CHEATGRASS CONTROL AND SEEDING

James A. Young and Charlie D. Clements

Currently, there is a rebirth of interest in using herbicides to control the invasive annual cheatgrass in conjunction with seeding perennial grasses, forbs, and shrubs to restore what once were big sagebrush/bunchgrass plant communities. This work is being conducted by a new generation of range scientists who may benefit from knowledge of how some of the basic principles of herbaceous range weed control were established.

This is a brief account of the development of several of the basic principles of herbaceous range weed control conducted in conjunction with seeding perennial grasses. It is the story of the accomplishments of three quality range scientists: Richard E. Eckert, Jr. and Raymond A. Evans of USDA, Agricultural Research Service (ARS) and Burgess L. Kay of the University of California.

The Cast of Players

Evans, Eckert and Kay started working together in the late 1950s. They came from diverse backgrounds and educational experiences. B. L. Kay was a graduate of the School of Forestry of the University of California at Berkeley. He was a range weed control and seeding specialist with the California Agricultural Extension Service at Davis. R. A. Evans received his Ph.D. from the botany department at the University of California at Berkeley. His dissertation was about seedling competition among annual range plants. He worked for the California Soil and Vegetation Survey before joining the ARS at Reno, Nevada. R. E. Eckert, Jr. received his Ph.D. in range science at Oregon State University where his dissertation concerned soil and vegetation relations in the high deserts of eastern Oregon. Previously, he completed a masters of science degree at the University of Nevada, working on winterfat communities and halogeton invasion.

These three conducted cooperative research in California and Nevada. Occasionally, they disagreed, rarely they fought, and for over 30 years they developed revegetation technology for rangelands. Their research effort defined the ecological principles of herbaceous range weed control. They built on the generation that preceded them and left a legacy for those that followed.

Setting the Environmental Stage

Perhaps, the first range scientist to state the most basic aspects of range weed control and seeding was Arthur Sampson working in the Wallowa Mountains of Oregon in 1907. He was not very successful in trying to seed degraded rangelands because of the limited choice of plant material available, but he had the vision to define the nature of the problem.

The basics of seeding degraded big sagebrush/bunchgrass to crested wheatgrass were developed by USDA, Forest Service scientists during World War II. The post war years brought a tremendous increase in rangeland seeding as a result of programs to suppress the poisonous weed halogeton. These efforts were highly successful, but most of the early seedings were established in degraded sagebrush sites where cheatgrass was not a problem. What principles did these initial trials conducted by scientists such as Joe Robertson, A. C. Hull. Jerry Klomp, or A. Perry Plummer establish (Table 1)? These points seem ridiculously simple, but at the time many seedings were lost to continuous grazing during the seedling year.

Table 1. Principles of seeding degraded big sagebrush/bunchgrass ranges with perennial grasses that were developed by the initial group of range scientists working in this area.

1. Tillage was necessary for control of big sagebrush. Disk plowing with wheatland type plows was used until the rangeland plow was developed.
2. The better the seedbed preparation, the better the chances of seedling establishment. Rough, trash covered seedbeds that resulted from plowing were a problem.
3. The seedling stands had to be protected from grazing until after seed ripe the second year after seeding.
4. If the seedings were protected by fencing, water development was required before they could be utilized.

Most of the early crested wheatgrass seedings in the Great Basin were established by plowing degraded big sagebrush stands. One exception to the requirement for mechanical tillage to control big sagebrush was the seeding of areas burned in wildfires. Prescribed burning, followed by seeding was not extensively practiced during the 1940s because of lack of herbaceous vegetation to carry fires. If there was enough native perennial vegetation to carry a fire, seeding was not necessary.

Gradually range managers reported seeding failures when they tried to seed degraded sagebrush ranges that were infested with the exotic pest cheatgrass. J. H. Robertson, in the early 1940s, determined that cheatgrass dominated plant communities were closed to the recruitment of perennial grass seedlings because of competition for moisture. Robertson became a professor of range science at the University of Nevada where he was the mentor of R. E. Eckert during his Masters of Science program.

B. L. Kay worked on the complex annual-dominated communities on the west of the Sierra Nevada where his aim was to establish annual legumes. Raymond Evans was familiar with the research being conducted by B. L. Kay and both cooperated with C. M. McKell when he was an ARS scientist stationed on the University of California, Davis campus.

First Rangeland Herbicides

The phenoxy herbicides had been discovered during World War II and such materials as 2,4-D found numerous applications in agriculture in the immediate post war years. Range scientists such as Don Hyder and A. C. Hull were quick to discover that 2,4-D could be used to reduce competition from over abundant woody species. Big sagebrush control was widely practiced in the Intermountain Area with 2,4-D applications. The early range herbicidal weed control scientist soon determined that it was useless to control sagebrush unless there were sufficient remnant perennial grasses to occupy the environmental potential released by killing the woody species. The standard for predicting the success of a herbicide application became, "You had to be able to step from one remnant perennial grass to the next for the brush control to be successful." Obviously, short range legged conservationists were at a disadvantage, but the general concept was valid.

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Halogeton was the major issue in range management in the Intermountain Area in the 1940s and 1950s. The herbicide 2,4-D was proposed and tried for the control of the poisonous exotic annual halogeton. The herbicide is a physiologically selective material in that when applied at proper rates it will kill broadleaf plants and not injure grasses. In the case of halogeton control it was not selective when applied to salt desert shrub communities infested with the poisonous weed. Although it readily killed halogeton it also killed the native broadleaf shrubs, creating more habitat for halogeton in subsequent years. In salt desert plant communities, the hazards of applying 2,4-D to halogeton infestations was exasperated by the lack of adapted plant material to revegetate areas where halogeton was controlled. You have to close the ecological near voids created by weed control treatments on rangelands with desirable plants. This applies to all types of weed control practices from mechanical, through herbicidal, and includes biological control.

Evans, Eckert and Kay used screen boxes to exclude cheatgrass seeds in an effort to determine the extent and nature of seedbank on sagebrush rangelands.

Evans, Eckert, and Kay were faced with a very challenging weed control problem. They wanted to control an annual grass, cheatgrass, and replace it with seedlings of a perennial grass.

New herbicide formulations were proliferating rapidly in the 1950s, but truly physiologically selective material never became available for cheatgrass control. Researchers turned to herbicides that killed cheatgrass and would also kill perennial grass seedlings. To make weed control systems work with such herbicides, they would delay seeding until phytotoxic residues of the herbicide were dissipated.

Seedbed Ecology of Annual Grasses

It became apparent that cheatgrass builds a large seedbank that contains 2 or 3 times as many viable seeds as the current years population of plants. A herbicide was never developed that killed dormant seeds in the seedbank. Control measures had to be applied after at least a portion of the seedbank had germinated or a herbicide had to be used that maintained herbicidal activity in the soil for a long period of time, killing the annual grass seedlings as they emerged.

The dynamics of germination and seedling establishment of annual grasses on rangelands put further constraints on the development of herbicidal control and revegetation treatments. In California annual grasslands, germination occurs with the first effective rain in the early fall. The first species to germinate and establish, gain initial dominance until the taller growing grasses win the competition for light. An effective herbicide must kill the emerging annual grass and broadleaf seedlings and leave no residue so seeding of forage species can follow immediately. If seeding is delayed until late in the fall it will be too cold for seedling growth of the revegetation species. In cheatgrass communities in the Intermountain Area, some germination can occur in the fall, but often the bulk of germination occurs in the very early spring. Again timing is of the essence. You have to wait until the cheatgrass emerges, control it with a herbicide, and get the seeds of the forage species to germinate, emerge, and establish before the onset of the summer drought.

Paraquat

The discovery of the herbicide paraquat in England and its subsequent development in the United States offered a new potential for herbaceous range weed control. Paraquat was a broad spectrum herbicide that killed most annual weeds upon on contact. The unique aspect of paraquat was that it was deactivated upon contact with the soil. This meant that herbicide application and seeding could be done simultaneously. For use on the California annual range, B. L. Kay installed a sprayer on a modified rangeland drill. Because in this environment competition was for light instead of primarily moisture, he successfully experimented with spraying bands directly over

In well established cheatgrass stands seedling density can reach 1,000 plants per square foot.

the drill row to reduce the cost of herbicide applied. For cheatgrass in the Intermountain Area, Evans and Eckert found that only broadcast spraying gave sufficient reduction in cheatgrass to allow for perennial grass seedling establishment.

In well established cheatgrass stands seedling density can reach 1,000 plants per square foot. In a pioneer competition study, R. A. Evans determined that cheatgrass densities from 64 to 256 per square foot severely decreased seedling growth of crested wheatgrass. Cheatgrass densities as low as 4 plants per square foot were detrimental to crested wheatgrass establishment. This study provided a guideline for the level of weed control that was required in the field. This was confirmed in the field in the studies where Evans and Eckert compared band and broadcast application of paraquat.

The paraquat technique became popular on the California annual ranges for establishment of annual legumes, but never was widely used in the Intermountain Area for cheatgrass control. There were several interacting reasons for lack of popularity for cheatgrass control. First was a general lack of interest by public land management agencies in the application of herbicides. Secondly, paraquat was never consistently aerially applied for cheatgrass control under Intermountain conditions. The final blow to paraquat was the discovery of its high mammalian toxicity (for a herbicide). Paraquat became a restricted use pesticide.

Chemical Fallow

Paraquat application with simultaneous spring seeding was a substitute for light disking or harrowing to reduce competition before planting. Chemical or herbicidal fallows are a substitute mechanical tillage to allow land to lie in a weed free fallow for a growing season before planting. Fallows are widely used in cereal grain production. Besides providing weed control, the fallow period stores moisture and nitrate for use by the subsequent planting.

The advantage of a herbicidal fallow is the weed control procedure can be applied aerially over soil surfaces and topography that make mechanical tillage impossible. The system proved to be very successful for the cheatgrass ranges of the Intermountain Area.

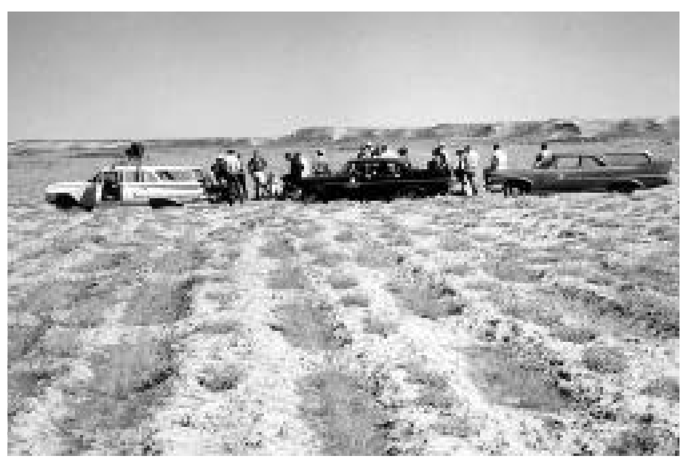
Evans and Eckert tried virtually all the available herbicides that had soil activity. These are herbicides that plants picked up through their roots rather than their leaves. This allows the herbicide to be applied before cheatgrass germinates (preemergence) and still kill the annual grass. Their two main evaluation criteria were: 1) the spectrum of control be broad enough to kill virtually all cheatgrass and associated annual species at an economical rate, and 2) the herbicidal active residue be gone by 1 year after application. Based on extensive trials they selected the herbicide atrazine applied at the rate of 1 pound per acre active ingredient. Atrazine was applied in the fall (October through November), the treated area was fallow the next growing season, and then seeded to perennial wheatgrasses the following October.

Successful large scale seeding in Nevada where a herbicidal fallow technique was used to suppress cheatgrass.

Evans, Eckert and Kay did not work in a vacuum. Harold Alley was very active in the field in Wyoming. Range Weed meetings and tours were sponsored every 2 years by the USDI, Bureau of Land Management where ideas were shared among researchers and land managers. Many land managers experimented with weed control-revegetation techniques. Herbicide manufacturing provided input through quality scientists such as M. D. Christensen who made valuable contributions to the success of the techniques.

Seedbed Quality

Eckert and Evans made the atrazine fallow technique work and fine tuned the process by understanding why the system was so effective. Atrazine is a very insoluble material that



Rangeland weed control and seeding tours were jointly sponsored by research and land management agencies during the 1960s and 1970s as a means of informing researchers about the needs of managers and for transferring the latest research information. Range weed tour near Worling, Wyoming attended by Ray Evans, B. L. Kay and Gerry Klomp in the early 1960s.

Ray Evans and Dick Eckert determined through micro-environ - mental monitoring that small furrows greatly enhanced the estab - lishment of wheatgrass seedlings.

As soon as electronic temperature, moisture, and relative humid - ity sensors became available, Evans, Eckert and Kay built from scratch data recorders that would operate at remote locations using batteries for power. They used this data to define the parameters of field seedbeds on both Intermountain and California annual domi - nated rangelands.

stays very close to the soil surface where the cheatgrass seedbank was located. Atrazine did not kill un-germinated, but viable cheatgrass seeds. The researchers consistently obtained better stands by seeding at the bottom of small furrows. This built on the research of William McGinnies that showed the favorable micro-environment for germination and seedling establishment that furrows created. In the case of atrazine fallows the furrowing action pushed any herbicide residues to the side, away from the planted wheatgrass seeds. The same action also moved the cheatgrass seedbank to the side.

There was virtually no cheatgrass competition in the seedling year of the perennial wheatgrass planting. There were still plenty of viable cheatgrass seeds in the surface soil seedbank, but they could not germinate because during the fallow year the thin skiff of cheatgrass litter had decayed or blown away leaving the seeds in a seedbed environment that was outside their inherent potential to germinate. The finding that the herbicidal fallow created a physical change in the seedbed that limited germination of the weed is among the most significant of Evans, Eckert and Kay's contribution to range science. The cheatgrass germination limiting aspect of the treatment is even more astounding when you consider that nitrate accumulations during the fallow help to break the dormancy of cheat-

Ray Evans (extreme left) and Dick Eckert (extreme right) reviewing with land managers (unidentified) the success of a 1,000 acre experimental plot in northern Nevada where cheatgrass was controlled with atrazine and perennial grasses established.

grass seeds in the seedbank making more seeds available if they were in an environment that permitted germination.

Fate of the Paraquat and Atrazine Methods

Eckert and Evans conducted cooperative atrazine weed control-revegetation trials with land management agencies where a single experiment was over 1,000 acres in extent. The experiments featured aerial application of the herbicide and the use of specially modified rangeland drills. The trials were uniformly successful.

Evans, Eckert. and Kay were instrumental in collecting the myriad of data that was necessary for the registration of paraquat and atrazine for use on rangelands for cheatgrass and other annual species control. Their innovative methods were outstanding, their interpretations of why systems worked was brilliant, but their timing was terrible. By the time their herbicide techniques were perfected in the mid-1960s the public land management agencies turned completely away from range improvement. The cheatgrass problem could be solved through grazing management systems. The requirements of new environmental laws made it impossible to apply pesticides without a prolonged environmental review process.

As previously mentioned, paraquat was found to be dangerous to handle and apply so it became a restricted use material. By the time it was necessary to renew the registration for the use of atrazine on rangelands it to was a restricted use pesticide because of problems with water contamination in the mid-west. These water problems are real, but they occurred in a humid environment where over 10 pounds per acre atrazine was applied annually to cropland for over 2 decades. The proposed range usage was 1 pound per acre and this was to be applied once only. At the time of registration renewal, atrazine was no longer a proprietary product. The original patent had expired. The current manufacturers looked at the record of rangeland sales and could not determine any potential for profit in the field so the registrations were not renewed.

The Future of Herbaceous Range Weed Control

The extent of cheatgrass dominance of former sagebrush/bunchgrass rangelands has grown to such a huge problem that the general public is demanding that public land management agencies do something to stop the endless cycles of destructive wildfires. A new generation of herbicides is being experimented with by a new generation of scientists and land managers. The previous generations of scientists such as B. L. Kay, R. A. Evans, and R. E. Eckert, Jr. did not evolve all the answers for cheatgrass control and revegetation, but their awesome legacy of knowledge should not be ignored.

Suggested Reading

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Authors are with the USDA-ARS, 920 Valley Road, Reno, Nevada 89512.