 1950s when entire sheep bands died overnight. *Life* magazine called it the "stock killing plant of the west." The Halogeton Act of 1952 provided funds for its eradication and control. Reallocation of federal research from Forest Service Experiment Stations to the Bureau of Plant Industries created a Range Research unit, which was placed within the Agriculture Research Service when it was established in 1953.

Halogeton poisoning of sheep was a symptom of a larger problem—the overgrazed and depleted condition of desert range.[2] Research showed that if range conditions could be improved, competition from perennial species would reduce halogeton and provide alternative nutritious forage. As a result, thousands of acres of depleted sagebrush range were seeded to crested wheatgrass. Other research projects showed that rumen microflora could be adapted to halogeton by feeding low levels of oxalate[3] such as those in shadscale. The major preventative measure was to keep hungry sheep from grazing dense patches of halogeton.[4] Poisoning occurred when sheep were stressed and hungry from hauling or trailing, then released to graze in areas where halogeton proliferated, such as disturbed areas around water sources or loading docks. Once this knowledge was available, losses generally ceased.

Veratrum

Western false hellebore (*Veratrum californicum*) caused birth defects in sheep in mountain valleys in Idaho. However, it was of great scientific interest because it was the first identified case of a dietary factor causing birth defects.[5] Chemists isolated the teratogen, cyclopamine,[6] and found it was dangerous for only a short part of the reproductive cycle. If a ewe consumes it on the 14th day of gestation, cell differentiation and migration is disrupted, causing a cyclopic or monkey-faced lamb. Limb deformities occur if it is consumed on days 27–32, and collapsed trachea on days 31–33.[7,8] This knowledge resulted in the simple management strategy of avoiding grazing Veratrum for 30 days after breeding. This was accomplished by simply reversing the grazing pattern so that the pregnant ewes were not in the Veratrum patches during early pregnancy (Lynn James, personal observation).

Lupine

Historically, lupine (*Lupinus* spp.) has been one of the largest causes of sheep poisoning in Montana, Idaho, and Wyoming. Quinolizidine alkaloids cause neurologic problems in sheep and acute death. Lupine seeds and pods contain high levels of alkaloids and are succulent and relatively palatable. A management strategy was developed to avoid grazing dense patches of lupine in the late summer and fall as the pods develop and ripen.

More recently, lupine has been linked to "crooked calf disease" in cattle in which calves are born with crooked necks,

Veratrum.

Lupine.

White locoweed.

spines, and legs. Research determined that crooked calves were born when their mothers grazed lupine during days 40–70 of gestation.[9] The teratogenic alkaloid, anagyrine, was identified[10] and was shown to inhibit fetal movement, causing the limbs and spine to develop in abnormal positions.[11] A simple management solution was proposed to stagger grazing so that the susceptible period of gestation (40–70 days) does not overlap the flower and pod stage of lupine growth when anagyrine is highest.[12]

Current research is refining the management recommendation by defining when and why cattle graze lupine. In the scablands of eastern Washington, cattle begin eating lupine in July, when annual grasses dry up and weedy forbs mature (Ralphs et al, in review). Lupine is a deep-rooted perennial that remains green and succulent later into the summer. The traditional breeding season begins May 1 and runs through July. This puts the susceptible period of gestation from June 10 to October 8. Since lupine consumption occurs during the susceptible period of gestation, producers should either alter the breeding season or deny cows access to lupine from July to September.

Locoweed

Locoweed remains the most widespread poisonous plant problem on western US rangelands. Species of *Astragalus* and *Oxytropis* occur in every major plant community. Locoweed causes chronic poisoning similar to wasting disease, and reproduction is compromised.[13]

The toxin has been identified as the indolizidine alkaloid swainsonine.[14] It is a small sugar-like molecule that inhibits glycoprotein metabolism and lysosomal function.[15] This inhibition causes a storage disease from accumulation of abnormal and partially metabolized sugars and proteins within the cell vacuoles. Eventually, the cells die.[16] Locoweed affects all body systems. Damage occurs to the nervous system, causing depression and/or aggression, impaired locomotion, and difficulty prehending food and water. If left unattended, the animals will die of starvation. Significant weight loss occurs in stocker cattle,[17] and subsequent feedlot gains are compromised (Glen Duff, unpublished data).

The greatest economic loss comes from reproductive problems.[18] In the male, spermatogensis stops, libido is reduced, and mating behavior is disrupted. In females, estrus is altered, and ovarian dysfunction occurs. Abortions and early embryonic death are common. Offspring that are carried to term are weak and retarded. Intoxication is exacerbated in nursing offspring when they receive swainsonine in the milk when their mothers graze locoweed.

Management strategies have been developed that will reduce the risk of poisoning from white locoweed on shortgrass prairies.[19] Producers should restrict access to locoweeds during critical periods in the spring and fall, when the green-growing locoweed is more palatable than dry-dormant warm-season grasses. White locoweed is restricted to shallow rocky soils; therefore, fencing along soil boundaries can create locoweed-free pastures on the deeper, more productive soils. Heavy grazing should be avoided during the summer; if cattle run short of green grass in the summer, they will switch to grazing locoweed. Progressive ranchers in locoweed areas ride through their cattle regularly and remove animals that start eating locoweed (David Graham, personal observation). This prevents further intoxication and prevents the loco eaters from influencing others to eat it. Other ranchers have started testing their stocker cattle at the beginning of the grazing season for their propensity to eat locoweed and removing those that eat it (David Graham, unpublished data). Animals can be trained to avoid eating loco through conditioned food aversion. The taste of the plant is paired with an induced illness, causing the animals to associate the taste with the illness, and they subsequently avoid eating the plant in the field.[20]

Most locoweeds can be controlled by common rangeland herbicides.[21] However, their seeds remain in the soil to germinate and reestablish when environmental conditions are favorable.[22] Drought also affects locoweed populations; they decline and die out during extended droughts but increase dramatically during wet periods.

Table 1. Scientific and common names of plants and type of poisoning.

Family / Genus / Species	Common name	Type of poison
Chenopodiaceae *Halogeton glomeratus*	Halogeton	Kidney damage and acute death
Liliaceae *Veratrum californicum*	Western false hellebore	Deformed fetus
Leguminosae *Lupinus spp.* *Astragalus spp.* *Oxytropis spp.*	Lupine Locoweed or milkvetch Locoweed	Birth defects, crooked calf disease Wasting disease Wasting disease
Ranunculaceae *Delphinium spp.*	Larkspur	Acute death from respiratory failure
Plants containing pyrrolizidine alkaloids		Liver damage, chronic poisoning
Compositae *Senecio jacobaea* *S. longilobus* *S. riddellii* *S. vulgaris*	Tansy ragwort Woolly or threadleaf groundsel Riddell's groundsel Common groundsel	
Boraginaceae *Cynoglossum officinale* *Amsinckia intermedia* *Symphytum officinale* *Heliotropium europaeum* *Echium plantagineum*	Hounds tongue Tarweed or fiddle neck Comfrey Heliotrope Paterson's curse	
Leguminosae *Crotalaria spectabilis* *C. retusa*	Showy crotalaria Rattlebox	

Larkspur

Larkspurs (*Delphinium* spp.) kill more cattle on mountain summer range than any other plant or disease. It is acutely toxic; cattle that eat a lethal dose die within 5 hours. There are over 40 alkaloids in tall larkspur, but the toxic class of alkaloids contain the *N*-(methyl-succinimido)-anthranilic ester group.[23] The mechanism of action of these toxic alkaloids is to block the nerve–muscular junction, resulting in muscular paralysis. This causes fatigue, collapse, and rapid death from respiratory paralysis.

Some drugs can reverse toxicity if the animals are down but not dead. Physostigmine and neostigmine (not yet approved for use in cattle) can reverse the nerve blockage,[24] but they can be toxic if the effective dose is exceeded.

Research has defined a toxic window when cattle are likely to be poisoned.[25] Toxic alkaloid levels are very high in the early new growth but decline over the growing season. Cattle will not graze larkspur early in the season but begin eating it as it begins to flower. Consumption increases as the plant matures, but there is not enough alkaloid in the plant after the pod stage to kill a cow. The management recommenda-

Tall larkspur.

tion was to graze early in the season when larkspur is unpalatable, remove the cows during the flowering period, then graze late in the season after the pod matures.[26]

There are several other management strategies that can reduce the risk of poisoning.[27] Graze sheep before cattle; sheep are 4–6 times more resistant to larkspur alkaloids, and larkspur is considered good sheep feed. Aversion conditioning can train cattle to avoid eating larkspur. Aversions are likely to last indefinitely if conditioned cattle are grazed separately from unconditioned cattle.[28] Herbicides can control larkspur patches where poisoning occurs, and losses can be reduced.[29] The larkspur mirid is host specific to tall larkspur and can be used as a biological tool to damage the larkspur plant. Livestock will not graze severely damaged plants.[30] If the mirid populations can be maintained at high levels, the risk of cattle poisoning can be reduced.

A decision-making handbook is available[31] to assist ranchers in determining their risk of poisoning. It includes measuring alkaloid levels and determining when cattle graze larkspur to define the toxic window, then avoid grazing at that time. Other management recommendations are also presented.

Ponderosa Pine and Broom Snakeweed

Ponderosa pine needles and broom snakeweed cause late-term abortion in cattle. Over several years, a major effort was made to isolate the abortificent compound in pine needles using a large animal bioassay (cow). Isocuppressic acid (ICA) was found to be the parent compound in the needles that induced abortions.[32] ICA has subsequently been identified in Monterey Cyprus, lodgepole pine, and common juniper.[33]

Cattle graze pine needles in cold winters and when deep snow covers the other vegetation.[34] Cattle in low body condition eat more needles than fat cows. The management recommendation is to keep cattle out of pines during the last trimester of gestation.

Broom snakeweed contains several toxic diterpene acids similar to ICA, but the specific abortificient compound has not been identified. Snakeweed is not palatable,[35] but livestock will graze it if all other forage has been depleted.[36] The management recommendation is to always provide adequate forage.

Plants Containing Pyrrolizidine Alkaloids

Pyrrolizidine alkaloids (PA) cause chronic liver damage (cirrhosis), and animals die weeks to months later. They cause the largest problem of plant poisoning worldwide in both livestock and humans. Research has determined the toxicity of the principal PAs in plants[37] and the damage they do as pyrroles in the liver.[38] Many of the invasive noxious weeds contain PAs (Table 1). Their seeds contaminate grains, and their foliage contaminates hay and fodder. They are usually not palatable when green. Management recommendations include identifying and controlling weeds and avoiding grazing when PA concentrations are high in late summer.[39]

Vaccines

We are also conducting research on immunologic assays of the toxins in larkspur,[40, 41] pine needles,[42] pyrrolizidine alkaloids,[43] and Veratrum.[44] These toxins are not large enough to be immunogenic or to stimulate the immune system by themselves. The approach is to attach these toxins to large-molecular-weight proteins that the body's immune system will recognize and to which it will generate an antibody response. If successful, this can be developed into ELISA diagnostic tools and perhaps vaccines.

General Management Recommendations

Most plant poisonings can be avoided by knowing when a particular plant is most toxic, understanding when livestock are likely to eat it, and avoiding grazing in infested areas at those times. Specific recommendations for important poisonous plants in the western United States can be found in USDA Bulletin 415, "Poisonous Plants of Western US,"[45] on our Web site (http://www.pprl.usda.gov).

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Exotic and Invasive Herbaceous Range Weeds

By James A. Young and Charlie D. Clements

Introduction

There is a considerable body of terminology developed during the 20th century concerning range weed control. This terminology was developed so individuals concerned with herbaceous range weeds could communicate. Nothing is more boring than terminology, but in the case of range weed control, if everyone gets on the same page in terminology, an artificially cloudy subject becomes much clearer.

A weed is simply a plant growing in a site where it is not desired. You can make up your own standards for what constitutes desirability. It may be forage production, nutritional quality, or season of growth or have little to do with forage characteristics. Watershed protection, chance of ignition and rate of spread of wildfires, and wildlife habitat are all plant characteristics that influence individual perception of plant desirability. A weed may be a desirable plant in one location and a weed in another. For example, in the salt deserts of Nevada, desert salt grass is a desirable forage species in alkaline/saline habitats surrounding playas. It is virtually the only herbaceous forage species adapted to grow in such environments. In the irrigated alfalfa fields of Nevada, it is considered a serious herbaceous weed.

Landscape dominated by cheatgrass. The conversion of millions of acres of big sagebrush/bunchgrass to cheatgrass in the Intermountain area of western North America is one of the most recent and extensive range type changes to occur in the world.

Herbaceous Weeds

The separation from woody range weeds is based on the persistence of woody cells in the stems or trunk of the plants. Obviously, woody species tend to be longer-lived perennials, but herbaceous species can also be perennials. Compare the annual cheatgrass to a pinyon pine and the herbaceous versus woody separation is ridiculously simple. However, if you try to walk through an old-growth stand of the herbaceous perennial pepperweed, the "woody" separation becomes somewhat nebulous.

Life Form

Herbaceous range weeds can be annuals, biennial, or perennial species. Perennial species are often subdivided into short- and long-lived species. This terminology and classification seems very straightforward, but some of our worst range weeds can be annuals, biennials, or at least short-lived perennials within the same species. Diffuse knapweed is a good example. It can flower and produce seed in 1 year as an annual, remain a rosette for its seedling year and flower the following year as a biennial or, more rarely, continue for at least a 3rd year as a short-lived perennial. Such species often

List of common and scientific plant names	
Common	**Scientific**
African mustard	*Malcolmia africana*
Alfalfa	*Medicago sativa*
Barbwire Russian thistle	*Salsola vermiculata*
Bottlebrush squirreltail	*Elymus elymoides*
Broom snake weed	*Gutierrezia sacrothrae*
Bull thistle	*Cirsium vulgare*
Bur buttercup	*Ranunculus testiculatus*
Canada thistle	*Cirsium arvense*
Cheatgrass	*Bromus tectorum*
Blue mustard	*Chorispora tenella*
Desert salt grass	*Distichlis spicata*
Diffuse knapweed	*Centaurea diffusa*
Filaree	*Erodium cicutarium*
Gum weed	*Grindelia squarrosa*
Halogeton	*Halogeton glomeratus*
Hare's ear	*Conringia orientalis*
Hoary cress	*Cardaria draba*
Juniper	*Juniperus* spp.
Medusahead	*Taeniatherum caputmedusae*
Musk thistle	*Cardus nutans*
Perennial pepperweed	*Lepidium latifolium*
Pinyon	*Pinus* spp.
Purple starthistle	*Centaurea calcitrapa*
Rabbitbrush	*Chrysothamnus* spp.
Russian knapweed	*Acroptilon repens* = *Centaurea repens*
Russian thistle	*Salsola targus*
Scotch thistle	*Onopordum acanthium*
Sicilian starthistle	*Centaurea sulphurea*
Skeleton weed	*Chondrilla juncea*
Small seeded false flax	*Camelina microcarpa*
Spotted knapweed	*Centaurea maculosa*
Squarose knapweed	*Centaurea squarrosa*
Tocalote	*Centaurea melitensis*
Tumble mustard	*Sisymbrium altissimum*
Yellow starthistle	*Centaurea solstitialis*

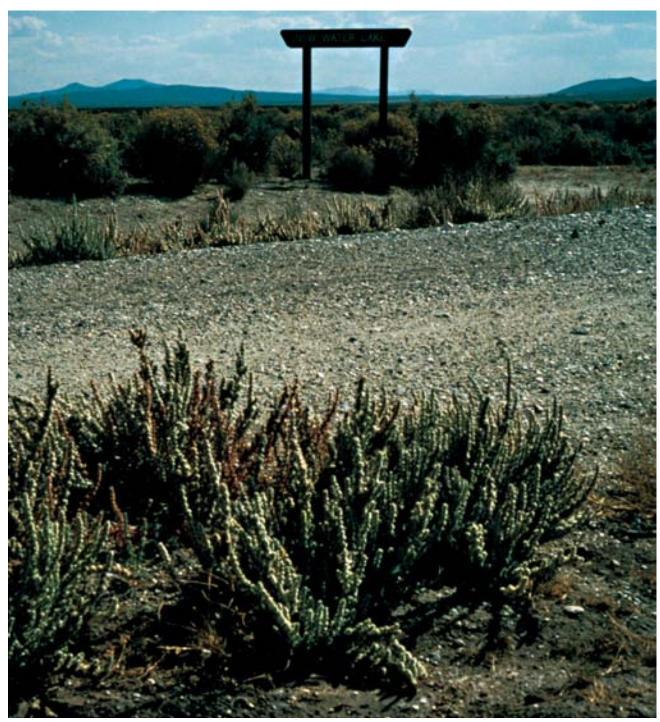
have plant size (ie, number of leaves in a rosette) and external environmental stimuli (winter chilling or vernalization) requirements to initiate flower production. The environmental quality of the site infested, density of the weed stand, and the amount and distribution of precipitation all interact to condition such weeds in their lifestyle. This variable life habit is surprisingly common among some of our worst herbaceous range weeds.

Invasive Weeds

A few decades ago when we started using this term, we modified it with "self-invasive," meaning weeds that colonize new areas without the conscious efforts of humans. In general, usage of the "self" has been dropped. Weeds that move and invade new habitats are among the most dangerous and destructive to the environment of the herbaceous range weed species. The common perception is that these weeds spread because of excessive or improperly managed grazing of domestic livestock. The invasive annual cheatgrass is often used for evidence of the validity of this presumption. Dr. Daubenmire clearly showed in the 1940s that cheatgrass could successfully invade bluebunch wheatgrass communities that, because of topographical barriers, had never been grazed by domestic livestock and were in excellent ecological condition.

Cheatgrass now dominates millions of acres of formerly big sagebrush/bunchgrass rangeland in the Intermountain area, but it is necessary to remember that invasion and dominance are separate aspects of the ecology of weeds. Cheatgrass dominates many areas because they were in poor ecological condition because of past excessive grazing. Cheatgrass has the ability to invade communities no matter what their seral status. Why is such knowledge important in the management of herbaceous range weeds? Many well-meaning individuals suggest, "Remove the domestic livestock from rangelands, and the invasive weed problem goes away." Sorry, this oversimplification misses the invasive potential of cheatgrass.

More recently, Roger Sheley and his associates have clearly demonstrated that diffuse and spotted knapweed can invade range sites in the Pacific Northwest that are in high ecological condition. This does not mean that these 2 knapweeds do not do well on degraded sites. In fact, they can explode across dis-



Herbaceous range weeds are not just cheatgrass. There is an entire series of exotic invasive species that form a seral continuum from bare ground to cheatgrass dominance and beyond. Halogeton is one of the first species to invade disturbed sites. Image made at Tobar, south of Wells, Nevada, where this poisonous annual was first collected in the 1930s.

Russian thistle is another early succession species on rangelands. As indicated by mature plants collected on a fence, Russian thistle has an excellent seed dispersal system.

turbed communities. The important point is that they will have to be managed in rangelands in excellent condition.

On the opposite end of the spectrum are invasive species such as Russian thistle and halogeton. These are herbaceous range weeds that produce huge numbers of seeds per plant and have excellent seed dispersal systems. They need these dispersal systems because these are not highly competitive species and must find bare ground for seedling establishment, growth, and flowering. These species are often referred to as ruderal species because of their omnipresence on roadsides, especially unsurfaced roads that are periodically graded to repair the road surface.

A plant does not have to be exotic (see the next section) to be highly invasive. A good example is gum weed that is native to the central and southern Rocky Mountains. The herbaceous species has spread along roadsides to California, where it is considered an exotic, invasive species.

Exotic Weeds

Often multiple adjectives such as "exotic invasive" weeds (more properly "exotic, invasive" or "exotic and invasive") are used to describe herbaceous range weeds. You have to be careful to define "exotic" in this usage. To the best of our knowledge, there are no weeds that are exotic to Earth. There are a lot of herbaceous range weeds in western North America that are exotic to the Western Hemisphere. The previously mentioned gum weed is native to the Rocky Mountains but is considered an exotic, invasive species in California. There are many woody species that are highly invasive of the western range in North America. Rabbitbrush, broom snakeweed, pinyon, and juniper are common highly invasive species of rangelands.

Noxious Weeds

In the case of weeds, "noxious" is a legal as well as a descriptive term. The legal connotation arises when a state or the federal government establishes lists of weed species and regulates these species by restricting their movement in commerce and requiring attempted eradication of the weeds from private and public lands. Normally, state noxious weed lists have a tiered structure with Category A weeds being the most serious pest that the state has either no infestations or very small and limited infestations for which complete eradication is being practiced. Category B weeds might be just as serious a pest, but infestations are sufficient in number and extent that eradication is difficult or impossible and complete containment and suppression is being attempted. If a Category C or greater noxious weed list is included in state regulations, the number and extent of infestations is greater than for A and B, but control is still being attempted. Depending on the state, these legal standards are backed by stiff fines and abatement proceedings where failure to control the weeds on private property can result in the state con-

Left: Cheatgrass dominance truncated plant succession after wildfires and both ensured continued dominance and greatly reduced the interval between wildfires on the same site. Area near Midas, Nevada, burned in the 1999 wildfires that consumed over a million acres during a 10-day period. Note the unburned area on the alluvial fan that escaped the fire by chance distribution of roads. On the mountain escarpment in the middle of the image, a fire safe site is visible between 2 cliffs that probably still has native perennial grasses. Right: Seedbed of area of cheatgrass dominance burned in the 1999 wildfires in Nevada. The site had long been dominated by cheatgrass. The fast-moving wildfire did not even blacken most of the abundant cheatgrass seeds on the seedbed surface. Even the cheatgrass seeds with their awns singed will still germinate. Penny for scale.

ducting the weed control practices and billing the property owner.

During the last decade of the 20th century, federal managers of publicly owned rangelands became aware they might be held liable for harboring noxious weeds on lands under their management. This sparked a heightened awareness of noxious weeds and prompted the employment of weed control coordinators in many federal land management agencies. The primary noxious weed laws within the United States are originated by state agencies. Noxious weed lists are similar among states but not necessarily identical. For example, a national forest that spreads across more than 1 state may have to deal with contrasting noxious weed lists, depending on the location of individual infestations.

Often, local administration of noxious weed laws is through a legally constituted weed control district. The most effective way to inhibit noxious weed introduction or to promptly recognize and deal with such infestations is through broad-based citizen groups working through local weed control districts.

Seral Communities of Exotic and Invasive Weeds

The science of range management that evolved during the 20th century in western North America was based on applied ecological concepts delivered by such luminary individuals as F. E. Clements, A. W. Sampson, and E. J. Dyksterhuis, among others. These scientists had in common an appreciation for succession as the controlling factor in the composition of plant communities. For many years in the late 20th century, Ben Roche Jr. was a lone wolf suggesting that a similar succession existed among communities largely composed and dominated by exotic, invasive herbaceous species and that eventually dominance by annual grasses would proceed to biennial and perennial weeds. Unfortunately for the rangeland environment, Dr. Roche's prophecy is becoming apparent on many rangelands.

Excessive, improperly timed, and continuous grazing during the late 19th and early 20th century greatly reduced the native perennial grasses in the understory of big sagebrush communities. These degraded big sagebrush communities were virtually fireproof because of the lack of herbaceous vegetation to spread fires from shrub to shrub.

Annual Herbaceous Range Weeds

This is the entry level for many exotic, invasive weeds. We previously mentioned Russian thistle, which was accidentally introduced to the Great Plains in the 19th century. It had spread to the West Coast of America before the beginning of the 20th century. It was not the first exotic, invasive annual to invade the western range. Filaree was established in southern California before the first Spanish settlers arrived with livestock. Apparently, it was introduced from Manilla galleons that stopped at what became San Diego for fresh water. Filaree had spread to the Great Basin at an early enough date to be the only exotic plant with a name in the Western Shoshone dialect. Another chenopod, halogeton, was not identified in America until the 1930s and a second species of Russian thistle, barbwire Russian thistle, until the 1960s. These entry-level species with tremendous seed production and efficient dispersal systems thrive on areas that have been disturbed to bare ground. They will persist on a given site as long as there is disturbance that perpetuates bare ground. This is well illustrated by the thousands of miles of roads that bisect rangelands in western North America. Road crews spend the winter and early spring scraping up the previous year's accumulation of Russian thistle, and the resulting bare ground ensures their employment for the next year. Russian thistle also illustrates an aspect of exotic, invasive species that is often overlooked as a significant forage species on desert ranges. Certainly there are much more desirable native or introduced forage species compared to Russian thistle, but its unique growth phenology provides green forage with digestible protein after annual and perennial grasses have matured and dried. The abundant seeds of Russian thistle are a huge input in the diet of many native insects, birds, and mammal seed eaters (granivorous rodents). Weeds do not just interact with other plants; they become an integral part of the ecology of a site they invade as well.

Even for the most primitive of the entry-level exotic, invasive species, their germination, seedling growth, maturity, and seed productions have vast ecological ramification both above and below the soil surface. Accumulations of wind-deposited soil particles, litter fall, and interactions with herbage consumers and a potential myriad of other unrecognized factors combine to change the nature of the seedbed so that species of the next stage of succession become established. This is basic Clementsian ecology that was true in the 1890s and remains a cornerstone of plant science.

Our apologies to range managers in the piney woods of Florida, the coastal plains of Texas, and the diverse rangelands of Mexico and Canada. You share some exotic, invasive species (ie, Russian thistle), but because of the gross differences in environments, you have successional novels with the same plot, played by different characters. We recognize that with environments of greater ecological amplitude, the story

The exotic, highly invasive cheatgrass became established in the degraded big sagebrush communities and provided an early maturing, fine-textured fuel that increased the chance of ignition and rate of spread and extended the season of wildfires.

line may be greatly enhanced, but we continue where our experience lies with examples from the semiarid and arid environments of the far western United States.

The second level of herbaceous annual succession is often dominated by species of the mustard family. Why species of this family? This is one of those obvious questions that slipped through the 20th century without being asked. Many of the exotic, invasive mustard species found on rangelands produce an abundance of small dense seeds that have mucilaginous seed coats. This mucilage appears to enhance the chances of seed germination on the surface of seedbeds, and this is a great advantage in semiarid and arid climates. Some of the mustards tumble at maturity like Russian thistle, and some have explosive capsules that enhance seed dispersal. R. L. Piemeisel, who conducted research on invasive, exotic annuals during the 1930s on Idaho rangelands, suggested that the introduced species that matures first wins the successional battle. His reasoning was based on Russian thistle maturing in late fall in the Intermountain area, tumble mustard in midsummer, and cheatgrass in late spring to early summer. These were virtually the entire complex of species Piemeisel had to deal with at the time. With the addition of more exotic, invasive annual species, the successional picture becomes much more complex. If you view secondary plant succession as a series of more or less distinguishable "steps," the addition of more species can create new steps while at the same time greatly extending the lateral amplitude and vertical magnitude of existing steps.

You may not have heard of small seeded false flax, desert alyssum, hair's ear mustard, shield cress, Wilson weed, or African mustard, but if you interact with rangelands where species of sagebrush are native, you are going to become familiar with these mustard family species. Some of these species were introduced a century ago and have remained rare species until the last decade of the 20th century, when they dispersed over vast distances on rangelands. The identification of environmental precursors that triggered this population expansion awaits some bright and witty (at least fractionally) graduate student.

Why are we having an explosion of exotic, invasive annual species of mustards on western rangelands? You can point at many of the issues that are paramount in science at this time, such as climatic change, and ponder if there is a connection. Remember that exotic, invasive species usually come not from radically different but rather relatively synonymous climates. Many of the exotic, invasive annual weeds that have come to the Intermountain area of North America had their origin in central Asia. Blame the end of the Cold War and increased tourism and commerce with the new republics of the former Soviet Union. In a decade we may be blaming our present military presence in southwestern Asia, even though the Department of Defense is making a concerted effort to prevent weeds hitchhiking back with military equipment.

The mustard stage of seral dominance is followed by annual grass dominance. Over millions of acres of formerly big sagebrush/bunchgrass range in the Intermountain area, the annual grass is cheatgrass. The seeds of cheatgrass do not have significant germination on the surface of bare seedbeds. Cheatgrass seeds need burial, litter cover, or rough microtopography to find safe sites for germination. Dr. Robert Blank has demonstrated that certain microphytic crusts provide a good germination environment for cheatgrass seeds. Once the mustard species have modified the site sufficiently for some cheatgrass plants to establish, the annual herbage litter fall, and the litter provided by the superabundant production of cheatgrass fruits (the embryo and endosperm covered with dry papery floral appendages) provides a self-sustaining litter blanket to ensure safe sites for cheatgrass germination. This litter houses a huge seed bank of dormant but viable cheatgrass seeds that further ensure that cheatgrass is not going to easily relinquish its hold on the site.

Practical Significance of Annual Herbaceous Weeds

Bare ground is one of the striking features of native big sagebrush/bunchgrass communities. A near century (A. W. Sampson started graduate studies in 1907) of graduate students have been surprised that the sum of shrub, perennial grass, and forb herbage cover is well below 100%. Such a site converted to cheatgrass dominance supports about 500 plants per square foot, and the resulting cover is 100%. In semiarid and arid rangelands, there is a finite amount of environmental potential to partition among plants. The precise microenvironmental monitoring studies of Raymond Evans clearly demonstrated that competition for water was the limiting factor in cheatgrass dominated seedbeds. He determined that 4 cheatgrass plants per square foot were sufficient to inhibit the establishment of perennial seedlings. This was first spelled out in the famous paper "Range Seeding and the Closed Community" by Robertson and Pearse published in 1945. Cheatgrass truncates succession for seedlings of native perennials and ensured for the second half of the 20th century its continued dominance.

The practical significance of the closed community concept was some form of herbaceous range weed control was necessary for the establishment of perennial forage or browse species. The significance of the concept to ecological theory has not received a lot of attention. Truncation of succession by an exotic, invasive annual flies in the face of basic Clementsian theory. If the cheatgrass community was not disturbed, the exotic should disappear, and succession would proceed to dominance by native perennial species. In long-term studies, Min Hironaka, using some of the old Piemeisel study sites in Idaho, showed that with complete freedom from grazing, the short-lived native perennial bottlebrush squirreltail would increase in cheatgrass stands and then die, allowing a return to complete cheatgrass dominance, but there never was succession to a long-lived native perennial grass. Minimal disturbance from rodents, wildlife, or even recurring drought is enough to apparently perpetuate cheatgrass.

By the end of the 20th century, it was obvious that there were other exotic, invasive species that on specific soils could invade and in some cases completely replace cheatgrass. These include the annual grasses medusahead, barb goatgrass, and wheatgrass and the broadleaf species yellow starthistle.

The addition of yellow starthistle to exotic, invasive annual plant communities is a dramatic step in environmental degradation. Yellow starthistle is a member of the genus *Centaurea.* We risk the wrath of the editor with this scientific name because the generally accepted common name for these species is "knapweeds," but not all knapweeds are members of this genus (ie, Russian knapweed), and we just introduced yellow starthistle as a member of the genus that is not known as a knapweed. *Centaurea* is a genus of the sunflower family. The 500 plus species of *Centaurea* are native to southeastern Europe and adjacent Asia. The members of the genus that have been introduced to North America are among our very worst herbaceous weeds of rangelands. The bracts that subtend the flower heads of these species bear spines that range from sharp prickles to viscous spikes. We used to consider yellow starthistle a problem on the annual grass–dominated ranges of the portions of California with a true Mediterranean climate. Since then, it has made spectacular spreads of its range in the Pacific Northwest and is well established in the colder, semiarid climate of the western Great Basin. A very similar species, tocalote, is well established in the warm desert portions of the southern Great Basin. The *Centaurea* are noted for producing various secondary compounds. Yellow starthistle produces a neural toxin for horses. Several species are suspected of being allelopathic, but interpreting the actual ecological impact of even proven allelopathy in the field is a will-of-the-wisp type of adventure. The smoke produced by burning squarose knapweed herbage has sent firefighters to emergency rooms. Unfortunately, anyone interested in rangelands is going to become a lot more familiar with species of *Centaurea.*

Some exotic, invasive weeds are poisonous. Halogeton and bur buttercup are good examples. Many of the herbaceous species on rangelands that are poisonous are native species. Their management is a highly specialized aspect of herbaceous range weed control on rangelands.

Bur buttercup has for the past few decades held the record for rapid spread of an exotic annual species on western rangelands. It is highly poisonous but produces virtually no herbage, so animals have a difficult time consuming enough forage to be poisoned by the weed. At Reno, Nevada, bur buttercup flowers in very early March and matures fruits (spiral, armed burs) by the end of April. Blue mustard is currently in a population explosion that may well eclipse bur buttercup. From vacant urban lots to thousands of acres of rangeland, it has magically appeared.

Succession Beyond the Exotic, Invasive Annuals

In the late 20th century, the skies seemed to rain down exotic, invasive herbaceous biennial and perennial weeds on rangelands. Suddenly, Ben Roche's prophecy changes from the theoretical to reality. Perhaps Clementsian theory is correct, and succession will proceed to perennial domination; but only exotic rather than native perennials?

Exotic, Invasive Biennial Species

Biennial species often form a rosette of leaves the first year. In the case of species such as Mediterranean sage, bull thistle, Dyer's woad, and Scotch thistle, these rosettes smother adjacent annual grass seedlings. These plants spend their first growing season developing root systems that exploit the entire soil profile for moisture and nutrients. The second year, flowering stalks of many of these biennials are leafy and tower above the annual grasses.

As previously mentioned, diffuse and spotted knapweed are nominal biennial weeds that can successfully invade bunchgrass ranges in high ecological condition. Nodding or musk thistle is primarily a species of meadow environments. Scotch thistle is another problem species in meadows, but it

In this image, cheatgrass shares dominance with yellow starthistle and medusahead.

Biennial and perennial herbaceous weed species can replace or share dominance with cheatgrass. Scotch thistle in cheatgrass community located in Big Valley, Lassen County, California.

has the ecological amplitude to invade much drier sites. Bull thistle is one of the most common species in meadows in the sagebrush zone.

Exotic, Invasive Perennial Species

These are the top of the successional heap among exotic herbaceous range weeds. Canada thistle followed the advent of agronomic agriculture across North America. It was reported introduced by missionaries to eastern Canada in the 17th century. The first noxious weed law in California specifically mentions Canada thistle in 1872. Hoary cress is another exotic, invasive perennial species with ties to Canada. Both of these species form nearly monospecific communities, but they usually occur in meadows or the margins of meadows, not as landscape dominants over vast areas of upland rangelands. There are always exceptions to generalizations, and in Baker County, Oregon, there are extensive upland formerly big sagebrush/bunchgrass areas currently occupied by a mixed community of hoary cress, medusahead, and yellow starthistle.

The exotic perennial herbaceous rangeland weed that has made the most spectacular spread on a regional basis is leafy spurge. This weed is also the model for regional integrated suppression programs and the use of specific types of domestic livestock grazing for suppression.

Klamath weed is often held up as the shining example of suppression through the introduction of a biological control agent. Biological control agents are never supposed to eradicate their host weed species, but Joe Balciunas related to the authors that he visited the site in Humboldt County, California, where the agent for Klamath weed was originally released and could not find a single plant. He did find abundant plants of medusahead, goat grass, and yellow starthistle!

This graphically illustrates the basic point of herbaceous weed control on rangelands. It does no good to kill the herbaceous range weed unless you replace the weed with a desirable plant that fully uses the environmental potential formerly used by the weed. Once this replacement is accomplished, you must implement a management system that ensures the persistence of the desirable replacement or periodically renew the replacement stand.

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Managing Yaupon With Fire and Herbicides in the Texas Post Oak Savannah

Yaupon invasion into historic grassland savannahs can be effectively reduced with prescribed burning and herbicides.

By Rob Mitchell, James C. Cathey, Brad Dabbert, Dale F. Prochaska, Stephanie DuPree, and Ron Sosebee

The Post Oak Savannah Ecological Region in Texas was once an open grassland savannah maintained by periodic fires.[1] The Post Oak Savannah can support mid- and tall grasses, such as little bluestem, indiangrass, Texas wintergrass, and purpletop. Today, the savannahs have been replaced by oak woodlands with dense yaupon (*Ilex vomitoria*) understories that limit grass and forb production and species diversity (Fig. 1). Restriction of fires in conjunction with poor grazing management and periodic droughts are often credited for the dense thickets that occur in the Post Oak Savannah.[2]

Yaupon is a native component of the Post Oak Savannah and is a slow-growing and erect evergreen shrub found in both open areas and in the forest understory.[2–4] It can form dense thickets from its multistemmed base and reach 26 feet in height.[4] Yaupon growth begins in March and continues through October if soil water is sufficient and grows best on sites with sandy soils and permeable subsoils.[3] Yaupon growing in open areas tends to produce high fruit yields during alternate years. It also reproduces asexually by root or basal crown sprouting.

Yaupon is easily top-killed by burning, but the plant sprouts from the base, resulting in low mortality. Most burning in the region occurs during winter, which provides the safest conditions for burning. However, winter burning favors forbs and reduces grass, which may be desirable for wildlife habitat but detrimental for livestock grazing.[5] A management plan that incorporates only winter burning usually results in fine-fuel loads dominated by forbs, promoting patchy, lower temperature burns in the future. Yaupon thrives under these conditions.

Locations and Treatments

Studies were conducted on the Gus Engeling Wildlife Management Area (WMA) near Palestine, Texas (Fig. 2).

Figure 1. A dense yaupon thicket during winter at the Gus Engling Wildlife Management Area near Palestine, Texas. Some yaupon in this thicket exceeded heights of 15 feet.

Sidebar

The use of individual plant treatments (IPT) to control problem plants is becoming an increasingly viable management alternative.[6] The suggested method for managing yaupon in Texas is to apply an IPT of 25% Remedy (triclopyr: 3,5,6-trichloro-2-pyridinyloxyacetic acid, butoxyethyl ester, 61.6%) in diesel fuel to wet completely around the lower 18 inches of the trunk anytime during the year.[7] However, little information is available for treatment options that incorporate prescribed burning. We investigated the impact of low-volume basal IPT of diesel and diesel combined with Garlon 4 (triclopyr: 3,5,6-trichloro-2-pyridinyloxyacetic acid, butoxyethyl ester, 61.6%) at rates of 5%, 10%, 20%, and 25% on yaupon plants that had sprouted 6 and 18 months after prescribed burning. We used Garlon 4 because it is labeled for controlling woody plants in forests and wildlife openings.

The climate is moist subhumid, with annual precipitation of about 40 inches and a 225-day growing season.[8]

Management units on Gus Engeling WMA are typically burned every 3 years. We chose 2 study sites that were burned on either February 15, 2000, or February 22, 2001. These areas allowed us to evaluate the use of herbicides 6 and 18 months after burning. Study sites were selected on the basis of accessibility and the presence of an adequate yaupon density for evaluation. The soils on each site were dominated by sandy loams with slopes ranging from 1% to 8%.[8] Woody plants varied by site and included post oak, sand jack oak, cedar elm, yaupon, hawthorn, dewberry, and greenbrier.

At each of the burned sites, 25 yaupon plants were selected and randomly marked for no treatment, treatment with diesel only, or 5%, 10%, 20%, or 25% Garlon 4 in diesel. We maintained 4–6 feet between treated trees to ensure that different trees were treated. The 2000 (18 months postburn) and 2001 (6 months postburn) burned yaupon trees had to meet 2 criteria to be selected for study. First, it must have been top-killed by the fire, and, second, the sprouts had to be in the short-shoot (reproductive) growth stage. A backpack sprayer fitted with a flat-fan nozzle was used to spray the basal portion of the plant, avoiding the foliage (Fig. 3). All herbicide treatments were applied between July 16 and 20, 2001. Mortality was evaluated 24 months after spraying. All trees that had any new or living leaves, new sprouts or stems, or pliable stems were considered living, whereas all trees with brittle stems and brown leaves were considered dead.

Response to Treatments

Previous observations on Gus Engeling WMA indicated that prescribed burning reduced the canopy of yaupon but did not cause mortality. However, when diesel or diesel mixed with Garlon 4 was applied 6 and 18 months after burning, mortality did occur at high rates (Table 1). All treatments containing Garlon 4 resulted in at least 92% mortality.

Yaupon sprouted vigorously after burning. Mortality due to burning was not evaluated since individual trees were not marked prior to burning. However, yaupon has proven to be a persistent competitor for resources even after prescribed burning. Its strong sprouting ability has limited the long-term control of mature plants by burning alone.

Management Implications

Yaupon is controlled with low concentrations of herbicide after prescribed burning. We suggest selecting the treatment on the basis of management objectives and cost. For example, to develop yaupon-free clearings within a forested management unit, spraying the postfire sprouts with 10% Garlon 4 six months after burning resulted in 100% mortality and would cost $0.40/killed tree. If about 85% mortality is acceptable, a basal application of diesel 6 months after burning would reduce treatment costs to $0.20/killed tree and eliminate the need to purchase herbicides. Although applying 25% Garlon 4 resulted in 100% mortality 6 and 18 months after burning, treatment cost increases to $0.73/killed tree, more than 4 times more expensive than diesel alone. It appears that applying herbicides with IPT 6 months after burning is slightly more effective than applying herbicides 18 months after burning. Plants treated 6 months after burning were smaller, and some of the herbicide was likely applied to the foliage in addition to the plant bases, likely flooding the plant system with herbicide. Prescribed fire alone will not reduce yaupon density and restore the flora and fauna of the Post Oak Savannah.

Yaupon can be readily controlled in most situations. We have provided several alternatives for managing yaupon after burning. Prescribed fire application at 5- to 7-year intervals and monitoring habitat to respond to yaupon invasions early will reduce the negative effects of yaupon. If yaupon is permitted to become too dense before burning, grass production

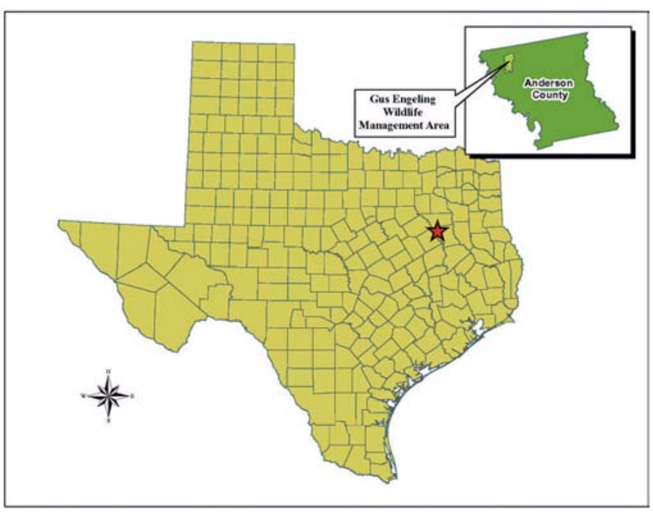

Figure 2. The study was conducted on the Gus Engeling Wildlife Management Area located in Anderson County near Palestine, Texas.

Table 1. Yaupon mortality (%) 24 months after treatment with diesel or diesel and four concentrations (5, 10, 20, and 25%) of Garlon 4. Study sites at the Gus Engeling Wildlife Management Area near Palestine, Texas, were burned during winter in 2000 and 2001, and herbicide treatments were applied in summer 2001, 6 or 18 months after burning. Costs per treated plant are based on the following assumptions: diesel cost = $2.05/gallon; Garlon 4 cost = $113/gallon; labor cost = $13/hour; 100 trees were treated/hour; each tree received 2.6 oz. of mixture for each treatment.

	6 Months post-burn	18 Months post-burn	Cost/plant
Garlon 4 concentration (%)	Mortality (%)		$/treated ($/killed)
Diesel only - 0	84	60	0.17 (0.20-0.28)
5	96	92	0.28 (0.29-0.30)
10	100	92	0.40 (0.40-0.43)
20	100	96	0.62 (0.62-0.65)
25	100	100	0.73 (0.73)

will be limited, reducing the ability to safely apply prescribed fire and reducing the grazing value and wildlife habitat quality of the site.

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Figure 3. Yaupon being treated with basal herbicide applications 18 months after burning. The plant was top-killed by burning and sprouted from the base, resulting in numerous stems per plant.

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Fuel Loading, Fuel Moisture Are Important Components of Prescribed Fire

By Russell Stevens

Many landowners will be implementing prescribed burns this winter and spring. Prescribed burning is a land management tool that should be used only when needed and after considerable planning, taking into account numerous factors including fireguards, equipment, labor, special concerns, smoke management, and fuel characteristics (loading and moisture).

A common goal with prescribed burning is brush control in pastures. Too often, not enough consideration is given to developing an adequate fuel load and determining fuel moisture for a successful prescribed burn. Without a proper understanding of fuel loading and fuel moisture, a manager risks wasting valuable time and money when attempting to implement a successful prescribed burn.

Grasses are considered 1-hour fuels and are the primary carrier of fire for most prescribed burns in the Great Plains. Fuel loading of grasses is the dry weight of grass in a burn unit, usually expressed in pounds per acre. Like estimating forage production, some experienced managers are able to visually estimate this value with fair accuracy. More accurate estimates can be obtained by clipping, oven-drying, and weighing. A minimum of 1,500 pounds per acre of 1-hour fuel is usually needed to carry a fire. However, for controlling brush, heavier 1-hour fuel loads are usually needed, depending on brush species and size. For example, 1,500 pounds of 1-hour fuels will probably kill seedling Eastern red cedar (*Juniperus virginiana*), the only fire-intolerant woody plant encroaching on the eastern and central Great Plains, but not most taller than 2 feet. Fire intensity increases with heavier fuel loads. Fuel loading also affects other fire behavior, such as ignition, rate of spread, and torching (fire racing upward from the ground to treetop).

There are 2 kinds of fuel moisture: live and dead. Live fuel moisture is more of an issue when burning live fuel during the growing season or live fuel such as Eastern red cedar during the dormant season. Since most prescribed burns in the Great Plains occur during the dormant season, it is important to know dead fuel moisture for fire control and success. Live fuel moisture can also be important during a dormant season burn. For instance, knowing live fuel moisture of Eastern red cedar will help determine its susceptibility to fire.

Fuels are classified into 4 categories by which they respond to changes in moisture. This response time is referred to as time lag. The 4 categories are the following:

- 1-hour fuels: up to 1/4 inch in diameter
- 10-hour fuels: 1/4 inch to 1 inch in diameter
- 100-hour fuels: 1 inch to 3 inches in diameter
- 1,000-hour fuels: 3 inches to 8 inches in diameter

Examples of 1-hour fuels are grass, leaves, mulch, and litter. Fuel moisture in these fuels can change within 1 hour according to factors such as temperature, rain, humidity, and shade. Conversely, larger diameter fuels, such as deadfalls, brush piles, and so on, take up to 1,000 hours to respond to changes in environmental factors.

Fuel moisture can be determined by clipping and immediately weighing the sample before oven-drying it to a constant weight. Then the following formula can be used to determine percent fuel moisture: [(Wet Weight − Dry Weight)/Dry Weight] × 100. Knowing the moisture in fuels to be burned will help managers understand the susceptibility of fuels for ignition, fire rate of spread, fire intensity and risk of spot fires, torching, and crown fires, all of which are factors that need to be managed to control the fire as well as to achieve desired goals.

Managers who understand and properly apply their knowledge of fuel loading and fuel moisture will have greater success in achieving their goals for using prescribed fire.

The Samuel Roberts Noble Foundation (www.noble.org), headquartered in Ardmore, Oklahoma, is a nonprofit organization conducting agricultural, forage improvement, and plant biology research; providing grants to nonprofit charitable, educational, and health organizations; and assisting farmers and ranchers through educational and consultative agricultural programs.

59th Society for Range Management Annual Meeting and Trade Show

Rangelands to Rain Forests: A Welcoming Plenary Session

By Hugh Barrett (on behalf of the Plenary Session Organizing Committee)

In his book *Steelhead Country*, Steve Raymond wrote, "The northwestern tip of North America leans over the Pacific Ocean like an old cedar limb weighted down with rain. The limb has a long reach and casts a long shadow that falls all the way down to the northern California Coast. Out of that shadow ten thousand rivers run." Some of those rivers, the great ones like the Klamath, the Columbia, and the Fraser, are born far in the region's eastern interior: on the western slopes of the Canadian and American Rockies, in the Cascades of Oregon and Washington, and in the mountains and valleys of the Basin and Range Province and in the Columbia Basin—the rangelands of the Pacific Northwest. These rivers are the distillate of the geology, the soils and vegetation, the farms and ranches, the cities and towns, and the attitudes and economies that fill their basins and watersheds.

Following the presentation of the colors by the Royal Canadian Mounted Police Color Guard (yes, Ann Harris, real, live Mounties) and welcomings from our distinguished invited guests—hopefully including the Queen's Representative, Lieutenant Governor Iona Campagnolo of British Columbia—the 2006 Plenary Session will explore the biophysical and social elements of this immense and diverse region that, in part, defines the Pacific Northwest Section of the Society for Range Management—"in part" because at the core of this section are its members, whom as John Buckhouse would say are, individually and collectively, "a delight."

A blend of speakers will guide us on a short and fascinating journey into this land—its character and history, its societies and economies—from the deep past to the present.

Wayne Choquette, an archaeologist from the interior of British Columbia, with a deep knowledge of the geology and prehuman and preglacial landscapes, climate and biota, and

Hornby Island, on the western edge of the PNW.

Thompson River heading into the Fraser River, interior British Columbia.

precontact peoples of the Northwest, will introduce us to the Canadian headwater country of the Columbia River.

A Toronto-born forest hydrologist, **Dr. Tom Pypker**, of Oregon State University, earned his doctorate in the canopies of old-growth forests of the evergreen part of our region where he learned how these old trees process water from rain and snow. His message holds valuable lessons for those of us who work in or study the more arid forests of ponderosa pine, pinyon, juniper, and cedars.

Bringing our session to its conclusion is the son of a Welsh father and an American mother, born and raised in Mexico City. **James Honey** heads up the Ranchland Renewal Program for Sustainable Northwest (SNW) in Portland, Oregon. James will describe SNW's successes of ecological, economic, and societal integration in Oregon and current efforts in the upper Klamath Basin with tribes, irrigators, ranchers, loggers, and rural communities in building new partnerships, alliances, and economies—breathing new life into the old West.

So that each of you has a chance to wake refreshed and well rested, the Plenary Session will begin at the most civilized hour of 9:00 AM on Monday, February 13, 2006, in the B.C. Ballroom of the historic Fairmont Hotel. See you there! ◆

Reversing Bush Encroachment: The Solution Is in the Soil

By Abbey Kingdon

When massive migrations of large herds crossed the northern South Africa of the past, the 10,000 acres of the Knight family's cattle farm, near Mokopane, in the Limpopo Province of South Africa, was a savannah. It was a low-humidity environment (referred to as a brittle environment by Holistic Management[1]) of open grasslands with broadly spaced acacia trees. It was, and still is, dependent upon the grazing and hooves of ruminants to maintain healthy ecosystem processes.

Over time, with the impact of human management tools, the grasslands gave way to excessive sickle bush (*Dichrostachys cinerea* ssp. *africana var. africana*), umbrella thorn (*Acacia tortillas*), and sweet thorn (*Acacia karroo*). But recently, the Knight family has begun to slowly but steadily reverse bush encroachment in their cattle paddocks, using holistic management methods.

Sickle bush and other bush species growing on the Knights' cattle farm.

Their approach to the issue of bush encroachment is true to the Knight family values and lifestyle: no quick-fix, bandage remedy, but instead, a creative, logical, carefully planned procedure. Three generations of Knights live on the farm, with well-established family traditions like holidays to Kruger National Park and fishing trips. In the early evening of most days, the family is found sipping tea on the east veranda, listening to birds and other inhabitants of the bush, quizzing each other on the origin of the sounds. Some evenings, they pack up the picnic basket and head out into the farm for refreshments in the bush. Their place in the midst of the dramatic South African ecosystem is a conscious choice. The family understands, appreciates, and enjoys the complexities of nature, with no ambition to place a conquering grip on the land.

Before deciding what tools could reverse bush encroachment, such as poison, fire, rest, or animal impact, the Knights determined the root cause of the problem.

The root cause was found, appropriately, in the soil. Others might not see the complex and powerful role soil life plays in ecosystem health, but the Knights dug beneath the surface.

Following the work of Elaine Ingham, a soil scientist, the Knights learned that all soil has bacteria, fungus, and other

[1]The Holistic Management Brittleness Scale (1–10), with 1 being a jungle and 10 being a true desert, determines land's vulnerability to desertification, the formation of deserts, and how quickly dead vegetation breaks down. The scale is linked to total rainfall but is more determined by the distribution of rainfall and humidity during the year. Savory, A., and Butterfield, J. 1999. Holistic management: A new framework for decision making. Washington, DC: Island Press. 616 p.

The Knight family enjoys drinks in the veld of their cattle farm, near Mokopane, South Africa.

microbes. The dominance of either bacteria or fungi will influence what types of plants thrive there, said Wayne Knight, who manages the farm and cattle herd with his father, Tom Knight. Bacterial dominance results from the breakdown of plant material in the warm, moist rumen of ruminants. In brittle environments, bacteria cannot survive without this symbiotic relationship between ruminants and grass; only fungi can, Wayne Knight said.

Bush species tend to grow in fungal-dominated soil and grass species in bacterial-dominated soil. The pH of the soil determines which—fungi or bacteria—will have control. Bacteria-based soil harbors annuals, weeds, and grass species. Such soils select for these species because they require nitrate as the predominant form of nitrogen and require an alkaline pH, said Ingham, who studies compost (especially compost tea), and who founded the Soil Foodweb, Inc.

Fungal-dominated soils, on the other hand, set up conditions to grow bushes, shrubs, and trees. Fungi maintain soil pH in the 5.5 to 7 range, which means ammonium is the predominant form of nitrogen, the form most selective for woody perennial plants, Ingham said.

The Knights concluded that if they could change the soil, they could change what grew in it. "Animal impact, dung, and urine will increase the bacterial-dominated soil," said Dick Richardson, a South African Holistic Management educator and author who consulted the Knights. Thus, they chose animal impact as the management tool to reverse bush encroachment.

In 1997, the Knight family changed their management practices. Up until that time, they thought rest from grazing was the remedy for bush encroachment on grass-producing ground. But fewer cattle worsened the encroachment.

Low stocking rates simultaneously allow overgrazing and overresting. Together, they create weak root systems that are not able to feed soil microbes, Wayne Knight said. The grazing camps looked devoid of life. Moribund grass tufts stood like scarecrows across the pastures that were otherwise shorn clean of grass.

With a new plan, the family consolidated their cattle into 1 big herd and decreased the size of their grazing camps, carefully planning impact and rest intervals for the farm. The family was able to make this management change without any major new fencing development or other investments. The land responded to the new management with increased productivity above- and below-ground. Planned grazing increased the organic and mineral content in the soil and its water-holding capacity and provided more favorable growing conditions for grasses, Wayne Knight said. After grazing, root systems feed soil microbes with carbohydrates they release as the plant downsizes and redirects nutrients to regrowing aboveground. As the grass is snipped off by grazing cattle, the soil life is fed as the plant reacts. During the rest interval, plant shoots regrow. This cycle accelerates the energy flow above- and below-ground, Wayne Knight said.

Now camps that were quiet and empty buzz with bugs, birds and cattle, half hidden in tall grass.

When the family initially sat down and put their heads together over the issue of bush encroachment, they thought the sickle bush and others were pushing out the grass. Now, they believe understocking the land invited the bush.

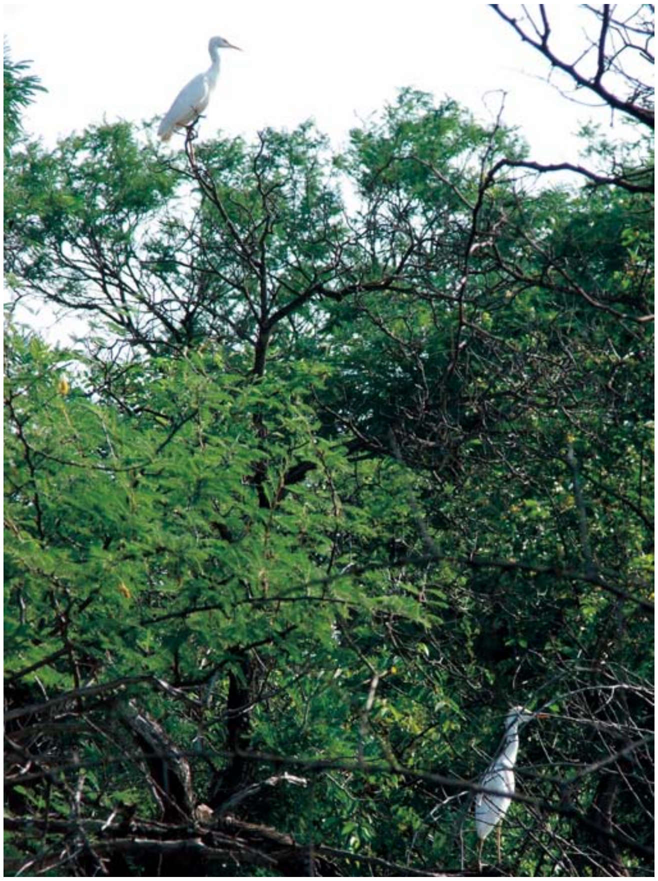
"At first we saw the bush encroachment as a problem, but Dick Richardson changed our perspective. Bush is there as a symptom of management decisions, which were to have stocking rates lower than the grassland ecosystem can handle," Wayne Knight said.

The lively soil created by new management practices encourages higher stocking, which rapidly recycles nutrients back into the soil, introducing even more bacteria through dung.

"The entire ecosystem process has been enhanced by planned grazing," Wayne Knight said.

Holistic Management identifies 4 ecosystem processes and asks which of them is altered to produce the problem condition in the land. Of water, energy and mineral cycles, and community dynamics, Richardson said community

A cattle camp shortly before the cattle enter. The cattle navigate through the bush to graze.



Tick birds rest for a moment in acacia trees as they move with the cattle through the camp.

dynamics were changed to produce the bush encroachment condition on the Knights' farm. The previous management decision of continual grazing with light animal impact resulted in a decrease in the community dynamics on the farm, and a few bush species were able to dominate.

A cattle camp on the Knights' farm that has responded well to holistic grazing planning (left). The camp on the right was recently grazed.

With animal impact and holistic grazing planning, sickle bush and others are giving way to perennial grasses.

Community dynamics are important because increased diversity of all life forms in the community will lead to greater stability; deeper, more mature soils; and higher energy flows, Richardson said.

Even though hardy, vibrant perennials grow under the gray skeletons of sickle bush in many places on the Knights' farm, there are still camps choked with bush. After crawling through the bush, garnering scratches and hair pulled by thorns, with feet sweating in boots full of thorn punctures, and with a constant awareness that black mambas reside in such places, one has the urge to just torch the whole tangled mess and be done with it. Wayne Knight said the main reason for not using fire is because this tool results in a loss of organic material (a spectrum of ground cover in a given location, with dead leaves and grasses at one end and formed soil at the other end), which takes years to build up in the brittle environment on their farm. The Knights viewed animal impact as the best tool for reversing bush encroachment on their cattle farm.

"If the environment is already degraded, burning it will further set back the grass plants and debilitate soil life, and then the whole cycle slips into a downward spiral," Wayne Knight said.

The Knights didn't have to wait long for feedback from the land on their decisions. Within one grazing season, they saw results. The veld responded with an increase in grass production, a decrease in plant spacing, and varying degrees of bush die-off. In some places, weed and bush germination increased after the initial high-density grazing. But after improved plant spacing and accelerated ecosystem processes, the bush started to die back, Wayne Knight said.

Author is a recent graduate of the Animal Science Department at Cal Poly, San Luis Obispo, CA. She is director of a nonprofit corporation for natural resource education called The River Center. She lives in Modoc County, CA.

Nara Desert, Pakistan

Part I: Soils, Climate, and Vegetation

By Rahmatullah Qureshi and G. Raza Bhatti

Introduction

Rangelands constitute an important component of the agricultural system in Pakistan. Besides providing grazing support for the 93.5 million livestock, they are a major source of fuel and timber and natural habitat for wildlife. Because of the arid and semiarid environment and limited irrigated facilities, these areas cannot be converted into cropland. However, this vast natural resource covering over 60% of the country provides great potential for livestock grazing and dry afforestation.

A range management program was initiated for the first time in Pakistan with financial and technical assistance of the U.S. government in Baluchistan province.[1] This project provided a base to identify the problems and their possible solutions by policymakers and natural resource mangers. A number of research-and-development projects for range management were launched in different ecological zones. These initial projects were based on a demonstration of water harvesting and sand dune stabilization techniques. Various parts of the country are explored for the establishment of local and introduced forage species. These range management programs are undertaken in many parts of the country, such as Baluchistan, the Pothwar ranges, salt ranges, Rabbi Hill, the Thal Desert, Cholistan, D. G. Khan, Kohistan, and the Tharparker Desert. The study area at Nara Desert was not previously included for study by the government. The authors explored this area floristically and recorded 160 species, a number higher than that in the Cholistan Desert, which consists of 115 plant species.[2]

A view of stabilized sand dune with dense population of *Aerva javanica*, *Calligonum polygonoides*, and *Dipterygium glaucum*.

The Nara Desert, an extension of the Great Indian Desert, is located in Sindh, which is the southeastern province of Pakistan. These regions are also known as Nara Thar and Parkar Thar, respectively (Fig. 1).[3] These names are used in the present study. The desert lies between 26°–28° north and 68°–70° east, and is comprised of about 23,000 km^2. The altitude is between 50 and 115 m above mean sea level. The study area is semiarid in nature. The topography is distinctly marked with sandy hills, steep slopes, and vast low-lying areas locally known as *Patt*. The accumulation of sand in a huge mass in the form of a hill is known as a sand

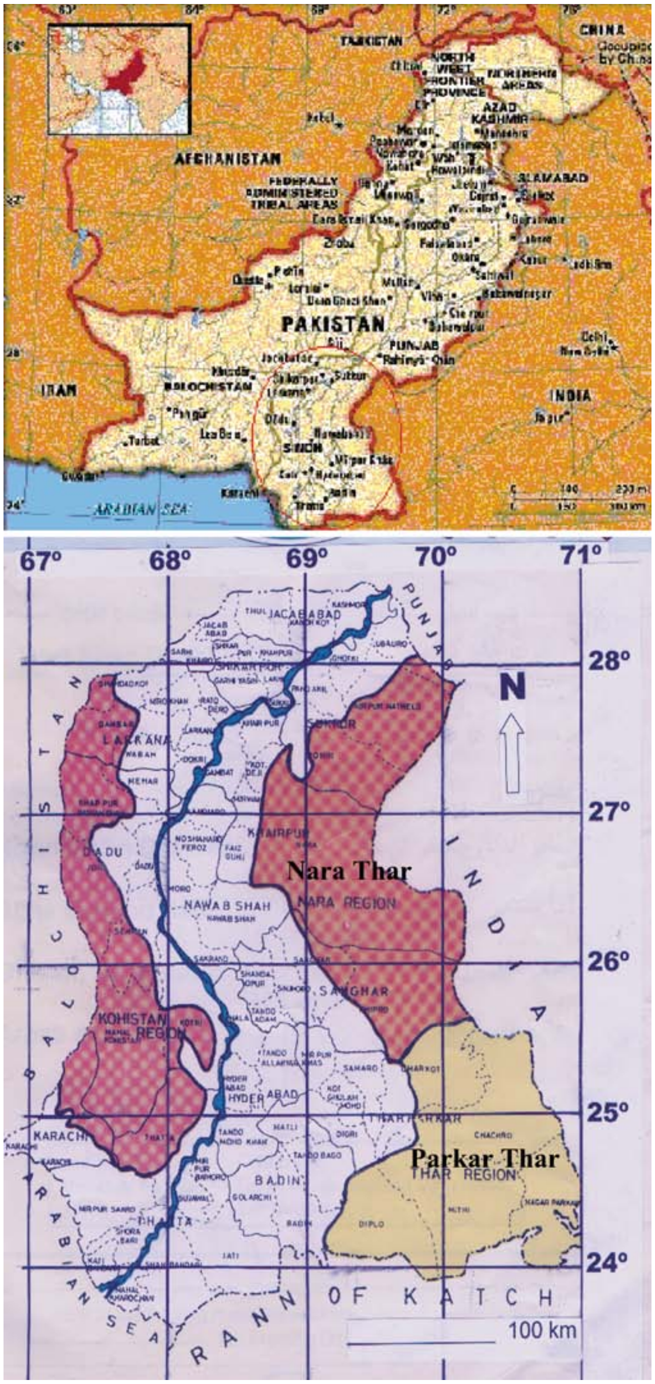
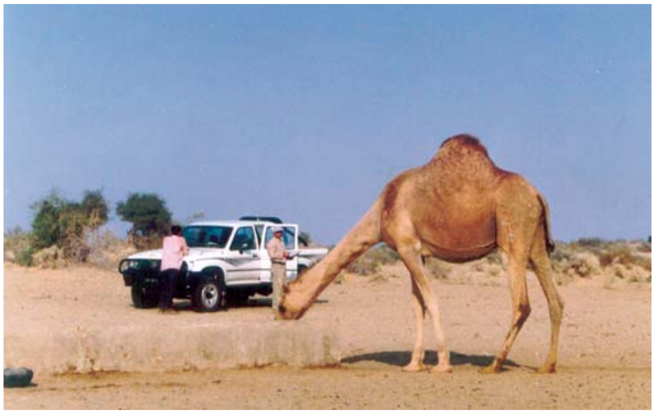


Figure 1. Map of Pakistan showing the location of the Nara Desert.

dune/ridge. A dune has a crest, the topmost portion; a swale (flank), the middle portion; and a foot, the base of the dune. The area between 2 successive dunes is called an interdunal valley. The dunes are of 2 major types: stabilized or unstabilized. The unstabilized dune is a movable heap of sand, not really fixed on the ground, but can be moved with wind action. It lacks or has scanty vegetation, whereas the stabilized dunes are characterized by mixed populations of plant species. The area under investigation has stabilized dunes with low-lying flat areas: the valleys. The typical features responsible for such dunes are the wind, which blows steadily and results in the collection of sand on the windward side, forming a long slope of sand. On its other side, the leeward side, the dune drops in a sharp, curving cliff. Hummock dunes are also common features of this area. These are formed when sand gets trapped around perennial trees or shrubs growing over the top of the sand dunes (crest) or its sides (slopes). It has been observed that the majority of the older bushes are growing on the hummocks, whereas the younger ones are found without the hummock.

The Thar in Hyderabad and Khairpur Division (at present Hyderabad, Mirpurkhas, Sukkur) is formed by sand, silt, salts, and fine seashells blowing from Runn of Kuchh, extended up to Rohri in recent geological times.[4] In Tharparkar districts, because of high wind velocities, the sand hills, sometimes 300 feet high, lie southwest to northeast along the direction of the wind. In southern Khairpur, where wind velocity decreases, the direction of the sand hills changes slightly and becomes south-southwest to north-northeast. In northern Khairpur and Sukkur districts (presently including Ghotki district), the sand hills lie south–north. The sand hills of Khairpur are not as high as those of Thar. There are *Dhandh* (lakes/wetlands), which are formed by rainwater sweeping down the sand mounds. Seepage from the canal recharges the *dhands* in the close proximity of the Nara Canal continuously. This canal is one of the Sindh's 14 main canal systems and originates from Sukkur Barrage at Sukkur. This canal is perennial except for a closure period in mid-January. The rainwater percolates down the sand, where it is held by impervious clay that lies under the sand. The water so trapped or perched out in the form of springs is locally called *Sim.* This process forms all lakes in the desert area. The salt content in these lakes depends on the salts dissolved by rainwater and appearing as *Sim.* Water in most of the *dhands* is brackish, as these salts keep accumulating in them year after year unless removed by humans. When water evaporates, cakes of salt are deposited.

Prosopis cineraria forms pure stands in low-lying flat areas (interdunal valleys).



A camel drinking water from a dugout well in *Taraies*.

Tanka of rainwater stored for drinking purposes.

In some cases, water from wells in the neighborhood is available at the higher water table and then in *the dhands* and is potable. This is actually the *Sim* water, which, instead of seeping into lakes, seeps into the wells.

The *dhands* are shallow, but some of them extend about a mile in length. At one time, these lakes yielded soda ash. *Dhands* close to Nara are even now always full of water because of seepage from the canal. This water is no longer so brackish and has instead become the abode of crocodiles and water-loving reeds and canes like *Sar*. The lakes away from the canal are highly saline. The range of alkalinity of the lakes of Khaipur is higher than that of the Thar lakes. There is always a dispute about the causes of this phenomenon. It is believed that the salt of the lakes, whether in Khairpur or in Sanghar district, are basically of similar ingredients, but in the Khairpur lakes, because of the presence of some bacteria or organic material, the sodium salts are converted into soda ash.

The soil of the desert is sandy silty and moderately calcareous. The entire study area consists of level and gently sloping plains broken by sand dunes. Brown sandy soil, desert soils, and gravelly foot slopes constitute the major soil types in the area. The color of the soil of this area is generally gray, grayish-white, or yellowish-gray. The desert margin consists mostly of flat ground having saline/sodic soils commonly known as *Kharror,* with pH ranging from 7.8 to 8.9 with a mean of 8.33. The electrical conductivity, a measure of the concentration of soluble salts, ranges from 0.15 to 29.3 with a mean of 2.83. Organic carbon content was very low, ranging from 0.14% to 0.78% with a mean of 0.33%.

Climate

Nara is a hot arid to semiarid sandy desert. The mean minimum and maximum temperatures are 20° and 45°C, respectively. The hottest months are May–July, where temperatures range from 47° to 51°C. The lowest temperature, 20°–28° C, was recorded in January. Aridity is the most characteristic feature of the Nara Desert, with wet and dry years occurring in clusters. The mean rainfall ranges from 88 to 135 mm. Rainfall is received mostly during the monsoon (mid-July to the end of August). Winter showers take place during the months of December through March and are of low intensity. No rainfall took place during the study period (1998–2003) in either of the seasons. Therefore, this period was regarded as one of drought.

The typical architecture of houses (*Chunra*) in the Nara Desert.

Exposed roots of *Salvadora oleoides* due to soil erosion.

Table 1. The most common plant species recorded from the Nara Desert, Sindh, Pakistan

Species no.	Plant species	Family	Local name	Life form/habit
1	*Acacia jacquemontii*	Mimosaceae	Banwar	Shrub
2	*Acacia nilotica*	Mimosaceae	Sindhi Babur	Tree
3	*Acacia senegal*	Mimosaceae	Angrezi Babur	Small tree
4	*Aerva javanica*	Amaranthaceae	Booh	Subshrub
5	*Aristida adscensionis*	Poaceae	Lumb Gaah	Grass
6	*Aristida funiculata*	Poaceae	Lumb Gaah	Grass
7	*Arthrocnemum indicum*	Chenopodiaceae	Laano	Shrub
8	*Calligonum polygonoides*	Polygonaceae	Phog	Shrub
9	*Capparis decidua*	Capparidaceae	Kirar	Tree
10	*Capparis spinosa*	Capparidaceae	Golaro	Subshrub
11	*Cassia italica*	Caesalpiniaceae	Ghora Wal	Subshrub
12	*Carthamus oxycantha*	Asteraceae	Uth Chaaro	Subshrub
13	*Cenchrus biflorus*	Poaceae	Mohabbat Buti	Grass
14	*Cenchrus ciliaris*	Poaceae	Bhurt	Grass
15	*Cocculus hirsutus*	Menispermaceae	Fareed Buti	Shrub
16	*Cynodon dactylon*	Poaceae	Chhabar	Grass
17	*Cyperus arinarius*	Cyperaceae	Moniah	Sedge
18	*Cyperus conglomeratus*	Cyperaceae	Moniah	Sedge
19	*Dactyloctenium aegyptium*	Poaceae	Gandheer Gaah	Grass
20	*Desmostachya bipinnata*	Poaceae	Drabh	Grass
21	*Dichanthium annulatum*	Poaceae	Dinohi Gaah	Grass
22	*Dinebra retroflexa*	Poaceae	–	Grass
23	*Dipterygium glaucum*	Brassicaceae	Phair	Subshrub
24	*Echinops echinatus*	Asteraceae	Kanderi Wal	Subshrub
25	*Eragrostis minor*	Poaceae	Makhani Gaah	Grass
26	*Fagonia indica*	Zygophyllaceae	Dramaho	Subshrub
27	*Grewia tenax*	Tiliaceae	–	Shrub
28	*Haloxylon stocksii*	Chenopodiaceae	Sacho Laano	Shrub
29	*Indigofera oblongifolia*	Fabaceae	Jhill	Shrub
30	*Lasiurus scindicus*	Poaceae	Booro	Grass
31	*Leptadenia pyrotechnica*	Asclepiadaceae	Khipp	Shrub
32	*Ochthochloa compressa*	Poaceae	Mandhano Gaah	Grass
33	*Panicum turgidum*	Poaceae	Sewan	Grass
34	*Prosopis cineraria*	Mimosaceae	Kandi	Tree
35	*Prosopis juliflora*	Mimosaceae	Devi	Tree
36	*Salsola imbricata*	Chenopodiaceae	Laano	Shrub
37	*Salvadora oleoides*	Salvadoraceae	Jaar/Peroon	Tree
38	*Saueda fruticosa*	Chenopodiaceae	Laano	Shrub
39	*Setaria pumila*	Poaceae	Sawri	Grass
40	*Stipagrostis plumosa*	Poaceae	Lumb Gaah	Grass

Table 1. Continued				
Species no.	Plant species	Family	Local name	Life form/habit
41	*Tamarix aphylla*	Tamaricaceae	Lao	Large tree
42	*Tamarix indica*	Tamaricaceae	Lai	Shrub
43	*Tribulus longipetalus*	Zygophyllaceae	Bakhro	Subshrub
44	*Zizyphus nummularia*	Rhamnaceae	Jhanguri Ber	Shrub

There is a scarcity of water in the Nara Desert. Water supplies are scanty, limiting agriculture activity. The groundwater resources are limited and are met at a depth of 50–300 feet from the surface. The only source of water for human beings and livestock is from dugout/natural ponds in which the rainwater is stored during the monsoon.

Natural Vegetation

Floristically, 160 plant species belonging to 118 genera and 45 families were collected from the Nara Desert during 1998–2001. Of them, 1 species of gymnosperm, 3 sedges, and 20 grass species were determined. Statistically, the area contains 21% of the plant families, 8% of the genera, and 3% of the total species of Pakistan.[5]

The vegetation in this region is typical of arid regions and consists of xerophytes, which are adapted to extreme temperature fluctuations and a wide variety of edaphic conditions. Most of the Nara Desert is covered by stabilized sand dunes. The entire area is occupied by a wide range of nutritious, palatable, and drought-tolerant species of herbs, shrubs, and trees. Although these plants are slow growing, they respond very well to favorable climatic conditions and provide ample biomass for livestock consumption. Important genuses of grasses include *Aristida, Cenchrus, Cynodon, Dactyloctenium, Desmostachya, Dichanthium, Dinebra, Eragrostis, Lasiurus, Ochthochloa, Panicum, Setaria,* and *Stipagrostis* along with sedges such as *Cyperus* and *Fimbristylis.* The most common and favorite forage grasses and browsing shrubs and trees are presented in Table 1.

Of these, *Acacia nilotica, Acacia senegal, Capparis decidua, Prosopis cineraria, Salvadora oleoides,* and *Tamarix aphylla* are notable indigenous trees in the Nara Desert.

Conclusion and Recommendations

Cyperus arenarius and *C. conglomeratus* are highly palatable and more desirable than the other plants. Their populations have been almost eliminated in the northeastern area of Nara Desert. Field observations reveal that this may be because of less or no rain during the reporting period. Severe climatic conditions during the past 5 years caused severe depletion of the grass and sedge populations because of overgrazing. The populations of grasses and highly palatable annual plants are gradually decreasing because of excessive utilization as forage at very early growth stages and before seed formation. This practice will remove the herbage cover from the soil surface. This—and the resulting decrease in litter formation—will decrease fertility over time.

Under the circumstances presented here, it is crucial to initiate projects in this rangeland to help sustain human life and to help strike a balance between living and nonliving components of the environment.

Authors are former PhD candidate (Qureshi) and Professor (Bhatti), Shah Abdul Latif University, Khairpur, Pakistan. Dr Qureshi is currently Seed Certification Assistant/Seed Testing Assistant for the Federal Seed Certification & Registration Department, Government of Pakistan, Rahim Yar Khan, Punjab, Pakistan.

Acknowledgement

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Nara Desert, Pakistan

Part II: Human Life

By Rahmatullah Qureshi and G. Raza Bhatti

Introduction

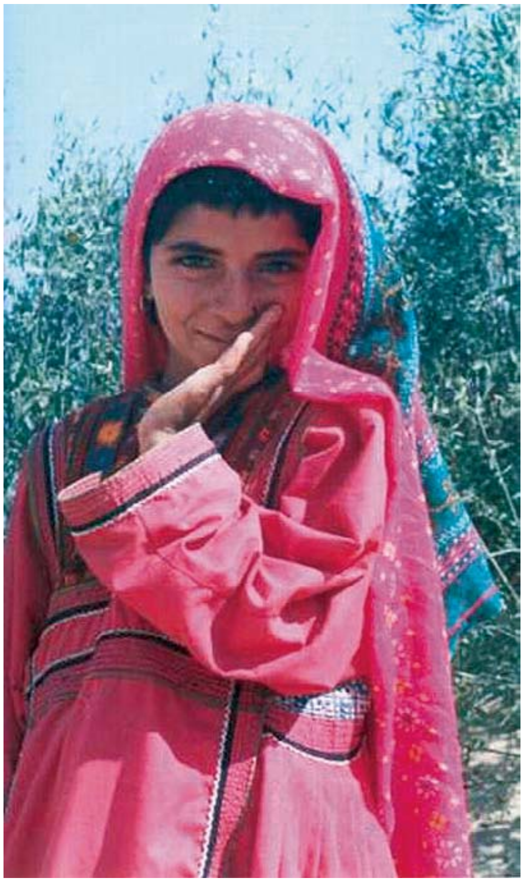
The livelihood of the people of the Nara Desert is largely dependent on their livestock, that is, sheep, goats, and camels. Shepherds with their herds migrate from their *Goth* (villages) toward the grazing grounds, establishing *Wandh* (huts constructed to settle down temporarily), living a nomadic life. There are *Tars* (where wells are situated) with permanent settlement. There are *Wandhs* near the *Tarais* (low-lying areas where water can stay or be stored for some time after rainfall). In addition, there are *Tobas*/*Tankas* (rainwater stored in manmade tanks) in *Taries.*

Agriculture

Agriculture is practiced on both the left and the right flank of the Nara Canal of this desert. It lies in the same topographical region, but the land under cultivation has been physically modified to receive water for irrigation purposes from the Nara Canal. The outermost boundaries are intermingled with desert habitat. Cotton and *Guwar* are the major crops of *Rabi* seasons, whereas wheat, *Brassica,* and *Alfalfa* are cultivated in the *Kharif* season.

Cultural Heritage

Joint family systems prevail in the Nara as in other parts of rural Sindh. All 3 generations—grandparents, parents, and children—live under 1 roof. The main duties of the men in the family are plowing, animal grazing, mat weaving, and house construction or other cash-earning activities, whereas



A nomadic girl with traditional dress in the Nara Desert.

The camel is the only means of transportation in the desert.

Local herders with cows grazing in the desert.

the women's responsibilities include bringing water from wells or ponds, cooking, washing, maintaining the house, embroidering, and so on.

Weddings of daughters are usually arranged without considering her consensus, age difference, or financial status. For the most part, close relatives or members of the family circle or caste are preferred for weddings. Most marriages are made at younger ages as per religious dictates. Marriage ceremonies in the Nara are generally simple and less costly compared to other parts of Sindh. The followers of Pir Sahib Pagara do not engage in drum beating, music, and other ceremonies.

Popular religious festivals in the Nara *taluka* are the monthly congregations at the tombs of Syed Kabeer Shah and Syed Arab Shah near Pharyaro (Monday Moon Night), Pir Moazam Shah near Chundko (Annual Festival), and Qalmee Quran near the Piranoo pattan crossing and Tajjal Sharif. An event of very high religious significance for the majority of population in the concession area is the biannual visit of Pir Sahib Pagara in which he offers *ziarat* (presents) among the followers at various points/villages, *jhalo* (an opportunity for selected followers to pray at their villages and/or accept light refreshments), and overnight stay and dinner with the main *khalifas* (representatives of Pir Pagara).

Socioeconomic Features

In spite of its low productivity, this desert sustains relatively high human and livestock populations—1.05 million and 1.25 million, respectively.[1] This livestock is the major source of meat and wool to the country. There is a tendency to increase the livestock population since it is the only livelihood of pastoralists. This increase in the livestock population is at the expense of the fragile ecosystem. Degradation of the land is verified by verbal information from the inhabitants of the Nara Desert. The overexploitation of vegetation by grazing and the chopping of trees and shrubs for fuel purposes have resulted in environmental degradation that threatens the natural resource base of this region. There is no modern transportation system in the study area. Local inhabitants use camels as their mode of transportation.

The pastoralists, accustomed to nomadic life, are opportunistic and do not adhere to regular movement patterns or timing for their pastures. They possess large herds of livestock, mainly camels and cows. They follow the distribution of rainfall and the resultant forage. Around the months of April–May, they move out of the desert toward surrounding irrigated areas. They are forced there by rising temperatures and the depletion of vegetation for food and of water in the desert area. The attraction for this movement includes browsing of livestock on weeds/wheat stubbles and drinking water for humans and livestock. The nomads and their herds return to the desert around July–September with the advent of the monsoon rains. There is no limit on traveling distance for migration purposes. The natural vegetation is the only source of food for browsing livestock. *Tobas, Tankas,* and wells serve as drinking water both for nomads and for their livestock. *Tarr* or *Tobas* belonging to the same clan are generally situated close to each other.

Nomads attach high value to their herds. Livestock are the only source of their living wage in the desert. A person's

Flocks of goats sitting under the shadow of *Prosopis cineraria* in a *Taraies* (flat area) in the desert.

Herd of cows in *Taraies* (low-lying flat area).

Chopping of *Prosopis cineraria* for charcoal formation.

status in the desert nomadic lifestyle is represented chiefly by his herd's size.

Correlation Between Plants and Human Life in the Nara Desert

In contrast to plants being used as forage, local inhabitants use them for different purposes, such as food, shelter, and medicine. A total of 160 plant species are recorded from this desert, and out of these, 148 are reported to have been used for various purposes by local inhabitants of the area under study. They used them in folk medicine, fuel wood, forage, food, vegetables, wild fruits, flavoring agents, tea making, roof thatching, agricultural implements, timber/furniture, matrices making, rope making, basket making, sitting chairs, broom making, tooth sticks, clothes washing, leather tanning, detergent, fencing/hedge, shade, ornamental/recreational, soil binders, windbreaks, and poisons.[2] The different uses of the native flora have been discussed in detail.[3] Medicinal properties of native flora have been discussed as well.[4–6] The people who live on the periphery of the desert collect tree trunks and shrubs as a source of fuel and timber material and sell them in local towns. For many years, the *Pathan* clan has chopped down the *Prosopis cineraria* trees and processed them into charcoal. This clan is also providing timber and fuel to the local market. A large area is being depleted by this practice and has disturbed the entire wildlife environment.

Problems of the Area

The main problems of the area under study are observed as follows:

1. The indiscriminate cutting of trees for fuel, timber, and coal formation has resulted in environmental degradation, which has threatened the natural resources base of the region.
2. Overgrazing by livestock in the area is damaging the vegetation. When livestock walk over young seedlings, the regeneration becomes difficult; this is one of the main causes of the gradual disappearance of some species.
3. Grazing directly on the topmost fertile layer of the soil results in soil deterioration.

Conclusion

The major concern of pastoralists is the quantity and quality of available forage in the desert so that the demands of their animals can be met. However, there are other factors that determine their movement patterns. These include extreme heat, a need for shade, avoiding disease-ridden areas, being adjacent to market, the availability of labor, and social/ritual relations.

The needs of the inhabitants of the Nara Desert are few and simple. There is a tendency to increase the livestock in the desert, so it is imperative to understand the balance between living and nonliving components under a given set of conditions. Major problems include shortages of drinking water for both human and animal populations and basic health facilities for living beings.

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USDA-ARS Global Change Research on Rangelands and Pasturelands

By Justin D. Derner, Gerald E. Schuman, Michael Jawson, Steven R. Shafer, Jack A. Morgan, H. Wayne Polley, G. Brett Runion, Stephen A. Prior, H. Allen Torbert, Hugo H. Rogers, James Bunce, Lewis Ziska, Jeffrey W. White, Alan J. Franzluebbers, Jean D. Reeder, Rodney T. Venterea, and Lowry A. Harper

The topic of global change is found almost daily in newspaper and magazine articles and on television. Global change refers to large-scale changes in the Earth's biological, geological, hydrological, and atmospheric systems, whether of human or natural origin. The primary concern of global change has centered on the rapid increase in atmospheric concentrations of primary greenhouse gases (carbon dioxide [CO_2], methane [CH_4], and nitrous oxide [N_2O]) since the Industrial Revolution in the latter part of the 19th century.[1] Increased concentrations of all 3 of these gases trap more of the sun's energy close to Earth's surface and lead to global warming, hence the reason that these gases are often referred to as "greenhouse gases." The concentration of CO_2 has increased by about 35% compared to preindustrial times and is predicted to reach twice the preindustrial concentration within the 21st century.[2] Plants convert CO_2 in the air into plant tissue, so CO_2 enrichment generally stimulates plant growth and improves the efficiency with which plants use water.[3] These changes, in turn, influence plant nutrition and the cycling of carbon and other mineral elements through the soil/plant system[4] and may have long-lasting ecological consequences for rangelands and pasturelands. For example, increased plant production with CO_2 enrichment[5,6] requires additional soil nitrogen, which is limiting in most rangeland and pastureland ecosystems, and this will modify nutrient cycling because less nitrogen is available for soil microorganisms to decompose plant materials.

The increase in methane and nitrous oxide concentrations in the atmosphere that have occurred are also a cause for concern as their warming potential as greenhouse gases surpasses that of CO_2.[7] Global warming is predicted to have numerous impacts on our climate, including altered precipitation patterns and a potential rise in sea levels. As such, global warming may have profound impacts on human activities and enterprises and is thus a concern to many. Rangelands and pasturelands provide much of the world's food and fiber, and because they occupy an extensive land area, changes in how these lands function could increase or reduce the atmospheric load of greenhouse gases. For example, land management strategies that increase the storage of carbon in plant biomass and/or soil organic matter on rangelands and pasturelands, in a process termed "carbon sequestration," offer opportunities to mitigate the rise in atmospheric CO_2 concentrations.[8]

To evaluate potential impacts that increasing concentrations of greenhouse gases may have, the United States Department of Agriculture–Agricultural Research Service (USDA-ARS), in its Natural Resources and Sustainable Agricultural Systems program, established a Global Change

Figure 1. Field experiment at Temple, Texas, used to study the influence of increasing atmospheric CO_2 on mesic rangelands. Photo courtesy of Scott Bauer.

National Program. An Action Plan, written in 2000 following customer and stakeholder workshops, identified 4 main components: 1) carbon cycle and carbon storage, 2) trace gases, 3) agricultural ecosystem impacts, and 4) changes in weather and the water cycle at farm, ranch, and regional scales (http://www.ars.usda.gov/research/programs/programs.htm?NP_CODE=204). The USDA-ARS has also formed a "Greenhouse gas Reduction through Agricultural Carbon Enhancement network" (GRACEnet) comprising over 25 research locations representing a broad range of climatic, land use, and soil variables with objectives of 1) determining effects of agricultural management practices on carbon sequestration and storage, trace gas emissions, and environmental quality; 2) providing land managers with practices and strategies that can be used to both mitigate greenhouse gases and improve soil quality; and 3) providing policy and decision makers with information on agricultural practices and strategies that can be used to mitigate and adapt to global change. This network is evaluating 4 proposed agricultural land management intensity scenarios encompassing 1) business as usual (most typical land management practice in the region), 2) maximizing carbon sequestration, 3) maximizing carbon sequestration and reducing greenhouse gas emissions (global warming potential), and 4) maximizing net environmental benefits to include air and water quality along with reducing greenhouse gas emissions.

A special symposium titled "Global Change in Rangelands and Pasturelands: A State of the State" was held at the 58th annual meeting of the SRM in Fort Worth, Texas, on February 8, 2005, in which USDA-ARS scientists provided information on 1) what is known regarding the influence of increasing atmospheric CO_2 on rangeland and pastureland soils and plant communities, and 2) how land management practices on rangelands and pasturelands might mitigate global change through the GRACEnet proposed scenarios. The following is a summary of those presentations; the scientist is identified so the reader may contact him or her directly for further information on a specific topic.

Session 1: Influence of Increasing Atmospheric CO_2 on Rangelands and Pasturelands

Semiarid Rangelands: Jack Morgan (Jack.Morgan@ars.usda.gov)

In semiarid rangelands, it is the indirect effect that increased atmospheric levels of CO_2 has on plant-water relations that may be most important in driving ecosystem responses to CO_2. These water relations can result in substantial increases in net primary production, and responses suggest that semiarid rangelands may be among the world's more responsive ecosystems to rising CO_2.[3,9] However, CO_2-enhanced productivity is accompanied by lower forage nitrogen concentration and reduced digestibility.[6] Thus, even though plant production is stimulated by elevated CO_2, the biomass produced is of poorer quality and is less desirable for livestock and wildlife. In addition, different responses among plant species to elevated CO_2 cause significant shifts in plant community species composition with important ecological and management implications/consequences.

Although much has been learned from small-plot CO_2 enrichment experiments, there are still major gaps in our knowledge, including the assessment of multiple factors involved in climate change under more natural conditions. A major challenge in CO_2 enrichment research is in determining how to interpret short-term experiments that are conducted as small, elevated CO_2 islands in otherwise present-day environments. While the incremental changes used in global change studies, such as doubling the CO_2 concentration above present ambient levels, may be useful for studying the effects of CO_2 on ecosystem processes like soil/plant/water relations, photosynthesis and net primary production, they may not provide accurate information on more slowly evolving ecosystem traits like soil nutrient cycling, individual plant species response, or plant species shifts. Further, such instantaneous changes in CO_2 concentration do not accurately simulate the continuous and incremental increases in CO_2 the Earth is experiencing.

Mesic Rangelands: H. Wayne Polley (wpolley@spa.ars.usda.gov)

Increasing CO_2 from preindustrial to an elevated concentration stimulated grassland production in central Texas by increasing the rate of CO_2 uptake by plants and by reducing the rate of water loss from leaves.[5] CO_2 enrichment accelerated a successional change in vegetation composition from dominance by warm-season grasses to codominance between grasses and broad-leaved herbaceous plants (forbs), such that the positive response of grassland biomass to increasing CO_2 was impacted by different species or groups of species during different years.[5]

The amount of additional carbon that can be fixed by plants and retained in soils is ultimately constrained by the availability of nitrogen. In order for rangelands to remain responsive to CO_2 for long time periods (decades to centuries), soil nitrogen supplies will likely need to be increased. For extensively managed ecosystems like rangelands, nitrogen availability could be increased by reducing nitrogen losses from leaching and gaseous emissions or by increasing the amount of nitrogen fixed by legumes. Whether these processes will be promoted by the continuous and incremental increases in CO_2 that are occurring in nature remains to be resolved.

Southeastern Pasture: G. Brett Runion, Stephen A. Prior, H. Allen Torbert, and Hugo H. Rogers (gbrunion@msa-stoneville.ars.usda.gov)

Pastures occupy 80 million acres in the southeastern United States, which is about 75% of the total pasture acreage in the eastern United States.[10] Rising CO_2 could impact pasture production and subsequent sequestration of soil carbon. Although the response of rangelands to rising CO_2 has been an important area of investigation for several years, managed pastures have received little attention with respect to global change.

The response of a southeastern pasture system (bahiagrass, *Paspalum notatum*) to current (365 ppm) and elevated (725 ppm) levels of CO_2 is being examined in a recently initiated experiment. After an establishment period, a nitrogen management factor (low nitrogen fertility = no nitrogen added vs high nitrogen fertility = 180 pounds of nitrogen per acre per year) will be added to the research. This study will examine the effects of CO_2 and soil nitrogen on growth and function of above- and belowground plant parts as well as changes in soil organic carbon and nitrogen, including assessing the potential of this pasture system to sequester CO_2 as soil carbon and the influence on trace gas emissions (CO_2, CH_4, and N_2O).

Weeds: James Bunce and Lewis Ziska (buncej@ba.ars.usda.gov)

Despite their large economic impact, weeds have received little attention in field studies investigating the effects of CO_2 enrichment in croplands, pastures, and rangelands. However, in recent years there have been a few comparisons of yield losses resulting from weeds in annual cropping systems at current and projected CO_2 concentrations. Elevated CO_2 often favors the most rapidly growing species or those active earliest in the growing season, which are frequently weeds.[11] The responsiveness of plants grown in isolation to elevated CO_2, however, is often a poor predictor of their responsiveness in competitive situations.

One of the major unknowns in predicting the impact of rising CO_2 on rangelands is how rapidly genetic adaptation to rising CO_2 occurs in weeds and in the species with which they compete. If evolution occurs more rapidly in weeds, then the changes in productivity or in community composition observed in experiments where CO_2 is suddenly increased may differ from those that will occur with a more gradual increase in CO_2.

Figure 2. Field experiment at Auburn, Alabama, used to study the influence of increasing atmospheric CO_2 on southeastern pastures. Photo courtesy of Stephen Prior.

Modeling Efforts: Jeff White (JWhite@uswcl.ars.ag.gov)

Field experiments provide the foundation for understanding how factors such as weather, soil conditions, and management interact to affect productivity in rangelands and pasturelands. However, the complexities of the underlying processes are often so great that researchers use computer-based models to complement field studies. Models of single species generally confirm the expectation that increasing CO_2 leads to increased photosynthesis and growth while reducing requirements for water and nitrogen.[12] Under conditions of low soil fertility, plant species (typically legumes) that convert atmospheric nitrogen to forms usable by plants may benefit more from increasing CO_2.

Uncertainties increase, however, as more quantitative predictions are sought. A difficult problem is anticipating likely genetic adaptations to increased CO_2 and how this would influence predicted impacts. For example, plants might evolve that have greater photosynthesis capacity than current genotypes, but these plants also may consume much more water and nitrogen. Research is under way to model how genetic variability might affect plant response to CO_2, but our understanding of the details of how elevated CO_2 affects photosynthesis and plant water is still incomplete.

Session 2: Land Management Practices on Rangelands and Pasturelands to Mitigate Global Change

Grazing Management Effects on Carbon Storage in Pastures: Alan J. Franzluebbers (afranz@uga.edu)

Pastures (improved, native, and naturalized) are grown on approximately 125 million acres of private land in the United States. Soil organic carbon has been shown to increase on these lands by approximately 0.5 tons of carbon per acre per year with grass establishment compared to cultivated cropland,[13] and cool-season plants such as tall fescue accumulate more soil organic carbon than warm-season plants such as bermudagrass.[14] This is because cool-season plants have a wider window of growth opportunities to utilize soil water and produce plant tissue carbon. The application of fertilizer can be used to enhance forage production to restore soil organic carbon following decades of crop cultivation; both inorganic and organic (animal manure) fertilizers have been shown to be equally effective in increasing soil organic carbon in pastures.[15] Soil organic carbon in bermudagrass pastures can also be increased by grazing at low to moderate rates compared to haying or no grazing.[15]

A significant effort has been invested in forage management and grazing studies in the eastern United States, but these efforts have focused primarily on plant and animal responses with little emphasis devoted to soil responses. Many management issues concerning carbon sequestration in forage-based management systems remain unresolved, including the type of forage species that provide the greatest carbon accumulation, whether carbon sequestration and economic return to producers have similar guidelines, the effect of soil type on management-induced soil responses, and a description of the biophysical limits under which grazing systems may result in negative or positive effects on carbon cycling and ecological function. More information is needed to enable development of specific management practices for effectively integrating cattle and crop production systems within the context of mitigating greenhouse gases.

Grazing Management Effects on Carbon Storage in Rangelands: Gerald E. Schuman and Justin D. Derner (Jerry.Schuman@ars.usda.gov)

Lands grazed by wild and domesticated animals comprise 830 million acres in the United States, with 48% of those acres classified as rangelands. Globally, rangelands account for more than one-third of the world's terrestrial carbon reserves.[16] Because of this large land area, rangelands can sequester a significant amount of additional carbon from the atmosphere. Management practices such as grazing, nitrogen inputs (fertilizer or legume introduction), revegetation of degraded lands, fire, and the use of improved plant species can all increase soil organic carbon storage in rangelands. Properly managed rangelands of the United States are estimated to have the capacity to sequester 19 million tons of carbon per year.[17] Improving management on 279 million acres of poorly managed US rangelands would sequester 11 million additional tons of carbon annually.[17] An additional 43 million tons of carbon per year could be preserved (avoided losses of carbon) in well-managed rangelands if good management were continued, no rangelands were broken out for cultivation, and reestablished perennial grasslands (Conservation Reserve Program) were maintained as grasslands and not recultivated.[17]

Grazing Management Effects on Inorganic Carbon Storage in Rangelands: Jean D. Reeder (Jean.Reeder@ars.usda.gov)

Research on carbon storage in rangelands has focused primarily on the influence of land management practices on soil organic carbon. Yet in many arid and semiarid rangelands, inorganic carbon in the form of calcium and magnesium carbonates is a major component of soil carbon. Soil inorganic carbon has been thought to be little influenced by land management practices since the turnover time is much slower than for organic carbon. Research in a short-grass steppe ecosystem demonstrated that both soil organic and inorganic carbon were higher under heavy grazing than no grazing, and inorganic carbon represented proportionally more (69%) of the increased soil carbon pool than soil organic carbon (31%).[18] The data indicate that most of the higher level of inorganic carbon with heavy grazing was the result of redistribution of existing carbonates associated with a shift in plant community composition and soil water dynamics; it

Figure 3. Livestock grazing on pasture in Georgia increases soil carbon storage. Photo courtesy of Alan Franzluebbers.

remains unclear if soil inorganic carbon is being gained or lost and at what rate. Additional questions remain regarding the influence that redistribution of soil inorganic carbon in the profile may have on other soil properties, such as soil pH or phosphorus availability.

Impacts of Agricultural Management Practices on Non-CO_2 Greenhouse Gas Emissions: Rod Venterea (venterea@umn.edu)

Biochemical processes occurring within the soil are very important in regulating atmospheric levels of the non-CO_2 greenhouse gases CH_4 and N_2O. Rangeland and pasture management can significantly alter these biochemical processes. Nitrogen fertilizer use is responsible for more than 70% of the increase in N_2O emissions because soil microbes convert a portion of the fertilizer nitrogen to N_2O gas.[19] Other microbes that remove CH_4 from the atmosphere are negatively affected by fertilizer use and also by increased tillage and cultivation.[20,21] Irrigation of semiarid lands can cause both an increase in soil N_2O emissions and a decrease in soil CH_4 uptake.[22]

The large land area represented by rangelands means that even small alterations in these processes per unit area have the potential to generate large impacts. Because of the limited number of studies examining the effects of range management on CH_4 and N_2O fluxes, we cannot accurately extrapolate these findings to global or even national scales. Other important areas for which there is little information are 1) how efforts to manage rangeland for increased carbon sequestration may affect non-CO_2 greenhouse gases and 2) how changes in environmental conditions such as increased soil temperature and shifts in geographic distribution of plant species may affect soil processes regulating atmospheric CH_4 and N_2O levels.

Methane Emissions from Grazing and Feedlot Cattle: Measurement, Treatments, and Results: Lowry A. Harper (lharper@uga.edu)

About 63% of all agricultural methane production in the United States is contributed by livestock digestion–related emissions; manure decomposition contributes 32%, and rice production produces another 5%. Three micrometeorological techniques have been developed to measure methane production by cattle in pasture and feedlot conditions with minimal disturbance. These techniques can monitor methane continuously for extended periods, allow for short-term observations (1–15-minute samples) to assess activity and diurnal effects, permit small to large numbers of livestock to be sampled, and are virtually nonintrusive to the livestock being evaluated. An integrated horizontal flux technique was developed to measure emissions from a small number of livestock (<6).[23] A modification of this technique using open-path laser spectrometry was developed to measure emissions from an intermediate number (10–25) of livestock.[24] These techniques may be verified using tracer-released methane. To assess methane emissions from a large number of livestock (50–100,000 animals), a dispersion analysis technique was developed (backward Lagrangian stochastic analysis) for remotely determining trace gases including methane and ammonia.[25]

Grazing animals emit more methane on an animal and per-animal-weight basis than feedlot animals. Livestock treated with methane-production inhibitors can reduce digestion-related emissions. Measurement of digestion-related emissions using noninterference techniques has provided more realistic emissions associated with livestock activity and grazing/feeding patterns.

Summary

Scientists with the USDA-ARS, together with university scientists and other stakeholders, are cooperating to determine effects of global change on rangelands and pasturelands and management practices to mitigate these effects. These coordinated research efforts across several locations in the United States are evaluating long-term impacts of global change on a variety of ecosystem processes, including plant community dynamics and nitrogen and carbon cycling, under different climatic conditions and across environmental gradients.

Several significant advances have been made regarding plant and soil responses to increasing atmospheric CO_2 and land management practices to mitigate global change. First, elevated CO_2 levels can significantly impact rangeland plant community dynamics, increase water use efficiency, and reduce nitrogen content of the plant material. Whether these plant community shifts and plant responses to single, large increases in CO_2 reflect what happens as continuous and incremental increases in CO_2 occur over decades remains unknown because plants and soil microorganisms possess the ability to genetically adapt to rising CO_2; therefore, this area of research merits further attention. Second, land management practices, such as grazing, fertilization, fire, and introduction of legumes and improved grass species, can increase soil organic carbon storage in rangelands and pasturelands. However, these carbon-directed management practices will need to be evaluated in terms of their impact on other ecosystem goods and services rangelands offer to fully evaluate their potential and sustainability. Third, the development of noninterference methods offers promise to monitor methane emission from isolated animals to large feedlots. Our knowledge of how trace gas emissions (N_2O and CH_4) are affected by increasing atmospheric CO_2 and land management practices is still growing, and available data are still too limited to extrapolate to large landscape situations with certainty, so additional research is needed in this area.

Our challenge now is to better integrate available knowledge and to scale our understanding, obtained primarily in small patch-scale experiments, to landscape and regional levels if we hope to construct realistic greenhouse gas budgets and management strategies for mitigating greenhouse gases. We also need to do a better job of predicting long-term effects of global change on world ecosystems, including rangeland and pastureland systems, to better prepare for a future that will likely feature higher atmospheric CO_2, altered precipitation patterns, and warmer temperatures. Better knowledge will be key to the development of intelligent and sustainable management practices that will serve society's needs and preserve our natural resource base. In conclusion, the charge for the Global Change National Program of the USDA-ARS is to continue to make significant inroads in understanding how global change affects rangelands and pasturelands and how management and cultural practices on these lands may aid in the mitigation of global change impacts.

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Early Rangeland Partners: Water and Wind

Windmill Pioneering in the American West.

By Christopher K. Wood, Tyler W. Wood, and M. Karl Wood

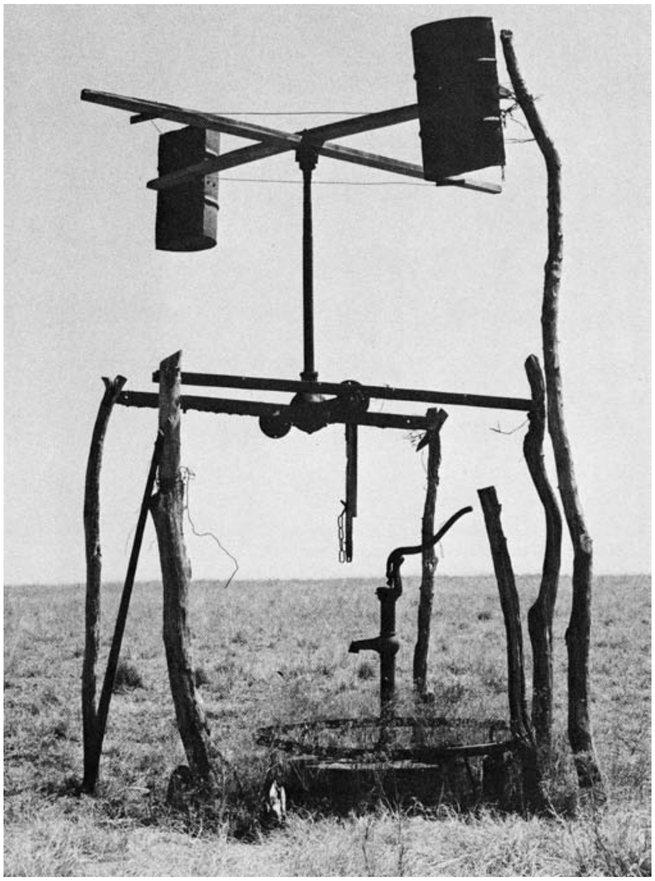
The western United States was explored by conquistadors, fur trappers, and soldiers, but settlement came from pioneers in mining, farming, and ranching using tools such as barbed wire and windmills. Windmills had been used in many parts of the world, especially Europe, for centuries. Designs of these large European windmills were adapted to the New World. A slow-moving cumbersome mill was erected near Jamestown, Virginia, in 1621 followed by hundreds of others throughout the English, French, Danish, Swedish, German, Portuguese, and Spanish settlements. Most of these mills were used to grind grain into meal or flour and were not adequate for pumping water to fill a trough or for operating machinery on a small scale.

A writer in *Scientific American* in 1860 expressed the need for water when he declared, "The great want of Texas is sufficient water… . There is a million dollars lying waiting for the 1st man who will bring us … a windmill, strong, durable and controllable." Settlement was limited to perennial streams with vast areas in between that were arable and grazable if only potable and stock water could be found. Indeed, much of the desert areas of the West had grazable forage, but grazing by wild ungulates such as bison and, later, domestic animals was often limited because of the lack of drinking water. The solution was developed by a rural mechanic in distant New England. Without improved windmills (products of the industrial revolution), occupancy of the plains, prairies, and deserts of the West might very well have been delayed for many decades.

Invention of Mills for the West

Daniel Halladay was the New England mechanic who invented the 1st commercially successful self-governing American windmill. Inventors throughout the country were attempting to find ways to harness the wind for pumping water or mechanical power, as steam, animal, and human power were considered too expensive. In Ellington, Connecticut, Halladay and his associate John Burnham saw the need for a mill that without human attention would automatically turn to face the wind and govern its own speed to prevent its destruction by centrifugal force. Within a short time, in 1854 Halladay had invented a windmill with a rigid vane that always kept the wheel facing the wind similar to a weather vane on the top of a barn. In light winds, the blades faced the wind at angles from which it derived the greatest power, but as the wind velocities increased and the wheel spun faster, a centrifugal governor changed the pitch of the blades so that they presented less of their surface to the wind and thus controlled their speed. An operator could also turn the blades into a position parallel with the vane and wind so that the wheel ceased turning. The mill was successfully tested for 6 months by pumping water from a 28-foot-deep well and forcing it a distance of 100 feet into a reservoir in the loft of a barn.

The widely promoted new mill was demonstrated at the New York State Fair and featured in *Scientific American,* but sales in the region never achieved the volume that its makers desired. The makers saw a much greater market in the Midwest, so they moved near Chicago to Batavia, Illinois, in



An example of a homemade windmill constructed in the 1st half of the 20th century. Photo from A Field Guide to American Windmills by T. Lindsay Baker.

1856. Railroads quickly became important customers for the company as they built across the plains and prairies into the West and needed water for boiler supplies.

The windmill was modified in 1868. The early mills only had 6 or 8 blades and ranged in size from 6 to 16 feet in diameter. The smaller mills had solid wooden blades, while the larger mills had iron frames covered with sailcloth. The newer models featured thin wooden blades nailed to wooden rims and mounted on hinged castings at the ends of wooden arms and became known as "sectional wheels." A vaneless windmill would blow around to the lee side of the tower and would turn behind the tower instead of in front of it. Vaneless mills were predominant among the sectional-wheel-type mills during the 1870s and 1880s.

A solid wheel pattern that did not fold in any direction was invented in 1866 by the Reverend Leonard H. Wheeler, a missionary among the Ojibway Indians in Wisconsin. These mills adjust their angle to the wind to control their speed and thus prevent their destruction from centrifugal force. This idea remains the most common form of governing used in windmills today. It was called the Eclipse, which became one of the most common windmills used in the 19th and early 20th centuries. By the 1880s, it was made in sizes from 8½–30 feet in diameter. The Wheeler's company eventually became the Fairbanks, Morse and Company in the 1890s. Like the Halladay mills, the Eclipse catered to the railroad industry.

Early Windmill Manufacture

Many makers followed and modified the pattern of the Eclipse. A few horizontal windmills were invented with a wheel that spun on a vertical shaft. Competition among windmill manufacturers from the 1850s through the 1870s was keen and at times even cutthroat. Claims of patent infringement were common.

Many farmers and ranchers chose to build their own windmills, and these windmills came into use by the 1870s on the plains and prairies. They were quite common in the central Great Plains by the 1890s. Homemade mills very often were erected by the most firmly established and affluent farmers and ranchers rather than individuals who simply could not afford to buy factory-made mills. Despite this fact, the greatest virtue of the comparatively inefficient homemade mills was their low cost. They were built with the builders' spare time and scrap materials on the farm. Total expenses seldom exceeded $4 or $5 and often cost nothing. Scrap materials included old lumber, lath, shingles, split rails, old packing boxes, barrel staves, coffee sacks, and the tin from old tin roofs plus cast-off farm machine parts with bearings and grease cups.

A common homemade mill was the Jumbo, also known as the Go-Devil or Ground Tumbler. This mill was similar to a water mill with a horizontal axle that depended on wind to overshoot the top. Most were not self-governing to adjust for wind direction and speed. Another quite common homemade mill was the Battle Ax. It was found throughout the plains, especially in the Platte River valley. It consisted of a horizontal axis with fan-shaped blades on a wooden tower. Other homemade windmills had horizontal mills with vertical axes. One horizontal mill near Lincoln, Nebraska, had a diameter of 40 feet with blades that were 12–14 feet high. A few miniature Old World mills were also built. Homemade windmills could not compete with the factory-made mills in efficiency, but with enough wind, the lower costs compensated for less efficient homemade windmills.

By the 1870s, windmills were being made exclusively from iron and steel. By 1890, steel had become sufficiently inexpensive to allow increasing numbers of competitively priced windmills. However, the number of wooden mills actually increased in the years before World War I, but the number of steel mills manufactured grew faster than the increase in wooden mill production. By 1914, wooden mills comprised 23% of all windmills. Steel mills were self-oiling but had a reputation for being weak and difficult to repair compared to wooden mills, which could be repaired with nails, wire, and rawhide. Wooden windmills remained on the market until at least 1940. In time, the economy and efficiency of steel windmills prevailed and became the windmill of choice.

A windmill with circular blades in east Custer County, Nebraska, in 1888. Photo courtesy of Nebraska Historical Society.

Windmill Designs

Many different designs were applied to windmills, especially the blades, with each manufacturer proclaiming its design to be the best. Thomas O. Perry, an engineer, conducted experiments in 1882 and 1883 for the U.S. Wind Engine and Pump Company to ascertain the design for the most efficient windmill wheel. In over a year's time, he tested more than 50 different windmill designs in more than 5,000 experiments. By the end of the trials, the engineer had developed a completely new wind wheel that was 87% more efficient than the wooden wheels used on most mills of the day. The new design consisted of concave sheet steel blades set on a specific angle to the wind and fastened to steel rims and arms that presented the least possible wind resistance while still retaining sufficient strength. His company rejected his new redesign because of all the changes that would have to take place in manufacturing the new product. In 1888, Perry joined up with another inventor named LaVerne Noyes to organize a company to manufacture Perry's scientifically designed windmill. Noyes thought of the name Aermotor, which today is known throughout the world.

The windmill devised by Thomas Perry and placed on the market by LaVerne Noyes became the basic pattern for many later mills. Its wheel was made from concave sheet steel blades mounted on steel rims and arms and is known today as the Perry wheel. Because it rotated so fast, a back gear was used, allowing 3 revolutions per stroke of the pump. This gearing gave the mill great leverage, allowing it to turn in a light wind of about 4 miles per hour. The back-gearing also gave the pump a long, easy stroke instead of the short, quick, and jerky strokes of the direct-stroke mills.

A major problem of steel windmills was corrosion. Mills were painted until about 1890, when galvanizing with zinc alloy became standard. The last major development in the windmill came in 1915. A housing that needed to be filled with oil only once a year was built around the mill's gears. This relieved the range rider of his biweekly greasing chores and somewhat diminished the windmiller's job. Because of the dependability of this improved windmill, worries over water shortages were eased for the rancher, farmer, and rural dweller.

Aermotor became the largest of the American windmill manufacturers. Only 48 mills were sold in 1888, 2,288 in 1889, 6,268 in 1890, 20,049 in 1891, and 60,000 projected for 1892. This was the heyday decade for erecting windmills. In 1889, there were 77 windmill factories in the United States; by 1919, the number had dwindled to 31. By the turn of the 20th century, Aermotor was producing 50% of the windmills in the United States, and they claimed to have sold over 800,000 windmills by the middle of the 20th century. Aermotor mills were still being manufactured in Broken Arrow, Oklahoma, until about 1970, when they moved to South America. By 1973, only 2 factories in the United States were still making complete old-fashioned ranch windmills. Several hundred mills are still sold each year. Storm damage to transmission lines, low voltages, and high utility rates have kept electric pumps from being the perfect alternative; gasoline engines need frequent fueling, and fuel costs keep climbing.

Today, windmills, parts, accessories, and repair services can be found on the Internet. Costs of windmills vary from about $3,000 for a 6-foot-diameter mill on a 21-foot tower to about $15,000 for a 16-foot-diameter mill on a 47-foot tower. Some farmers and ranchers continue to experiment with scrap metal and wood to make homemade windmills.

Uses of Windmills in Pumping

Besides providing boiler water for railroads, windmills sustained many rural homes, including water for elevated storage tanks at the house and troughs for livestock. Initially, ranchers used little logic in locating the mills across their wide expanses of land. However, as the marketing of cattle changed from a per-head basis to a per-pound basis, the weight loss of

Windmills and reservoir near Marfa in western Texas. Photo courtesy of the U.S. Geological Survey.

stock caused by long walks to water convinced ranchers to locate wells so that distances between watering places was reduced to a minimum. The goal was to place water sources so that cattle did not have to travel over 2 miles to water.

At the end of the 19th century, the Fairbanks, Morse and Company claimed that the famous 3-million-acre XIT ranch was using over 500 of its Eclipse mills. This was 1 windmill about every 3 miles, which was probably very good for such a large ranch. Besides pumping water, windmills were used for recreation by youngsters and as lighthouses on the plains. Lights were used to help people find their way home late at night. Windmill irrigation was important at a few locations. In times of drought, windmills were used as a backup source to stream-source irrigation and dryland farming. Windmills were used to drain marshes and swamps along some coastal areas and to remove water from shallow mines. Near Richmond, Missouri, an 18-foot Eclipse mill drained 11,000 gallons of water from a mine each day. Today, as remote areas are settled, especially by retirees, windmills are occasionally desired. The use of windmills brought about 2 of the most colorful characters of the West, the driller and the windmiller, and altered the lifestyle of another, the range rider.

The Role of Well Drillers

A necessary component of the windmill is the well beneath it. Settlers had to either dig wells by hand or hire so-called professional well diggers or drillers. The well digger was usually a loner and seldom seen by anyone except the range rider and windmiller. He followed the fence crews and, after guessing at where he might find water, bored wells with his horse-powered drilling rig. Many well diggers gave up on their 1st well, while others were renowned in their localities and spent much of their lives underground in the dangerous work of excavating and curbing wells. In most of the West, water was so deep that digging wells with shovels was not much of an option. Hand boring with an auger on a 1-inch-diameter rod was effective only to about 25–30 feet. Another shallow-water alternative involved men using sledgehammers to literally pound a pipe fitted with a special well point into the ground. A hollow metal point served as a sharp spike to ease its entry into the ground and as a strainer at the bottom of the well once it was completed. Both pounding and auger techniques were limited in areas with rocky formations.

On the plains and prairies and in desert areas, water was too deep to use any of these methods. Mechanical well-drilling machines were used. During the late 19th and 20th centuries, nearly all drill rigs were of the percussion type, called cable-tool rigs. These machines consisted of a heavy drill bit or other sharp tool fastened to a cable with a suitable derrick or tower for lifting it and then allowing it to drop. This forced a hole into the ground and pounded rocks into fragments small enough to be removed. The bits often weighed about 15–20 pounds. For shallow wells, manually operated wells could be used, but most used horsepower. As animals walked in a circle, the drill was raised on the end of

The Hart & Company well-drilling outfit at Cliff, Nebraska, about 1890. Photo courtesy of Nebraska Historical Society.

the cable to a prescribed level and then, on release, plunged into the ground. A few stream-powered rigs were used in the late 19th and early 20th centuries, but they were expensive and required greater expertise. With time, rotary drilling rigs were used, but smaller operators have continued to use motorized percussion rigs to the present time.

As the hole was made, water was pored down the hole so that after the drill had pulverized some of the subsurface material, a bailer could be let down into the hole to remove the pulverized rock, soil, and water mixture. The process was repeated over and over until the water table was reached. Generally, the drilled wells were lined with iron casing to prevent them from caving in. The cost of drilling a well was not cheap. During the mid-1880s on the XIT Ranch in northern Texas, drillers received \$1.50 per foot for the 1st 150 feet, \$2.00 per foot for the next 100 feet, and then \$0.50 more per foot for each subsequent 100 feet until satisfactory water flow was reached. A well in Nebraska was 444 feet deep and cost \$600. Most old-time well drillers were solitary men who traveled across the country with their workers searching for business and then went about their mysterious work that few people understood. Much of their success depended on experience and familiarity with subsurface geological structure. Customers often were elated with their new wells, and their friends sent them congratulatory messages.

Maintenance and Repair

Initially, most mills were maintained by their owners. But hundreds of thousands of windmills in the West led to the need for maintenance and repair. Itinerant windmillers provided this service. These were often farm or ranch kids whose help was no longer as valuable because of the increasing mechanization of agriculture. They lubricated the mills, repaired pumping cylinders, repaired wind-damaged wheels and ironwork, replaced bearings, and fished out and repaired broken sucker rods. Their work was as important to the ranch as the doctor, veterinarian, or preacher. When the well digger was successful the windmiller followed and set up a mill. Owners of the larger ranches usually employed several windmillers to make continuous rounds, checking and repairing windmills. The windmillers lived in covered wagons and saw headquarters only once or twice a month. The early mills had to be greased twice a week, and this was the range rider's job. He kept a can (or beer bottle) containing grease tied to his saddle. When he rode up to a mill that was squeaking, he would climb it, hold the wheel with a pole until he could mount the platform, and then let the wheel turn while he poured grease over it. Whoever climbed the tower was always in danger of attacks from swarms of wasps, which hung their clustered hives beneath the windmill's platform; there was the added danger of falling from the tower when such attacks occurred. Windmillers' wagons were replaced by trucks in the 1920s and 1930s. Today, short courses in windmill maintenance and repair are taught at several places in the country, and online training programs are available.

Final Remarks

Artists often portray the rigors and failings of the Old West with paintings, sculptures, and photographs of windmills. Indeed, a shop at Old Town in Albuquerque, New Mexico, has only paintings of windmills. Invariably, their portrayals are of broken-down and dilapidated structures. These characterizations of windmills usually represent not failures but rather replacements by pumps powered with gasoline and electricity. Windmills brought settlement, development, and better times rather than failure. Indeed, on an outhouse wall behind a 1-room school in Cherry County, Nebraska, a child scribbled the following:

We like it in the sandhills,
We like it very good,
For the wind it pumps our water,
And the cows they chop our wood.

Several companies continue the manufacture of windmills in the United States. These firms include the Aermotor Windmill Company, Inc., of San Angelo, Texas; Dempster Industries, Inc., in Beatrice, Nebraska; Muller Industries, Inc., of Yankton, South Dakota; and KMP Pump Company in Earth, Texas. The American West Windmill Company in Amarillo, Texas, imports and distributes mills made in Argentina; Second Wind Windmill Service in Fort Worth, Texas, imports and sells mills made in Mexico; while O'Brock Windmill Distributors in North Benton, Ohio, imports and sells mills made in South Africa.

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Jeff Mosley

Browsing the Literature

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 publishers or senior authors (addresses shown in parentheses). Suggestions are welcomed and encouraged for items to include in future issues of *Browsing the Literature*.

Animal Ecology

Dominance, age and weight in American bison males (*Bison bison*) during non-rut in semi-natural conditions. C. Roden, H. Vervaecke, and L. Van Elsacker. 2005. *Applied Animal Behaviour Science* 92:169–177. (RZSA, CRC, Koningin Astridplein 26, B-2018 Antwerp, Belgium). Older and heavier individuals occupied the higher social ranks in a linear dominance hierarchy.

The Starkey Project: A synthesis of long-term studies of elk and mule deer. M.J. Wisdom (technical editor). 2005. Alliance Communications Group, Lawrence, KS 66044. 252 p. (ISSN 1-891276-40-9). This book summarizes 20 years of research from northeastern Oregon about mule deer and elk responses to land management activities.

Viability of Bell's sage sparrow (*Amphispiza belli* spp. *Belli*): Altered fire regimes. H.R. Akcakaya, J. Franklin, A.D. Syphard, and J.R. Stephenson. 2005. *Ecological Applications* 15:521–531. (Applied Biomathematics, 100 North Country Rd., Setauket, NY 11733). In the foothills and mountains of southern California, sage sparrows depend on chaparral habitat with fire-free intervals of about 30 years.

Grazing Management

Livestock grazing management impacts on stream water quality: a review. C.T. Agouridis, S.R. Workman, R.C. Warner, and G.D. Jennings. 2005. *Journal of the American Water Resources Association* 41:591–606. (128 CE Barnhart Bldg., Univ. of Kentucky, Lexington, KY 40546). Reviews the research basis for livestock grazing best-management practices commonly implemented in the southern humid region of the United States.

Hydrology/Riparian

Beginnings of range management: An anthology of the Sampson-Ellison photo plots (1913 to 2003) and a short history of the Great Basin Experiment Station. D.A. Prevedel, E.D. McArthur, and C.M. Johnson. 2005. USDA Forest Service General Technical Report RMRS-GTR-154, 60 p. (Publications, Rocky Mountain Research Station, 240 West Prospect Rd., Fort Collins, CO 80526). Presents a photographic record of high-elevation watershed conditions in 1913, the 1940s, 1972, 1990, and 2003 in central Utah. The photo plots were initiated by Arthur Sampson and later maintained by Lincoln Ellison—2 men who pioneered range management.

Surface water and ground-water thresholds for maintaining *Populus–Salix* forests, San Pedro River, Arizona. S.J. Lite and J.C. Stromberg. 2005. *Biological Conservation*

125:153–167. (School of Life Sci., Arizona State Univ., Tempe, AZ 85287). Fremont cottonwood and Goodding willow were dominant over tamarisk on sites where surface flow was present more than 76% of the time; yearly groundwater fluctuation was less than 1.6 feet, and maximum depth to groundwater averaged less than 8.5 feet.

Measurements

Plot shape effects on plant species diversity measurements. J.E. Keeley and C.J. Fotheringham. 2005. *Journal of Vegetation Science* 16:249–256. (US Geological Survey, Sequoia National Park, Three Rivers, CA 93271). Average species richness did not differ between square and rectangular sample plots.

Plant/Animal Interactions

Mesquite (*Prosopis glandulosa*) germination and survival in black grama (*Bouteloua eriopoda*) grassland: relations between microsite and heteromyid rodent (*Dipodomys* spp.) impact. B.D. Duval, E. Jackson, and W.G. Whitford. 2005. *Journal of Arid Environments* 62:541–554. (Dept. of Fishery and Wildlife Sci., New Mexico State Univ., Las Cruces, NM 88001). Rodent activity may be responsible for increased mesquite density in Chihuahuan Desert grasslands.

Plant Ecology

Quantifying tree cover in the forest–grassland ecotone of British Columbia using crown delineation and pattern detection. Y. Bai, N. Walsworth, B. Roddan, D.A. Hill, K. Broersma, and D. Thompson. 2005. *Forest Ecology and Management* 212:92–100. (Dept. of Plant Sci., Univ. of Saskatchewan, Saskatoon, SK S7N 5A8, Canada). In a 250-acre site of grassland and forest, about 27% of the open grassland was lost to tree encroachment between 1966 and 1995.

Variation in nitrogen deposition and available soil nitrogen in a forest–grassland ecotone in Canada. M. Kochy and S.D. Wilson. 2005. *Landscape Ecology* 20:191–202. (S. Wilson, Dept. of Biology, Univ. of Regina, Regina, SK S4S 0A2, Canada). Fire without ungulate grazing may accelerate expansion of aspen into grassland, whereas fire accompanied by ungulate grazing will not.

Rehabilitation/Restoration

Benefits of classical biological control for managing invasive plants. T.W. Culliney. 2005. *Critical Reviews in Plant Sciences* 24:131–150. (USDA–APHIS, 1730 Vars Drive, Suite 300, Raleigh, NC 27606). "Since establishment of the stringent standards and regulatory apparatus currently in place in the United States and elsewhere, there have been no reported cases of biological weed control causing significant harm to nontarget populations or to the environment at large."

Canada thistle (*Cirsium arvense*) and pasture forage responses to wiping with various herbicides. C.W. Grekul, D.E. Cole, and E.W. Bork. 2005. *Weed Technology* 19:298-306. (E. Bork, Dept. of Agriculture, Food and Nutrition Sci., Univ. of Alberta, Edmonton, AB T6G 2P5, Canada). Wick applications of broadleaf herbicides (clopyralid, or picloram plus 2,4-D, or 2,4-D plus mecoprop plus dicamba) effectively controlled Canada thistle without reducing grass production.

Diflufenzopyr influences leafy spurge (*Euphorbia esula*) and Canada thistle (*Cirsium arvense*) control by herbicides. R.G. Lym and K.J. Deibert. 2005. *Weed Technology* 19:329-341. (Dept. of Plant Sci., North Dakota State Univ., Fargo, ND 58105). Leafy spurge control was enhanced when diflufenzopyr, an auxin-transport inhibitor, was applied with either quinclorac, picloram, or dicamba. Diflufenzopyr reduced the efficacy of glyphosate but did not affect imazapic.

Examining the strength and possible causes of the relationship between fire history and Sudden Oak Death. M.A. Moritz and D.C. Odion. 2005. *Oecologia* 144:106–114. (151 Hilgard Hall 3110, Univ. of California, Berkeley, CA 94720). Presents evidence that a fire-free interval of 50 years or less may help control Sudden Oak Death, a pathogen-caused disease that kills oak trees.

Host plant specificity and potential impact of *Aceria salsolae* (Acari: Eriophyidae), an agent proposed for biological control of Russian thistle (*Salsola tragus*). L. Smith. 2005. *Biological Control* 34:83–92. (USDA–ARS, 800 Buchanan St., Albany, CA 94710). A mite that feeds on leaves and flower buds can suppress Russian thistle without harming nontarget plants in North America.

The effect of season of picloram and chlorsulfuron application on Dalmation toadflax (*Linaria genistifolia*) on prescribed burns. J.S. Jacobs and R.L. Sheley. 2005. *Weed Technology* 19:319-324. (Dept. of Land Resources and Environmental Sci., Montana State Univ., Bozeman, MT 59717). Chlorsulfuron applied in the fall or spring and picloram applied in the spring effectively suppressed Dalmation toadflax cover, biomass, and density for up to 3 years.

Socioeconomics

Landscape patterns of exurban growth in the USA from 1980 to 2020. D.M. Theobald. 2005. *Ecology and Society* 10(1):32 [online] URL: http://www.ecologyandsociety.org/vol10/iss1/art32. (Dept. of Natural Resource Recreation and Tourism, Colorado State Univ., Fort Collins, CO 80523). In the lower 48 US states, the amount of land covered by urban, suburban, and exurban development increased from 10.1% to 13.3% from 1980 to 2000. By 2020, it is predicted that 16.5% of the land area will be covered.

Support for hunting as a means of wolf (*Canis lupus*) population control in Sweden. G. Ericsson, T.A. Heberlein, J.

Karlsson, A. Bjarvall, A. Lundvall. 2004. *Wildlife Biology* 10:269-276. (T. Heberlein, Dept. of Rural Sociology, Univ. of Wisconsin, Madison, WI 53706). Among 4 groups of people surveyed (general public, all hunters, the public living in areas with wolf populations, and hunters living in wolf population areas), a majority of all 4 groups found it acceptable to hunt wolves to reduce the risk of livestock depredation (53%–91%).

The wildland-urban interface in the United States. V.C. Radeloff, R.B. Hammer, S.I. Stewart, J.S. Fried, S.S. Holcomb, and J.F. McKeefry. 2005. *Ecological Applications* 15:799–805. (Dept. of Forest Ecology and Management, Univ. of Wisconsin, Madison, WI 53706). The wildland–urban interface in the lower 48 US states covers 9% of the land area and contains 45 million housing units.

Soils

Patterns of soil erosion and redeposition on Lucky Hills Watershed, Walnut Gulch Experimental Watershed, Arizona. J.C. Ritchie, M.A. Nearing, M.H. Nichols, and C.A. Ritchie. 2005. *Catena* 61:122–130. (Remote Sensing Lab, USDA–ARS, Beltsville, MD 20705). Soil erosion decreased as the percentage of rock fragments in the top 10 inches increased, but soil erosion was unrelated to the amount of vegetative cover.

Probable origin of laterally coalesced nabkas and adjacent bare lanes at Dugway Proving Ground, Utah, USA. N.E. West and D.A. Johnson. 2005. *Arid Land Research and Management* 19:241–255. (Dept. of Forest, Range, and Wildlife Sciences, Utah State Univ., Logan, UT 84322-5230). Evidence suggests that nabkas or "desert ripples" (ie, long, thin mounds of silt on the ground surface) are formed by wind erosion rather than by prehistoric floods.

Response of soil delta N-15 and nutrients to eastern red cedar (*Juniperus virginiana*) encroachment into a relict calcareous prairie. A. Bekele and W.H. Hudnall. 2005. *Plant and Soil* 271:143–155. (Tarleton State Univ., PO Box T-0410, Stephenville, TX 76402). Encroaching woody plants in Louisiana prairie alter the surface soil pH in the top 4 inches, making the soil more forest-like.

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The Recipe Corner

Editor's Note: There are many "family" recipes that are passed from generation to generation that are never seen by outsiders. Many of these recipes would be enjoyed by others. This column is being established to present some of these recipes so others can enjoy them. The following recipe was submitted by Ann Harris, Lakewood, Colorado.

Champ

My mother came to the United States from Ireland as a young lady. As you can imagine, her family used the traditional Irish recipes for their meals. The following is a simple dish that was a favorite of our family.

Champ might be considered the Irish version of "mashed" potatoes seasoned with scallions, onions, or chives. In times past, Champ was considered a meatless main dish. In modern times, it is often served as a side dish.

2–3 bunches of scallions
½ pint milk
5 pounds of potatoes
butter
salt and pepper as needed

Boil the potatoes and mash well. Chop scallions and heat with milk, then beat into potatoes with wooden spoon. Season and serve hot with a large knob of butter in the center of each plateful.

Eat from the outside in, dipping each forkful into the melted butter. ◆

Thad Box

Weed That I Am

I was taught that a weed is a plant out of place. The same concept applies to animal weeds and other things we think are pests. That seems rather straightforward. On first blush, it isn't likely to cause arguments among land care professionals and those they serve. But it does. Value-laden concepts, such as what offends us, always generate heartfelt differences of opinion.

Range professionals do not agree what is out of place on rangelands. To some range conservationists, bison are acceptable grazers; cattle are weeds. To others, land seeded to exotic wheat grasses and dryland alfalfa are acceptable; invading native brush species are out of place. Both groups may consider invasive and "noxious" species like dyers woad unacceptable. Some citizens call dyers woad beautiful yellow "wildflowers."

In the 19th century, a lovely, hardy, flowering shrub was introduced to brighten gardens throughout the Southwest. Californians found tamarisk an ideal plant to stabilize river banks. It did its job well. Too well. It spread to most desert waterways and irrigation systems. Millions of dollars are spent each year fighting it, dozens of papers have been published in *JRM*, and tamarisk is still winning most expansion battles.

A little over a hundred years ago, coddling moths were ruining apple orchards in Utah. A prominent family imported 200 pairs of English sparrows to eat the moths. Salt Lake City passed an ordinance protecting the bird. Anyone disturbing them was fined. The sparrows crowded out native songbirds.

From where I write, most plants I see are aliens. Coddling moths ruin my apples. English sparrows flit between the trees. Every weed was brought in because someone thought it was good. There are pretty, bright, yellow dandelions in my lawn and a few volunteer pansies. Breeding and introducing grasses for lawns (weeds on rangelands) is a major industry. Dandelions are a weed everywhere; pansies are a noxious weed in Colorado.

Whether something is out of place depends on one's viewpoint and philosophy and society's concerns. Norway maples line my street. Ecologically speaking, they are weeds. The city forester, home owners, and members of the historic district rightly maintain they are a major part of the aesthetic and historic ambience of our neighborhood. They provide beauty and shade along Center Street. Each tree produces a bushel or more of winged seeds. The most common weeds removed from my flower beds are maple seedlings.

Whether my maples are weeds depends on opinion. Its role as an invasive species is determined by its biology, its ability to reproduce and thrive in existing vegetation. Weeds are weeds by definition. Invasive species are biologically programmed to crowd out other species.

European carp occur in most waters in America. Their wide environmental tolerance and expansive reproduction capacity allow them to exist in all kinds of places. They crowd out native fish and change the aquatic habitat. Carp are usually considered a weed. They are also a classic invasive species.

Americans are eating more fish. The pet food industry competes with humans for fish protein. The seas are strained for small fish to remold into faux crab and scallops. Millions of tons of carp await inventors, marketers, and entrepreneurs who can change carp, a weed, into a useful product. Once they do, carp will change from weed to crop. Its role as an invasive species may be slowed by the offtake of thousands of individuals, but the species will still be invasive.

Invasive species are persistent. They dominate habitats and change the environment to suit their kind. Knapweed, leafy spurge, and medusa-head rye are taking over more land each year. Much of the Great Basin has changed from desert shrub to cheatgrass in my lifetime. The list could go on.

Our profession's role is not to decide what is or is not out of place on rangelands. It is even arguable whether our role includes killing weeds and pests. We seek to understand and promote the principles of community dynamics so that rangelands can be managed for whatever purpose society decides.

Society's unwritten goal for survival gives us another role: to ensure that the basic productivity of land is not diminished. Our first responsibility in dealing with weeds and pests is to make sure the community is sustainable—that ecological processes continue to function regardless of what mix of species occupy the land.

Killing weeds a species at a time doesn't work well. Broad-scale treatment with pesticides, mechanical devices, or fire to control one species is often counterproductive. Single-species wars often push the community to a threshold of lower productivity and less stability.

Introducing natural predators works sometimes, but often the predator brought in becomes a pest, altering ecological processes. Changing a weed to a useful product may tame some species. Our role as land care professionals is to ensure long-term sustainability. Functioning ecosystems, rather than ephemeral economic gain, should be our guide.

Maybe our main roles are just to understand the system and to become the best ecologists possible. Managing land to give a competitive advantage to desired species is often the best long-term weed and pest strategy. Ecology, like the free market, allows healthy communities.

Every species is different. On those firmly established, some aggressive weed control may be necessary. But land managed using ecological principles is less likely to be reinvaded by weeds. And weeds are with us. I look toward the mountain. Two months ago, it was green. Now it is cheatgrass brown, tinderbox dry. Parachute-like seeds of dandelion and thistle drift past my window. A starling strolls across my bluegrass lawn.

Back in 1989, I attended a weed control conference at Las Cruces, New Mexico. As I sat and listened, I wrote the following:

WEED

a weed is a plant out of place
an invader following disturbance
or one with virtues
not yet discovered

a tomato plant in the petunia patch
marigolds and chinese elm
wildflowers
on a cattle range

a cowboy speaking for animal rights
accident lawyers, insurance salesmen
women
in the work force

a vegetarian at a barbecue
tin men and siding salesmen
farmers
on a family farm

environmentalist at a loggers ball
sprayers and herbicide salesmen
students
of ecology

an oboe player in a punk rock band
booking agents and t-shirt makers
writers
from the hinterlands

a baptist in a muslim mosque
super studs and battered moms
children
black and brown

put them weeds in their places
spray them, chop them down
all save me
weed that I am

Ninth in a Series: Insight From SRM's Charter Members

The Society for Range Management (SRM) History Committee has conducted interviews with many of the Society's charter members to capture their perspective of events leading to and subsequent to the formation of the American Society of Range Management in 1947–1948. Interviews from several of these individuals will be shared for today's SRM members to enjoy and learn from.

SRM Charter Member – Wayne W. West

Editor's Note: Wayne West, of Wendell, Idaho, was interviewed on January 9, 2004. The following is transcribed from the taped interview but in a paraphrased format done by Tom Bedell.

Wayne West is a native of Idaho born about 25 miles away from Wendell. He started his career with the U.S. Forest Service doing range surveys using the square-foot density method, continuing with the Service until the war started. He participated in the war and after the war came back to the Forest Service doing range reconnaissance in 1947 and 1948 on the Umatilla National Forest in Oregon.

He worked under range staff officer John Clouston, from whom he heard about the American Society of Range Management in the process of being formed. Wayne was impressed by not only John Clouston but also Ken Parker and Joe Pechanec in the research branch, so he joined the Society. John Clouston was executive secretary from 1956 to 1968. It seemed to Wayne that the Society would be a good organization for range people, as there was no place for them in the Society of American Foresters.

Wayne recalls that there were no sections in the beginning. He was not able to attend the first ASRM meeting in Salt Lake City.

With regard to his expectations, Wayne thought since ASRM was open to all people and especially to range practitioners as well as scientists that more recognition of range management would come about. He states that this has always been a struggle and still is a struggle, maybe getting worse than it was.

Wayne's career with the Forest Service was as assistant district ranger and then district ranger on the Umatilla Forest. He then went to the regional office in Portland, Oregon, for a few years. Region 8 in Atlanta was looking for a staff person to take charge of getting a handle on wild hogs and sheep in southeastern forests. Wayne took that job for 5 years and felt progress was made under his tenure there. He relates that there was suspicion of anyone driving a government vehicle, as they thought it was the revenuers coming. All government employees were looked on with some suspicion in those days. After the Atlanta stint, Wayne returned to California as branch chief of range management in the California regional office for 9 years. He retired from there at age 55 and moved to Idaho, where he has been living these past 32 years.

Wayne states that the Forest Service was very encouraging of their employees participating in ASRM. He said that at least 4 people from the regional office at San Francisco would go to an annual meeting. This doesn't seem to be so true now. Good support from the range management boss was important. Wayne participated in the old range reseeding/revegetation committee. When in Atlanta, he pushed for more Society membership. While there, he was chairman of the Southern Section and worked on the newsletter after that.

He states that in about 1963 or so, things began to change, with fewer employees authorized to go to meetings and that some deemphasis was made in range management. This was due primarily to budget limitations. It was a matter of priorities. He could see that coming over 30 years ago.

Wayne did not serve as an officer after the Southern Section chairman but was involved with a number of committees over time before he retired.

Wayne's observations and perspectives on the Society and the profession: He is concerned that fewer practitioners seem to be involved in the Society with more emphasis by college professors. He thinks this affects how the operation may be run and perhaps the kinds of advice being given, that is, that maybe it is not as practical as it could be. He reflects back on trends that developed years ago. He suggested that rangeland uses needed to be allocated, a sort of carrying capacity for things like recreation. If not, some uses could get too large and out of control. He feels uses should be balanced but also felt that was hard to get accepted in the early 1960s.

Wayne currently is concerned that resource management decisions seem often to be made by politicians; especially the current administration seems to do this with the result that management agencies are weakened and someone else can do the work, ie, a form of outsourcing.

Advice to young people: Wayne says he can't say what will happen in the future but feels the trend of fewer range jobs in public agencies will make it more difficult for young people to get started. In times past there was a range conservationist on every ranger district, and now there may be only one per forest. This trend started some years ago but hasn't been changed around. He recognizes a great deal of the pressure stems from inadequate funding for range and cites a discussion he had before he retired when the operations officer suggested he get rid of his GS-11 assistant, a professional taxonomist, and hire two GS-3 or 4 people! He stated that kind of thinking really bothered him.

Regarding skills being taught, Wayne reflected that he did not know just what is being taught currently. He did cite the beneficial uses of remote sensing for vegetation as contrasted to the entire on-the-ground survey work he had to do. Ground truthing is still needed, he said, and he is concerned too much emphasis may be given to in-office work only. Fieldwork still is necessary for management.

Last thoughts: Wayne senses that the last several years of drought and the devastating fires have resulted in making the range more at risk. A series of better moisture years would be greatly beneficial. Sometimes we fault the government management agencies when weather conditions are the primary factor. However, he does cite an instance where he was able to spray the right chemicals to stop a spruce budworm outbreak on the Umatilla that helped vegetation stay healthier and be not so fire prone. That can't be done now, so management options are fewer and fire hazards more prevalent.

SRM Charter Member – George Rogler

Editor's Note: George Rogler lived at 1000 West Century Ave, Apt. 233, Bismarck, North Dakota 58503. George was 89 years old at the time. He had the question format and responded directly (ie, he wasn't asked the questions by Jon Hanson or Al Frank). Transcriber Tom Bedell has paraphrased a good deal of the responses. George passed away in 2003.

George feels there may be some things that SRM members would not know generally about the origins of the Society. He went to a meeting in Woodward, Oklahoma, in 1948 or perhaps 1947 where the discussion was starting of a professional range organization, as there was no such organization at that time. They talked about things that applied to range management and related activities. The next meeting was called by Kling Anderson at Kansas State University, and the first formal meeting was at Salt Lake City in 1948.

George grew up on a cattle ranch in the Kansas Flint Hills, 70 miles south of Manhattan. His father and brother piqued his interest in grasses and range management. George got a B.S. in general agronomy at Kansas State University. He went on to the University of Minnesota and studied genetics. He did not give details on his formal education except to say it was essentially range management or range-related.

Except for 1935 and 1936, when he was at Manhattan with the Bureau of Plant Industry, he has been at the Mandan Field Station, Bismarck, North Dakota, in research. George started working in the grass program at Mandan in 1936. He said he had essentially free rein to study grasses, as very little research was done before then. In 1941, with the advent of the retirement of J. R. Sarvis, George took over the range management project at the station. The experience he gained being raised on the ranch was instrumental in successfully managing that project. The Bureau of Plant Industry was a predecessor of the Agricultural Research Service–USDA. George said that at the time he took over the range work that there were only two people between him and the secretary of agriculture in line authority!

George, as mentioned, stayed at one location his entire career. He explains it this way. While at Manhattan, he found he was going to be transferred to Tucson, but he got a telegram informing him that the position was filled and would he go to Mandan. He didn't know anything about Mandan, but he said yes. So, as he says, he got married, and they packed up and went to Mandan, where he has been ever since. George retired from ARS in June 1973.

He became a member in 1948. He was unable to attend the first meeting at Salt Lake City but did go to the second one at Billings, Montana. Sections came along soon after the initial organization, and he has been a member of the Northern Great Plains Section all his life. He held several offices at one time or another but said the plaques on his wall should be used for reference since he has forgotten. The NGP Section has several chapters because of its large size.

Regarding expectations of range management when he joined in 1948, George believes there hasn't been nearly enough common sense utilized. He says there are some things that people overlook where common sense would have helped them to much better address the problems. In terms of application of practices, George feels that using more common sense and less science is desirable.

George believes that SRM is on the right track. He says he kind of loses track of some things, as he has been retired so long. There are a lot of fine and wise people in the SRM, and although he doesn't always agree, the differences are probably important. Again, he stresses the importance of experience and common sense when managing rangelands.

Lastly, George says there is much yet to be done, and encourages young people to enter the rangeland management field. He used the example of range production in the northern Plains area being enhanced with the proper use of fertilizers and believes this practice still should be pursued.

Jon and Al led a short discussion on the need for knowledge and experience, fires, and crested wheatgrass. George cited the necessity for knowledge on plant responses and the experience desired to use that knowledge. He cited the example that in 1936 a group from Washington, D.C., came to Mandan with the statement that the country is ruined. Dave Savage was with them and said, "Oh no it's not; these plants will come back." In 1938, George said it was like a garden of Eden. George worked actively for 40 years and remained as a consultant for an additional 19, resulting in 59 years with the USDA.

Using fire to manage vegetation purposely is valuable, especially in the Flint Hills, the Osage Mountains, and maybe even the sandhills under careful control. Forage plants green up and are available sooner in the spring, stock gain better, and invasion of woody plants is kept under control.

On crested wheatgrass, a subject dear to George's heart, he waxes eloquent. George spent a significant part of his research energy on development and use of crested wheatgrass. He is concerned that some people, in and out of range management, don't have the understanding and appreciation for created wheatgrass when managed properly. It greens up nearly a month ahead of native plants, is highly nutritious for cattle and other herbivores, makes good hay, and cattle can gain as much as 3 pounds per day. On the other hand, when it gets ahead of one, nutritional value is reduced as well as palatability, and gains may be low. George attempted to develop a hollow-stemmed cultivar but was not too successful. He was able to get some plants through selection but not enough on a practical scale.

Tom Bedell is a member and former chairman of the SRM History Committee and a member of the Pacific Northwest Section living in Philomath, Oregon.

*A*sk The Expert

Editor's Note: How often have you been faced with reading or hearing a topic that sounds interesting but do not quite understand some of the details. We have selected such a question and have had an expert on the topic provide an answer.

QUESTION:

What is integrated pest management?

RESPONSE:

A pest is defined as any organism judged to be a threat to humans or to their interests. Pests include certain insects, plants, animals, and pathogens. Integrated pest management is the coordinated use of tactics to maintain pest damage below economic levels while minimizing hazard to humans, animals, plants, and the environment. Effective integrated pest management programs rely on information and knowledge of the 1) biology and ecology of the pest, 2) biology and ecology of the host or plant community affected by the pest, 3) causes of pest invasion, 4) tactics available to manage the pest, and 5) benefits and risks of the integrated pest management strategy to agriculture and society. Preventing pest dispersal into new habitats and early detection of the pest invasion are critical to successful pest management programs.

Once a pest is discovered, there are several steps to developing an integrated pest management program. First, accurately identify the pest. Second, investigate and understand the biology and ecology of the pest and host or plant community. Third, conduct a survey to quantify the level of pest infestation. Fourth, determine if the pest is sufficiently abundant to require action. Fifth, evaluate available control tactics and select those that, when applied in the appropriate sequence and combination, yield the desired result. Sixth, continue to monitor and evaluate the pest population after the integrated management strategy is implemented and make adjustments as necessary to increase pest management efficacy.

On rangelands, unwanted plants or weeds tend to be the most common pests. Tactics to manage rangeland weeds include biological, cultural, mechanical, and chemical control technologies. Biological control of weeds is the planned use of living organisms to reduce a plant's reproductive capacity, abundance, and impact. Biological control can involve conservation, augmentation, or importation of natural enemies. Conservation involves manipulating the environment to enhance the effect of existing natural enemies of the weed. Augmentation is the repeated release of natural enemies and is usually restricted to managing weeds in high-value food crops because it requires large investments of time and money. Importation, also known as classical biological control, is the planned relocation of natural enemies of exotic or nonindigenous weeds from their native habitats onto weeds in habitats they invade. This strategy seeks to reestablish weed and natural enemy interactions that reduce the weed population to a desired level. Cultural practices include fire, grazing, revegetation or reseeding, and fertilization. These methods are aimed at providing a barrier to weed invasion by enhancing desirable vegetation. Mechanical treatments involve either removal of the aerial portions of the weed or removal of enough of the root and crown to suppress the plant. Chemical controls involve the application of pesticides to manage pest populations. Herbicides to control unwanted plants are probably the most commonly used pesticides on rangelands. Herbicides are classified according to their chemistry and mode of action and are usually selectively phytotoxic within certain rates of application, environmental conditions, and methods of application. Foliar-active herbicides are applied directly to the leaves or stems of plants, where they are absorbed and translocated within the plant. These herbicides may or may not remain active once moved into the soil. Soil-active herbicides are absorbed by the roots from the soil water solution and have a phytotoxic affect on susceptible plants. A successful and sustainable integrated pest management strategy involves careful consideration, selection, and application of appropriate control tactics in a mutually supportive manner that enables land management objectives to be met.

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If you have a question on a topic, please send a short note to: Rangelands Editor-in-Chief, 7820 Stag Hollow Rd, Loveland, Colorado 80538, or e-mail: gfrasier@aol.com. If selected, we will attempt to locate an expert for an answer and publish it in a future issue of Rangelands.

HIGHLIGHTS

Rangeland Ecology & Management, September 2005

Multiscale Detection of Sulfur Cinquefoil Using Aerial Photography

Bridgett J. Naylor, Bryan A. Endress, and Catherine G. Parks

Sulfur cinquefoil is an exotic perennial plant invading interior Pacific Northwest rangelands. Aerial photography was taken at 3 spatial scales to determine the effectiveness for detecting, monitoring, and mapping sulfur cinquefoil infestations. The accuracy of detecting infestations increased from small to large scale with nearly 77% of the cases correctly identified using 1:3,000 scale and nearly 60% at 1:12,000 scale. Although tree canopy can hinder detection, aerial photography is a valid tool for detecting infestation in open forests and rangelands.

Hyperspectral One-Meter-Resolution Remote Sensing in Yellowstone National Park, Wyoming: I. Forage Nutritional Values

Mustafa Mirik, Jack E. Norland, Robert L. Crabtree, and Mario E. Biondini

This study evaluated the ability of 1-m-resolution, hyperspectral remote sensing to estimate nitrogen, phosphorus, and neutral detergent fiber values from grassland, sagebrush, and riparian areas in Yellowstone National Park. Useable relationships for all nutrient components were found on an area basis, whereas poor relationships were found on a percent dry matter basis. These useable relationships can be applied to provide nutritional estimates over the whole image, which can be important in rangeland research and management.

Hyperspectral One-Meter-Resolution Remote Sensing in Yellowstone National Park, Wyoming: II. Biomass

Mustafa Mirik, Jack E. Norland, Robert L. Crabtree, and Mario E. Biondini

Hyperspectral remote sensing holds the promise to be an effective tool in estimating biomass on rangelands. This study evaluated the ability of 1-m-resolution, hyperspectral imagery to estimate biomass from grassland, sagebrush, and riparian areas in Yellowstone National Park. Useable relationships between ground samples and the hyperspectral imagery were found for total biomass in all vegetation types and for willows, sedges, litter, and grasses found in dryer areas. Poor relationships were found for sagebrush and forb biomass. These useable relationships can be a tool for generating biomass estimates for the whole image, which could be useful in rangeland research and management.

Demography of Grazed Tussock Grass Populations in Patagonia

Gabriel Oliva, Marta Collantes, and Gervasio Humano

Tussock grasslands of *Festuca gracillima* in the Magellanic region of south Patagonia are slowly being replaced by dwarf shrublands under continuous sheep grazing. Tussock were counted from photographic maps obtained over a decade, and demographic matrix models were calculated. Our results indicate that grazing modifies demographic processes in a slow and persistent way, changing the size structure of the population and patch structure of the grassland over a timescale of decades. These changes may not be perceptible for range managers until the population has been affected. Moderate stocking rates seem to be a management option to slow down, but not to stop, the process.

Poplar Afforestation Effects on Grassland Structure and Composition in the Flooding Pampas

M. del Pilar Clavijo, Marisa Nordenstahl, Pedro E. Gundel, and Esteban G. Jobbágy

Planting winter deciduous trees for timber production on mixed (C3–C4) grasslands could benefit ranching systems in the Pampas if cold-season grasses were promoted. Yet, it can threaten biodiversity through local extinctions and invasions. These possible effects were evaluated using 9 poplar plantations and adjacent nonafforested grasslands. With almost half total herbaceous plant cover, afforested stands had a higher proportion of C3 grasses in their understory. Little evidence of local extinctions or invasions with afforestation was found. Deciduous tree plantations in the study region host a good forage source in their understory that could complement nonafforested natural grasslands in quality and seasonality.

Creating Weed-Resistant Plant Communities Using Niche-Differentiated Nonnative Species

R.L. Sheley and M.F. Carpinelli

Invasive plant management that continues may require creating and maintaining weed-resistant plant communities. We tested whether spotted knapweed invasion was limited as the richness of desired nonnative species increased on low- and high-producing sites. These species occupied different niches. Although less important on productive sites, increasing niche occupation by nonnative desired species may increase resource use and productivity, thus minimizing the establishment of unwanted weeds during rehabilitation of marginally productive rangeland.

Heifer Performance Under Two Stocking Rates on Fourwing Saltbush-Dominated Rangeland

Justin D. Derner and Richard H. Hart

Use of rangeland dominated by fourwing saltbush (*Atriplex canescens*) during the winter season may be an alternative for livestock producers instead of providing supplemental feedstuffs, but there is a lack of information concerning stocking rates and animal gains. Yearling heifers had a greater gain per head per day with light, compared with moderate, stocking rates when grazing in late fall or early spring, but gain per unit land area was similar for both stocking rates. Land managers with rangeland containing fourwing saltbush should consider using these pastures during the late fall or early spring using light stocking rates.

Heifer Production on Rangeland and Seeded Forages in the Northern Great Plains

M.R. Haferkamp, M.D. MacNeil, E.E. Grings, and K.D. Klement

Pastures of perennial cool-season grasses can be used to reduce grazing pressure on native rangelands and to provide quality forage for livestock during selected seasons. We compared performance of yearling heifers grazing seeded forages in spring and autumn to those grazing native Northern Great Plains rangelands. Findings show seasonal gains may be better on seeded pastures than on native rangeland, but early spring gains may not be maintained when cattle are moved from seeded pastures to native rangeland for the summer grazing season. Livestock managers may need to modify their tactics to take full advantage of increased gains on seeded pastures.

Forage Production and Quality of a Mixed-Grass Rangeland Interseeded With *Medicago sativa* ssp. *falcata*

Matthew C. Mortenson, Gerald E. Schuman, Lachlan J. Ingram, Venerand Nayigihugu, and Bret W. Hess

Enhancing forage production and forage quality for livestock on rangelands has been a goal for decades. We examined the long-term effects of interseeding yellow-flowered alfalfa (*Medicago sativa* ssp. *falcata)* in a northern mixed-grass prairie on forage production and quality. Forage production increased by 82% with interseeding, and forage quality increased in many of the native species due to the nitrogen fixed by the alfalfa compared with the untreated native rangeland control sites. This research showed that interseeding yellow-flowered alfalfa into rangelands is sustainable over decades and will increase forage production and forage nutritive value on rangelands in the Northern Great Plains.

Evaluation of California's Rangeland Water Quality Education Program

Stephanie Larson, Kelly Smith, David Lewis, John Harper, and Melvin George

The prospect of increased regulations to reduce nonpoint source pollution associated with rangelands and ranching prompted California's range livestock industry to implement a voluntary program of water quality assessment and pollution prevention. University of California Cooperative Extension and USDA Natural Resources Conservation Service implemented a ranch water quality–planning short course to help rangeland owners understand nonpoint pollution, identify potential sources, and develop water quality plans for their properties. A survey of short course participants demonstrated that a voluntary industry-initiated program can increase implementation of management practices addressing water quality and can be a successful alternative to state regulation.

Quantifying Declines in Livestock Due to Land Subdivision

Randall B. Boone, Shauna B. BurnSilver, Philip K. Thornton, Jeffrey S. Worden, and Kathleen A. Galvin

Landscape subdivision is ongoing in group ranches of Kajiado district, Kenya, and limits movements of pastoral livestock. Livestock unable to access a variety of forage patches may not find sufficient food. We used ecosystem modeling to quantify changes in livestock populations under subdivision. In a group ranch of moderate productivity and habitat variability, subdivision down to 1-km^2 parcels led to a 25% decline in livestock supported. Declines did not occur as the most productive group ranch was subdivided. Responses to subdivision differ across group ranches, but in most areas, parcel owners should maintain open access to lands.

Long-Term Successional Trends Following Western Juniper Cutting

Jon D. Bates, Richard F. Miller, and Tony Svejcar

Studies reporting understory response following pinyon-juniper control have been limited to early successional stages. This study assessed successional dynamics spanning 13 years following cutting in a western juniper woodland. Herbaceous standing crop and cover did not change after the 5th year posttreatment; however, significant compositional shifts occurred, highlighted by a continued increase in perennial grasses, whereas annual grasses decreased through the 13th year posttreatment. Shifts in herbaceous composition across years suggests that long-term monitoring is important for evaluating plant community response to juniper control and to develop appropriate posttreatment management strategies to promote continued site improvement.

Economics of Western Juniper Control in Central Oregon

Gwendolyn A. Aldrich, John A. Tanaka, Richard M. Adams, and John C. Buckhouse

Distribution of western juniper (*Juniperus occidentalis*) is expanding with resulting management and environmental issues. We developed a model to evaluate the economically optimal juniper control methods for different sizes of ranches and under different conditions. We found that the type and mix of control methods used depend on site productivity and the ranching operation, and that factors like erosion and wildlife populations will be affected differently. As land managers decide on a course of action, and if other resource values are deemed important, this model is one tool for assisting in that decision.

Research Note: Timing of Vegetation Sampling at Greater Sage-Grouse Nests

Doris Hausleitner, Kerry P. Reese, and Anthony D. Apa

Habitat management guidelines for greater sage-grouse (*Centrocercus urophasianus*) nest sites based on vegetation studies at the nests may not represent the conditions when the female initiates nesting because sampling occurs 30 days after nest initiation, which is after the eggs hatch. We investigated differences in 22 habitat variables at initiation and at hatch by sampling 30 randomly selected nests marked 1 year earlier. Results suggested some structural variables (sagebrush cover, visual obstruction, nest shrub height, and forb, bare ground, grass, and litter cover) can be measured throughout incubation to describe nest sites at initiation; however, grass cover and height should be assessed at nest initiation.

Technical Note: A Laser Point Frame to Measure Cover

L.K. VanAmburg, D.T. Booth, M.A. Weltz, and M.J. Trlica

Collecting point data, such as ground cover, using a conventional point frame is tedious and time consuming. We tested a point frame using lasers in place of conventional metal pins and found data could be collected faster. Correlations between cover data from a conventional frame and the laser point frame (LPF) were acceptably high (r = 0.67–0.81). We conclude that the use of the LPF has the potential to reduce the cost of data collection; however, we recommend further testing to confirm the apparent LPF advantage and to assess the relative accuracy of the LPF. ◆

Saving the Ranch. Conservation Easement Design in the American West. By Anthony Anella and John B. Wright. Photographs by Edward Ranney. 2004. Island Press, Washington, D.C. 176 p. US$60.00. ISBN 1-55963-741-2.

The picture of the American West—the open range, the sweeping domain of the solitary rancher who tends to his stock and ekes out a noble living through hard work and determination—is fading. The ranching industry is evolving on pace with the rest of the mechanized world. Large corporations are taking the place of the small-scale operator.

One loss that results from this restructuring of the industry is the consequential restructuring of the landscape. As small ranchers are unable to compete with consolidated corporations in terms of production, they must now look to other options to survive. For most ranchers, the most profitable option is to sell their land to developers who supply the demand of the public to possess their own piece of the American West. The outcome is that the landscape is slowly being transformed from open range to subdivided residential areas.

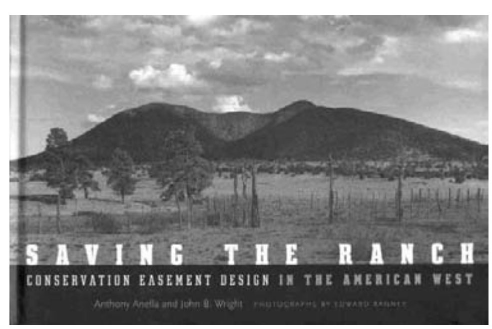
Saving the Ranch gives ranchers another economically feasible option. This book examines conservation easements as a way for individual ranchers to access the inherent value of their land rather than only the production value. *Saving the Ranch* is presented as a comprehensive, step-by-step guide for ranchers to explore and set up a conservation easement on their property. It clearly outlines the process from start to finish, addressing all issues along the way, including hiring advisors and financial analysis, including tax planning. It provides a question-and-answer chapter that tackles common questions that may arise. It also includes many case studies that detail the actual design and implementation of conservation easements on actual ranches. The last section of the book includes a real model of an actual deed of conservation easement.

The straightforward and practical manner in which this book is organized and presented is its biggest asset. Rather than extolling the social and moral responsibility issues involved with conservation, it presents the idea of easements as an economic commodity rather than as a restriction to business. In this way, the book reaches its audience effectively. The authors successfully present the concept of conservation easements through the use of real examples and by portraying the issue in concrete terms rather than as just an abstract idea.

The striking black-and-white photographs of ranchland buttress the authors' message of preserving the open landscape of the West. They also reinforce the real-world value of considering and using the land as a commodity in itself.

Saving the Ranch is a useful resource in educating ranchers in an important option that might be an alternative to subdividing their land. Its simple yet detailed approach to the issue of conservation easements should help ranchers keep the picture of the American West from vanishing.

Erien Preus, Washington State University, Pullman, Washington. ◆



BOOK REVIEW

Short of a Good Promise. By William Vern Studebaker. 1999. Washington State University Press, Pullman, Washington. 163 p. US$16.50 paperback. ISBN 0-87422-181-1.

The setting for William Studebaker's family biography, *Short of a Good Promise,* is in the backwoods of southern Idaho. Studebaker's story of his parents and grandparents is set in a scenic landscape of hopeful dreams, promise, and newly established farmland of the Northwest. The author recalls childhood memories of growing up in an old folks' home and encountering situations and experiences that bring to light the expansion of urban life in the area.

First, Mr Studebaker tells of his grandparent's life and how they traveled west to Idaho to farm and raise a family in the vast expanses of the new territory. His grandfather on his mother's side owned and operated an old folks' home south of Salmon, Idaho. Studebaker recalls the tenants that resided there and how his encounters with a blind fiddle player taught him lessons of life. Among his adventures in the big house, as they called it, he remembers cooking in the industrial kitchen with his grandmother and recalls the stories she would tell. His grandmother did not live with his grandfather, and their marriage was awful. She recalls seeing many different mistresses entering his office throughout the day and did nothing to confront him about his extramarital affairs. Later, they would divorce, and his grandmother would bury his body in the cemetery alongside those of the girlfriends and the mistress he had been in a car accident with.

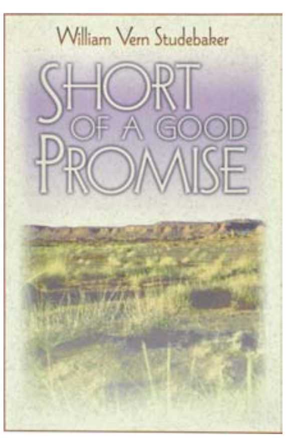
The divorce, as Studebaker recalls, was mostly due to the size of his grandmother. She was very heavy and Studebaker conveys to the reader her massive weight through a memory in which they took her to the grain company to weigh her because the doctor's scale topped out at 250 pounds. It was a degrading situation. The whole town crowded around the scale to witness the big event.

In Part II, Studebaker acquaints us with the life and times he shared with his father's parents. Yellow Jacket, Idaho, was the scene for his winter life in the snow-capped mountains. Here, his grandparents owned a ranch where they raised horses and cattle. Later, these horses would have life-altering consequences for his family through riding and handling accidents. The author's little brother is kicked in the head by a horse. They traveled 10 miles to the nearest town, then were flown to Montana, where he was pronounced dead, although the doctors continued to try to revive him in a desperate attempt to save his life.

The story of his grandparents is short as he transitions into his life with his parents. His father was a fire watcher in the summer, where he would board both himself and his entire family in a cabin at the highest peak of the range. Here, Mr Studebaker remembers how their family was miles away from anyone else, and all cuts and scrapes were tended by his mother, who was skilled at homemaking.

Studebaker combines his childhood memories with those of his parents in this thoughtfully written book. The descriptions of life in the southern Idaho valley put the reader right in Salmon, living in a one-room farm house. The details are notable for someone who has gone back 3 generations to tell the story of his family and how they made lives for themselves in a changing world. *Short of a Good Promise* is an uplifting book that will prove entertaining for readers of any age.

Kit Watson, Washington State University, Pullman, Washington. ◆



BOOK REVIEW

Diet for a Dead Planet: How the Food Industry Is Killing Us. By Christopher D. Cook. 2004. The New Press, New York. 326 p. US $24.95 hardbound. ISBN 1-56584-864-0.

The most eye-catching feature about Christopher Cook's book *Diet for a Dead Planet* is the vivid, pea-green cover with a white skull and crossbones on the front. Only, instead of crossed bones, it has a crossed knife and fork. The simple yet dramatically done cover is an appropriate representation for how Cook feels about the current food industry in the United States, and it is effective at grabbing a potential reader's attention. On page 11, Cook states that the "one underlying purpose of this book, is to lay bare these connections [between food consumption and production] to stimulate thinking and encourage action." Cook does an admirable job of meeting this goal. *Diet for a Dead Planet* is effective at inspiring thought and is also a reasonably thorough introduction to the issues faced by agriculture today.

The book is divided into 3 parts, with each part containing 4 or 5 chapters. Part 1 is titled "Consumed," and contains chapters 1 to 4, which cover a range of topics including consumer choices, Wal-Mart, animal-borne diseases like mad cow disease, and food-borne diseases like salmonella. The second part, titled "The Rise of the Corporate Cornucopia," contains chapters 5 to 8 and covers the history of agribusiness and technology. The third and final section, "Recipes for Disaster" (chapters 9–13), wraps up the book with a discussion about the environmental effects of agriculture, the abuses of food service workers and immigrant workers, and the Rachel Carson era and the subsequent creation of the various environmental protection policies like the Clean Air Act and the Clean Water Act.

Part 1 of the book is slightly confusing because it covers many different topics. At times it proved difficult reading because there wasn't any real connecting thread between the chapters to lead from one topic to the next. In chapter 1, Cook gives an overview of the issues he will be covering throughout the book, and he also states what he hopes to accomplish by the end of the book. Chapter 2 is about the politics and policies behind food pricing, supermarkets, and major food supply corporations like Wal-Mart. Chapter 2 also covers food availability and consumption patterns of the public. Chapter 3 focuses on livestock diseases like bovine spongiform encephalopathy (BSE), or mad cow disease; the avian flu virus; the elevated toxins in seafood; and how these problems come to exist within our food supply. Chapter 4 discusses how a process called *bacterial blowback* is increasing the frequency and deadliness of food-borne bacterial outbreaks while at the same time decreasing our ability to treat these outbreaks with antibiotics.

Part 2 of the book is a more cohesive section, as all the chapters are in chronological order and cover the history and development of agriculture in America. Chapter 5 covers President Nixon and his farm bill, the addition of the American food supply to the global market, the Homestead Act, the Civil War, and how these events have led to the conversion of farming from a singular occupation into a modern business. My favorite quotation of the book is in a section on page 94 from a farmer's refrain that reads, "The guys who farm farmers are the ones who get the spoil." Chapter 6 covers the Dust Bowl, farming techniques, and the use of biocides. One of the more thought-inspiring quotations is on page 102, where Cook states, "Many pesticide formulations had started out as nerve agents perfected by the Nazis." The effects of these pesticides are still being realized and are among the major environmental issues discussed in part 3 of the book. Chapter 7 covers mainly the "classic boom-bust cycle" of agriculture and the unexpected societal effects of the loss of the small farmer. Chapter 8 examines the top 3 companies in agriculture (Cargill, ConAgra, and ADM), genetically modified organisms (GMOs), and the green revolution. Also, this chapter discusses how the GMOs and the green revolution have resulted in a complete loss of what little bargaining power farmers previously had at the negotiating table. The result of the power loss is that the food supply chain in America from seed to the dinner table is now owned by a few select companies.

Part 3 effectively analyzes most of the environmental effects of our food industry and consumption choices of the public, but it covered these issues so briefly that it is difficult to understand just how big and controversial some of the issues are. Despite the brevity of the discussion about the environmental issues, the discussion about the exploitation of immigrants and food service workers is informative and thought provoking. Chapter 9 explains the effects and use of biocides and states that even before the use of biocides, we had a problem with overproduction in America. Chapter 10 examines the high levels of air and water pollution that occur from the high concentration of animals in the animal feedlots. Chapter 11 examines the food workers and immigrants and the Direct Job Placement program instituted by some welfare programs. Chapter 12 gives a more in-depth discussion of the Dust Bowl with a new focus on the farming subsidies, surplus policies, and price controls created by the federal government. It also discusses how these policies were used on both local and global food markets. In the final chapter, 13, Cook ends with a discussion of the potential solutions to these problems, some of which are already being implemented on small scales, and considers what we need to do to implement changes on a larger scale.

Diet for a Dead Planet is interesting reading for anyone wanting to know more about the food they eat and how their choices as consumers can affect farmers, our society, and the environment. The book provides a solid introduction to the issues, some potential solutions, and what is currently being done to address some of the problems. The book is aimed at the general public rather than at scientists or specialists in the subject. Cook is an investigative journalist who focuses mainly on people and politics, so his book approaches the arguments mainly from a more humanist-political perspective. The discussions about the effects of agriculture on humans, such as those on the food service workers, are strong and arresting arguments. However, the discussions about the environmental effects and animal abuse are superficial, and these sections read less intensely. These issues therefore come off as weaker, lesser interests and imply to the reader that they aren't as important. The book would be more interesting and balanced if an environmentalist or animal rights activist viewpoint had been effectively incorporated into the parts of the book related to these issues. A slightly more balanced approach to some of his arguments would have beefed up some of the weaker sections and increased the impact of the arguments. Ultimately, though, because Cook's discussions of the issues are successful at inspiring thought and the need for action, I would recommend this book to all.

Holly Bowers, Washington State University, Pullman, Washington. ◆

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