Interior Columbia Basin
Ecosystem Management Project
Science Integration Team
Terrestrial Staff
Range Task Group

Scientific Contract Report

Preface

The following report was prepared by University scientists through cooperative agreement, project science staff, or contractors as part of the ongoing efforts of the Interior Columbia Basin Ecosystem Management Project, co-managed by the U.S. Forest Service and the Bureau of Land Management. It was prepared for the express purpose of compiling information, reviewing available literature, researching topics related to ecosystems within the Interior Columbia Basin, or exploring relationships among biophysical and economic/social resources.

This report has been reviewed by agency scientists as part of the ongoing ecosystem project. The report may be cited within the primary products produced by the project or it may have served its purposes by furthering our understanding of complex resource issues within the Basin. This report may become the basis for scientific journal articles or technical reports by the USDA Forest Service or USDI Bureau of Land Management. The attached report has not been through all the steps appropriate to final publishing as either a scientific journal article or a technical report.

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Robert R. Kindschy
Certified Wildlife Biologist
1765 Second Ave. W.
Vale, OR 97918
503-473-2590

EASTSIDE ECOSYSTEM MANAGEMENT PROJECT
112 East Poplar Street
Walla Walla, WA 99362-1693

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PART TWO: **CRESTED WHEATGRASS IN THE ECOSYSTEM**

In 1897-1898, Professor N.E. Hansen from South Dakota was sent to Russia as a special agent for the Division of Botany in the U.S. Department of Agriculture. He was charged to secure seeds and plants valuable for a variety of purposes. Among 70 forage plants collected were seeds of crested wheatgrass, Agropyron desertorum and A. cristatum (Sharp 1986). Later, about 1906, a second introduction of crested wheatgrass from the same areas as the first was distributed to various experiment stations (Dillman 1946).

Crested wheatgrass has long been the major grass species used in rangeland improvement and rehabilitation projects in western North America. Its many favorable agronomic, forage and ecologic qualities have made it the grass of choice, although reservations about its widespread use have arisen in recent years (Johnson 1986).

In the opinion of many rangeland managers, scientists and educators, crested wheatgrass may be the most important range grass in North America, having played a larger role in the management of Great Plains and Intermountain rangelands over the past 50 years than any other grass.

In becoming established in the Intermountain West, crested wheatgrass has replaced a predecessor in many locations that suffers great stress under even relatively light defoliation. Yet that predecessor, bluebunch wheatgrass [Pseudoroegneria spicata (Agropyron spicatum)] is generally held in much higher ecological esteem (Dwyer 1986).

Economically and ecologically astounding by most measures, crested wheatgrass produces from 3 to 20 times the forage of so-called native plants it has been called on to replace. It sustains productivity surprisingly well under heavy and long or even continual grazing, much to the surprise of most early range ecologists (Dwyer 1986).

Because crested wheatgrass evolved in an environment where heavy grazing has occurred for centuries, it is well adapted to early and close defoliation. This is not true of most native cool season grasses of the West. This characteristic was of special importance in areas where grazing animals had to be removed early in the year from hay producing lands of ranches. Feeding hay is normally more expensive than graz-

ing animals on rangeland. Having range forage available at an earlier date reduced costs of operation and made ranch enterprises more economically viable (Sharp 1986).

Good seed production, ease of seed harvesting, high germination rate of seeds, remarkable establishment rates, drought tolerance and a wide amplitude of adaptability to semi-arid ranges add greatly to the value of crested wheatgrass. Yearling cattle gains of 1.1 kg/day (2.5 lbs/day) are not uncommon in the spring season (Sharp 1970).

During the 1940s and 1950s, crested wheatgrass was seeded in areas where halogeton [Halogeton glomeratus] was a problem. This poisonous exotic annual forb is not a good competitor with perennial plants. Crested wheatgrass minimized losses due to halogeton (Sharp 1986).

A value not commonly recognized, and difficult to document, relates to improvement of adjacent native range. This occurs because crested wheatgrass seedings often reduce grazing pressure on native range areas, or provide for management programs that are more suitable for improvement of native ranges (Sharp 1986, Heady 1988).

Historically, livestock were turned onto rangelands in March or April, depending on snowmelt. Grazing followed spring plant growth into the upper elevation ranges until

the onset of autumn storms forced stock downward to the areas of initial turnout. This pattern of livestock use deprived perennial plants of leaf tissue necessary for food manufacture through photosynthesis. Root carbohydrate reserves gradually decreased weakening the plants and lessening forage production.

Crested wheatgrass furnished a solution to this physiological problem because high quality early season production of seedings provided an alternative to pasturing native vegetation.

Although the total amount of land seeded to crested wheatgrass is not well documented, during the Vale Rangeland Rehabilitation Program in southeastern Oregon, some 109 thousand ha (267 thousand acres) were seeded, mostly to crested wheatgrass (Heady and Bartolome 1977).

Focus of Paper

This paper addresses environmental consequences of crested wheatgrass seedings within the Columbia Basin province. Effects on wildlife will be emphasized, however ecological relationships with native plant species will also be addressed.

METHODS

Both a review of existing literature and nearly 4 decades of experience of the author will be incorporated in evaluat-

ing the impact of crested wheatgrass within the Columbia Basin area.

RESULTS

Two criticisms of crested wheatgrass seedings are that crested wheatgrass is an exotic plant, and, secondly, that monocultures are a result of such seeding. Both allegations are, to varying degrees, true. As previously noted, crested wheatgrass was brought into the Intermountain West from Russia. It, like so many other species of plants and animals, arrived on the North American continent after initial descriptions of flora and fauna had occurred. Although exotic, it is surely well established within western North America. There can be little doubt that it now qualifies for residency (Dwyer 1986).

Concerning the second count, that is being a monoculture, there is little doubt that this was true during early seeding programs. Fortunately, nature through natural succession, has alleviated this monoculture problem with natural reestablishment of sagebrush and other native plants in the community. In fairness, it should also be mentioned that mixed seedings of forbs and shrubs, including adapted species of alfalfa were also seeded in many rangeland projects (Kindschy 1991).

Reasons for seeding

Uncontrolled livestock grazing had depleted and permanently altered vegetative composition of rangelands as early as the turn of the century (Griffiths 1902). Exploitation continued until at least 1934, with the passage of the Taylor Grazing Act. Enforcement, however, often did not result in meaningful change until well into the 1960s (Durran 1976, Box 1977, Carpenter 1981). By then much of the arid plant community was divested of native plants. A prolonged severe drought during the 1930s undoubtedly caused widespread mortality of weakened native perennial grasses (Pechanec et al. 1937, Lang 1945, Blaisdell 1958, Wernstedt 1960). Exotic species, such as cheatgrass (Bromus tectorum], filled the void (Young and Evans 1978).

Eventually a number of concerns became apparent. First, there was not sufficient forage to meet licensed livestock use. Second, invasion of weedy plants was creating problems including increasingly large areas burned repeatedly by wild fires (Conrad and Poulton 1966, Uresk et al. 1976, Bunting 1991). Other complications were also developing. Big game suffered a lack of both summer and winter forage (Gruell 1986). Watershed conditions were such that erosion was often rampant (Rauzi and Hanson 1966, Laycock and Conrad 1967, Buckhouse et al. 1981).

Crested wheatgrass seed was commercially available. A strong history of establishment success was well known (Long 1958, Heady and Bartolome 1977, Evans and Young 1978).

Diversity of vegetation is normally paralleled with a diversity of animal species. Monocultures are limited in both plant and animal diversity. Seedings of a grass, for example crested wheatgrass, initially produced a monoculture. The same may be said for any grass or herbaceous species. Degraded rangeland, dominated by a shrub species, notably sagebrush [Artemisia tridentata], also became monocultures. Neither were well suited to wildlife (Kindschy 1978, Oakleaf et al. 1983, Holechek et al. 1982, Ellis et al. 1989).

Over time, sagebrush often becomes reestablished in seedings of crested wheatgrass. Sagebrush is, of course, a part of the potential natural plant community within much of the Columbia Basin (Passey and Hugie 1962, Vale 1975). Such reestablishment creates an improved diversity of vegetative components, that is grasses and forbs plus shrubs. Many wildlife species obligatory to the sagebrush community reenter crested wheatgrass habitat when sagebrush cover becomes present (McAdoo et al. 1989). Degraded sites are less diverse due to lack of variety in plant species. Sites

with a long history of degradation may pass the point of successional recovery due to an absence of native grasses, forbs, and some shrubs. Such sites have been aptly termed "locked in" because they are, for practical extents of time, not subject to change (Tausch et al. 1993).

Botanical Influence of Crested Wheatgrass

As a well adapted and easily established perennial, crested wheatgrass soon out-competes annuals ... such as cheatgrass [Bromus tectorum, Russian thistle [Salsoa kala], and halogeton. Thus, crested wheatgrass has been extensively used in reclamation of disturbed sites (Rogler and Lorenz 1983).

DePuit (1983) described reclamation as one obvious solution to the environmental trade-off dilemma of drastic land disturbances. Reclamation's goal being to insure that society does not lose actual or potential land use opportunities available prior to disturbance. Reclamation has been recognized for some time as ethically, ecologically and agriculturally important (Box 1978); for many types of disturbance it is now legally mandated as well.

Most literature concerning use of crested wheatgrass on disturbed sites dealt with eastern Montana and Wyoming coal mine reclamation. There, frequent summer precipitation from thunder storms probably favored crested wheatgrass, often over other seeded desired species (Sindelar 1978, Ries et

al. 1978). This was perceived as competitive aggressiveness. Additionally, crested wheatgrass responds to fertilization in the Great Plains (DePuit and Coenenberg 1979).

The Columbia Basin region, including the northern Great Basin, is influenced more by storms from the north Pacific Ocean. Summers are normally very dry with often a month or more without any measurable precipitation. Mean annual precipitation for this region is 28 cm, (11 in.), commonly ranging with elevation from 15 cm (6 in.) to 41 cm. (16 in.) in the highest mountain ranges (Kindschy 1985, Miller et al. 1991).

Crested wheatgrass in the Columbia Basin environment seems more at a par with native bunchgrasses. My observations of ecological processes within an southeastern Oregon livestock exclosure built by the Civilian Conservation Corps and Grazing Service in 1939, show seeded crested wheatgrass living in evident balance with native grasses, especially bluebunch wheatgrass, Thurber's needlegrass [Stipa thurberiana], and bottle-brush squirrel-tail [Sitanion hystrix]. Each are reproducing and filling voids left by old plants. Such observations would suggest that crested wheatgrass is not an overly aggressive competitor with native grass species. There is no doubt that it is highly competitive with

annuals, however.

Kindschy (1988) examined native and introduced vegetation of several protective exclosures in southeastern Oregon. He observed that crested wheatgrass rarely spread from the actually seeded site. In those few instances, crested wheatgrass filled the void created when other introduced grasses died. Crested wheatgrass was never seen in native sagebrush communities more than a few meters outside experimental seedings. Hull and Klomp (1967) reported similar observations in southern Idaho. In recent years I (Kindschy) have observed crested wheatgrass growing down the center of remote "2-track" truck trails, many kilometers removed from the nearest seeding. Without doubt, vehicle undercarriages gathered ripe seed while traversing crested wheatgrass seedings, then brush wiped it off along the truck trail. Again, crested wheatgrass seems to be confined to the center where introduced (Kindschy unpub.).

Once established, which requires 3 to 4 growing seasons following seeding, crested wheatgrass seedings become difficult sites for other plant species to colonize. In this sense, crested wheatgrass is quite competitive. It establishes a closed community where inter-spaces between plants are fully occupied by their root mass.

Stress from repeated grazing or drought reduces vigor and competitiveness of crested wheatgrass. During such times drought hardy species, especially sagebrush, may become established in inter-spaces (Miller et al. 1991). I have also observed annual grasses and forbs, for example cheatgrass and halogeton, fill interspaces among drought dormant crested wheatgrass. once more normal moisture returns, however, annuals fail to compete with revitalized crested wheatgrass and nearly all disappear from the site. Similar phenomena occur between native bunchgrasses and annuals (Kindschy 1992).

Heady and Bartolome (1977) examined the success of several hundred seeding efforts in southeastern Oregon. Kindschy (1991) reported on the great amount of success with seeding 'Nomad' dryland alfalfa [Medicago sativia], concurrently with crested wheatgrass. Success has also been attained with four-wing saltbush [Atriplex canesens] and bitterbrush [Purshia tridentata].

If seedlings are given equal opportunity to become established, because there are no highly competitive dominant mature plants present, each species has a good likelihood of establishment. All seedlings grow and may ultimately reach maturity. Stands of 'Nomad' variety alfalfa have coexisted

with crested wheatgrass for over 25 years in the Vale Project rehabilitation area of southeastern Oregon (Kindschy 1991). Rumbaugh (1982) summarized information on alfalfa survival over time as well as natural reproduction within crested wheatgrass seedings. In Utah, research has shown enhanced crested wheatgrass production when grown with alfalfa (Gebhart et al. 1993). Studies in Montana by White and Wight (1984) found improved total forage yields and quality when dryland grasses, such as crested wheatgrass, contained legumes. The deep tap root of alfalfa utilizes a deeper soil horizon than the more shallow and spreading roots of bunch grasses. Thus competition for moisture and soil nutrients is lessened. An additional factor may be atmospheric nitrogen fixation by legumes which can stimulate growth of grasses ... provided sufficient moisture is available for such growth (McGinnies and Townsend 1983).

Zoological Influence of Crested Wheatgrass

It has been estimated that sagebrush covers up to 109 million ha (270 million acres) of western rangeland, with big sagebrush [Artemisia tridentata] comprising more than half of this area (Beetle 1960). Animals inhabiting this sagebrush steppe are, more often than not, brush or shrub obligates. Thomas et al. (1976) stressed the importance of

reproductive and foraging needs of animals. For sagebrush obligatory animals, complete removal of this dominant shrub will cause immediate displacement of individuals to areas where habitat requirements of reproduction and foraging can be met (Kindschy 1978).

Braun et al. (1976) listed non-game bird species that are known to forage and nest in sagebrush communities. Shrubnesting species include Brewer's sparrows (Spizella breweri], sage sparrows [Amphispiza belli], sage thrashers [Oreoscoptes montanus], gray fly-catchers [Empidonax wrightii], and loggerhead shrikes [Lanius ludovicianus]. These species will decrease or even disappear from sites where shrubs have been eliminated by natural causes, such as fire, or human actions involving mechanical techniques such as plowing or chaining. Chemical application retains dead brush structure for a period of years and has, consequently, less immediate short-term impact to shrub obligatory animals (Kindschy 1978).

On the other hand, ground-nesting birds, for example horned larks [Eremophilus alpestris], western meadowlarks [Sturnella neglecta], vesper sparrows [Poecetes gramineus], and lark sparrows [Chondestes grammacus] are less impacted by reduction of shrubs. In fact horned larks and meadowlarks are normally the most common birds in crested wheatgrass seed-

ings devoid of sagebrush cover (Kindschy, unpub.).

McAdoo et al. (1986, 1989) presented an excellent summary of non-game bird responses to type conversion of sagebrush communities. Trade-offs occur when sagebrush dominated habitats are converted to monoculture crested wheatgrass seedings. Although shrub-nesting bird species are displaced, grass-nesting species respond favorably to the openness and increased herbaceous cover resulting from shrub removal and seeding. As secondary succession proceeds, sagebrush and associated shrub-nesting bird species return while grass-nesting species remain.

If pristine sagebrush steppe shrub communities actually did have more grass cover than their present counterparts, then the vegetation structure and bird communities of seedings where sagebrush has become reestablished may more closely resemble presettlement conditions than do those of present degraded sagebrush habitats with sparse herbaceous understory.

Snakes and especially lizards suffer from lack of solar shading during summer where shrubs have been removed. In addition, parallel drill-rows of seeded grasses leave wide inter-spaces of barren ground that are hostile habitat for both reptiles and small mammals (Kindschy, unpub.).

Boula and Sharp (1985) studied species composition and abundance of small mammals within native rangeland vegetation and a crested wheatgrass seeding of southeastern Oregon. They found post-recruitment populations were highest and most diverse in native upland shrub habitat. Crested wheatgrass seedings yielded fewer species and a lower total capture biomass. They noted much greater soil compaction within seedings sampled ... likely a result of trampling from cattle. Fossorial species would experience an obvious negative impact from this compaction.

Protection from predation may be an important habitat feature for small mammals that is limited in drilled crested wheatgrass seedings. Feldhamer (1977) reported a positive correlation between small mammal species density and canopy cover in shrub habitats. Westoby and Wagner (1973) found that black-tailed jack rabbits [Lepus californicaus] fed extensively in outer margins of large crested wheatgrass seedings, but avoided the central area of seedings more distant from shrub cover. My observations in southeastern Oregon have been similar with nearly all black-tailed jack rabbit use within 400 m of the seeding boundary. However, when 6% to 10% ground cover from sagebrush becomes reestablished, black-tailed jack rabbits ... and many other sagebrush obligates ... return to use the entire seeding

(Kindschy, unpub.).

Several big game mammals, pronghorn antelope [Antilocapra americana], mule deer [Odocoileus hemionus], bighorn sheep (Ovis canadensis], and Rocky Mountain elk [Cervus canadensis], use crested wheatgrass seedings to varying amounts depending on seeding location and season of year. Two additional large mammals, bison [Bison bison] (Van Vuren et al. 1983), and the feral or "wild" horse [Eguus caballus], are largely grass consumers and will make extensive use of wheatgrass.

Habitat requirements of pronghorn were described by Kindschy et al. (1982) as more resembling the low structured vegetation of eastern Wyoming and Montana with shrub height 50 cm (20 in.). In addition, watering sites no more than 3 km (2 miles) apart are most desirable. Presence of shrubs, grasses, and forbs is important with an ideal mixture supporting 10-30% forbs. The natural vegetation of eastern Washington and Oregon fails to meet all foregoing criteria. That is likely the reason the Columbia Basin is considered as peripheral habitat for pronghorn. Reduction of typically tall sagebrush and development of watering sources greatly enhanced pronghorn habitat. In sites where alfalfa was seeded with crested wheatgrass, a valuable forb was supplied

to a habitat which normally was lacking in green succulents after early June. Response of pronghorn to rangeland development, including crested wheatgrass seedings and their attendant water developments, have been dramatic (Heady and Bartolome 1977). In southeastern Oregon's Malheur County ... the principal area of the Vale rangeland rehabilitation project ... pronghorn census has increased from an average of 900 head to >3,000.

Mule deer can benefit from crested wheatgrass in areas where autumn "green-up" occurs (Austin and Urness 1983). This is especially so if crested wheatgrass seedings are in an area where deer normally winter (Leckenby and Toweill 1983). My observations agree with Leckenby and Toweill.

Mule deer make extensive winter and spring use of the Rome complex of crested wheatgrass seedings. Biologists of Oregon Department of Fish and Wildlife (ODFW) have tallied these animals during March of each year since 1979. Numbers vary, mostly due to winter severity, but five to eight hundred deer seems normal with a gradual trend toward increased numbers over time.

Fecal analysis from deer wintering within these seedings was performed by Colorado State University on randomly selected deer pellets gathered by the writer. Crested wheatgrass averaged between 84 and 92 percent of the volume

of excreted material.

Autumn green-up of crested wheatgrass is common to the area although occasionally fall precipitation does not occur. it is this green-up of crested wheatgrass, Sandberg's bluegrass and cheatgrass that affords high quality forage for deer.

Urness (1983) found in northern Utah that fall regrowth and spring growth of crested wheatgrass favorably affected the nutritional plane of mule deer on winter range dominated by big sagebrush having intermingled seedings of this exotic grass.

Urness (1986) provided a more detailed evaluation of the importance of crested wheatgrass for big game. He cited observations of Leckenby (1969) in the Silver Lake, Oregon, mule deer winter range where crested wheatgrass ranges accounted for 34% of deer use observations.

In the same paper, Urness cited several authors' observations of higher acceptability to deer of crested wheatgrass that had been utilized previously by livestock, thus removing cured "straw" materials. While this was generally true for snow-free periods, ungrazed straw can significantly increase the amount of green regrowth via the "black-body" effect. Thus basal green leaves on previously ungrazed plants become available through differential snowmelt where

as those on heavily grazed plants do not.

Urness concluded that often only about one third of seeded areas where deer concentrate in winter need be rested. Preferably this would be in many scattered small units, rather than a few large ones.

Willms et al. (1979) also observed that moderate or heavy fall grazing by cattle of bluebunch wheatgrass in British Columbia made spring forage more attractive to deer through removal of cured growth.

Holechek (1981) treated a number of attributes of crested wheatgrass. He stated that "deer and elk seek early spring foliage of crested wheatgrass following snow melt, and they also use fall growth."

Austin and Urness (1983) discussed mule deer use of crested wheatgrass in northern Utah. Mule deer diets during winter consisted primarily of crested wheatgrass regrowth. They noted an average daily consumption of 0.63 kg/deer of crested wheatgrass (1.4 lbs/deer/day). They recommended that managers should curtail fall livestock grazing on critical deer wintering areas to assure maximum regrowth availability for deer. They concluded that green crested wheatgrass regrowth is an important over-winter forage for mule deer and, where available, should be considered in management plans.

Crested Wheatgrass Management for Optimizing Values

Sagebrush will reestablish (invade) within crested wheatgrass seedings because it is a component of the climax plant community. Reasons for and rates of sagebrush reestablishment vary. It is beyond the scope of this paper to address this issue. Nonetheless, such reestablishment negates the criticism of monoculture habitat. The extent of sagebrush may be important insofar as crested wheatgrass production is concerned. Rittenhouse and Sneva (1976) reported a 4% decline in crested wheatgrass production for every 1% increase in cover of sagebrush. I suspect this varies by environmental conditions such as soils and precipitation. McKell (1986) found a 5% to 10% shrub canopy best for growth of understory grasses and forbs. On privately owned rangelands forage production for the owner's livestock may well be a primary concern. On public land managed for multiple use objectives, the additional value of diversity from sagebrush reestablishment needs to be considered. Heady (1988) found sagebrush encroachment to be curtailed by competition from crested wheatgrass with sagebrush seldom covering more than 10% of land area. Evaluation of land use objectives for each site should be made prior to initiation of sagebrush reduction.

Established seedings of crested wheatgrass are, essentially, closed communities. It is difficult to establish other plants within an existing wheatgrass stand. Competition from existing mature crested wheatgrass need be removed prior to successful establishment of introduced vegetation. Stevens et al. (1981) discuss techniques of interseeding and transplanting. Chemical treatment techniques are discussed by Vogel et al. (1983).

Livestock Management of Crested Wheatgrass

There should be little doubt that crested wheatgrass has a lot going for it. The past decades have proven that it filled a void in livestock forage resources of western U.S. rangelands. It's early season production, and resiliency to utilization at that time, filled a need that wasn't met by native perennial grasses. In addition, crested wheatgrass has a remarkably wide range of site adaptability and is fairly easily established. The most forage productive strains tend, however, to become rather rank or "wolfy." Therein lies a problem with crested wheatgrass or "macaroni grass," as it was referred to by Basques of southeastern Oregon due to this trait. Thus, although it had a lot going for it, crested wheatgrass had some management problems too.

It might be termed overproduction and underutilization. Both are correct. Crested wheatgrass is now available in

various varieties, some, such as 'Hycrest', are more palatable than others,and are thus less apt to become rank or wolfy.

Unfortunately, those crested wheatgrass plants that are grazed receive all the grazing pressure in following years, and, in fact, may become over-grazed. Wolf plants are avoided by grazing stock and wildlife. Hence, it is possible to have a portion of a seeding of crested in an over-grazed status while the remainder is not utilized at all. This amounts to over-grazing and under-utilization. It's not good for grass or the dependent grazing livestock or wildlife.

A "double utilization standard" is useful in describing use of crested wheatgrass. Rather than just averaging out use at, say, 60%, the suggested method calls for two standards. The first is percent of plants that exhibit use; second is amount of use on plants that have been grazed. Thus one might record that 30% of plants have been used 60% (while 70% of plants were not used at all!). Such a description of seeding forage utilization will alert the manager to the fact that a wolf plant problem is developing.

A loss of forage production from the seeding transfers this grazing use to native forage species with a subsequent loss

in grazing flexibility and possible deterioration of that resource. As seeding forage production decreases, more use of native range must occur. Eventually a manager is back to the point he was prior to range seeding development.

Obviously a corrective measure would be removal of accumulated dead plant material. This can be accomplished by several means, however only two appear to be economical at the present time: biological and controlled fire.

Biological control utilizes livestock to remove accumulated plant material. It is best accomplished with cattle, preferably "dry" cows from which calves have been weaned, or horses. The stock are placed in the pasture in late fall or early winter when the added moisture has softened cured grass. A supplement is necessary to balance the diet; either protein block or PMS-type protein rich additive. In addition, confinement to small portions of the pasture is necessary. Solar powered electric fencing has proven to be effective in confining stock to the portion being grazed. Although the technique is labor intensive, it is attractive to livestock producers in that it is an option to feeding of often high priced hay.

Fire can be useful in cleaning off accumulated dry grass. The weather conditions need to be rather severe, that is low humidity, high temperature, and a wind, to carry fire

through crested wheatgrass. Such burns seem to stimulate crested wheatgrass, partially due to nitrogen and other element release, and partially from reduction of competition from other plants in the stand. Some of these plants, for example sagebrush, may be desirable in providing habitat diversity for wildlife. A mixture including from 6% to 10% ground cover of sagebrush has proven to be adequate for many sagebrush obligatory wildlife and does not greatly restrict productivity of crested wheatgrass for livestock forage. Some of the more diverse rangeland vegetation on western rangelands is now afforded by older crested wheatgrass seedings. A proper prescription for the controlled burn is necessary. Unburned areas can be created through localized burning of fire lines prior to the main burn. Ideally, a mosaic of vegetation is created. A condition better for both wildlife and livestock.

Subsequent management of crested wheatgrass is mandatory. The problem developed because of low intensity - long duration grazing. The solution requires the opposite condition, namely large numbers of stock for short periods of time. This not only forces uniform utilization of the forage resource, but eliminates the situation where individual plants are repeatedly grazed over a longer period of time.

If soil moisture is still adequate, crested wheatgrass can regrow following early use. Such growth enables food manufacture and translocation into root reserves to improve vigor of plants. Regrowth is often valuable to wildlife during winter and will also provide a forage cushion for turnout in the advent of a late spring.

Thus high intensity - short duration grazing appears to be a solution to the wolf plant problem of crested wheatgrass seedings. Such grazing technique requires relatively small pastures to concentrate livestock use. It is also mandatory to have reliable water for stock over a wide period of time. Benefits can be considerable. Not only is the forage resource perpetuated but calf crops tend to be improved due to concentration of cows allowing ready access to bulls at breeding time. Livestock health can be improved by more frequent attention of owners as they move stock from pasture to pasture under the short duration system.

Management of livestock on seedings important for big game wintering range is important (Leckenby 1983). Avoidance of "wolf plant" development, namely ungrazed plants with massive accumulation of old material, is necessary to maximize availability of new growth to wildlife. Thus close utilization during spring and early summer by cattle and then complete rest during late summer and fall is recommended.

Autumn "green-up" is then available during snow-free periods of winter. Crested wheatgrass, unlike most native bunch grasses, is able to initiate autumn growth when sufficient moisture is available but temperatures are cool to cold. Only Sandberg's bluegrass [Poa secunda] and the exotic annual, cheatgrass [Bromus tectorum], are similarly capable. Each provides nutritious and easily digested forage for wintering animals.

To best utilize crested wheatgrass seedings, cross fencing and water developments are necessary. Each pasture must be able to supply forage and water at a variety of grazing seasons to enable flexibility of grazing use required for proper utilization of seedings and enable deferment or rest of native range.

Rotational grazing of pastures within an allotment is the best practice for regaining vigor and productivity of forage. Crested wheatgrass seedings can play an important role in providing flexibility for such rotations. It is also important to have several pastures within the seeding so that early use can be rotated from year to year.

New Seedings

Design of new seedings of crested wheatgrass should now incorporate additional species of forbs and shrubs. Avoid-

ance of large blocks of land through contour or patch seeding to maximize edge effect is also desirable.

Adapted dryland varieties of alfalfa remain one of the best forbs for concurrent seeding with crested wheatgrass. Kindschy (1991) recommended the following sequence in site preparation: spring plowing of the site using an off-set disk-type plow such as the Brushland plow. Let the site lay fallow over summer. Drill to crested wheatgrass at 7.8 kg/ ha (7 lbs./acre). Early the following spring, after danger of killing frost, aerially seed inoculated alfalfa seed at 1.1 kg/ha (1 lb./acre). Allow 2 growing seasons rest from livestock use to enable establishment. Other forbs such as small burnet [Sanguisorba minor], sweetclover [Melilotus officinalis], and sainfoin [Onobrychis viciaefolia] hold some promise in future-mixtures (Stanton 1973).

Shrubs species for seeding with crested wheatgrass include fourwing saltbush [Atriplex canescens] (Otsyina et al. 1982), the cultivar 'Rincon' is now commercially available and well adapted to the Columbia Basin province. Winterfat or white-sage [Krascheninnikovia (Eurotia) lanata] shows promise as the cultivar 'Hatch' is now available. Winterfat is especially well suited to the more arid portions of Wyoming sagebrush habitat including the transition into salt desert shrub communities. Antelope bitterbrush [Purshia

tridentata] is an excellent browse shrub in sites of > 30 cm (12 in.)annual precipitation. Bitterbrush is slow growing, however, when compared to four wing saltbush. Its great palatability also can make it hard to establish. Finely, big sagebrush [Artemisia tridentata var. tridentata and wyomingensis] seems best suited to transplanting in "mother colonies" which can then distribute seed onto surrounding rangelands. The best technique is to dig seedling sagebrush plants in late fall and plant in groups on sites cleared of competitive vegetation.

Discussion and Management Implications

Although an "exotic" and initially planted in monocultural seedings, time has established crested wheatgrass as one of the most important grasses in the Columbia Basin province. Time has also corrected, in the case of older seedings, the single species poverty initially introduced into the ecosystem. The positive attributes of crested wheatgrass as a highly productive and easily established perennial forage grass are well documented. Its value to wildlife varies by animal species, but can be considerable.

Perhaps one of the main attributes of crested wheatgrass is the flexibility it affords in rangeland management. Seedings can be utilized during the spring growth period when

native grasses and forbs are most negatively effected by utilization. Such relief from use can ... and has ... enabled remarkable improvement in the ecological condition of native-rangelands.

Attention should be paid to design of future seedings to ensure plant species diversity and maximization of edge. Many new cultivars of grasses, forbs, and shrubs are now available for inclusion in seeding mixtures.

Older seedings, where native vegetation has become reestablished, may require periodic treatment through the use of fire or herbicides to maintain the initial objective of livestock forage production. Ecologically, the best prescription incorporates some retention of plant diversity and edge. How this is achieved depends upon the land owner or manager. Surely, in the case of public lands, where multiple resource values are of primary concern, it becomes a mandate.

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