competition, biodiversity, invasion, and wildlife useage of selected introduced grasses in the Columbia and Great Basins

Research Report 155
Utah Agricultural Experiment Station
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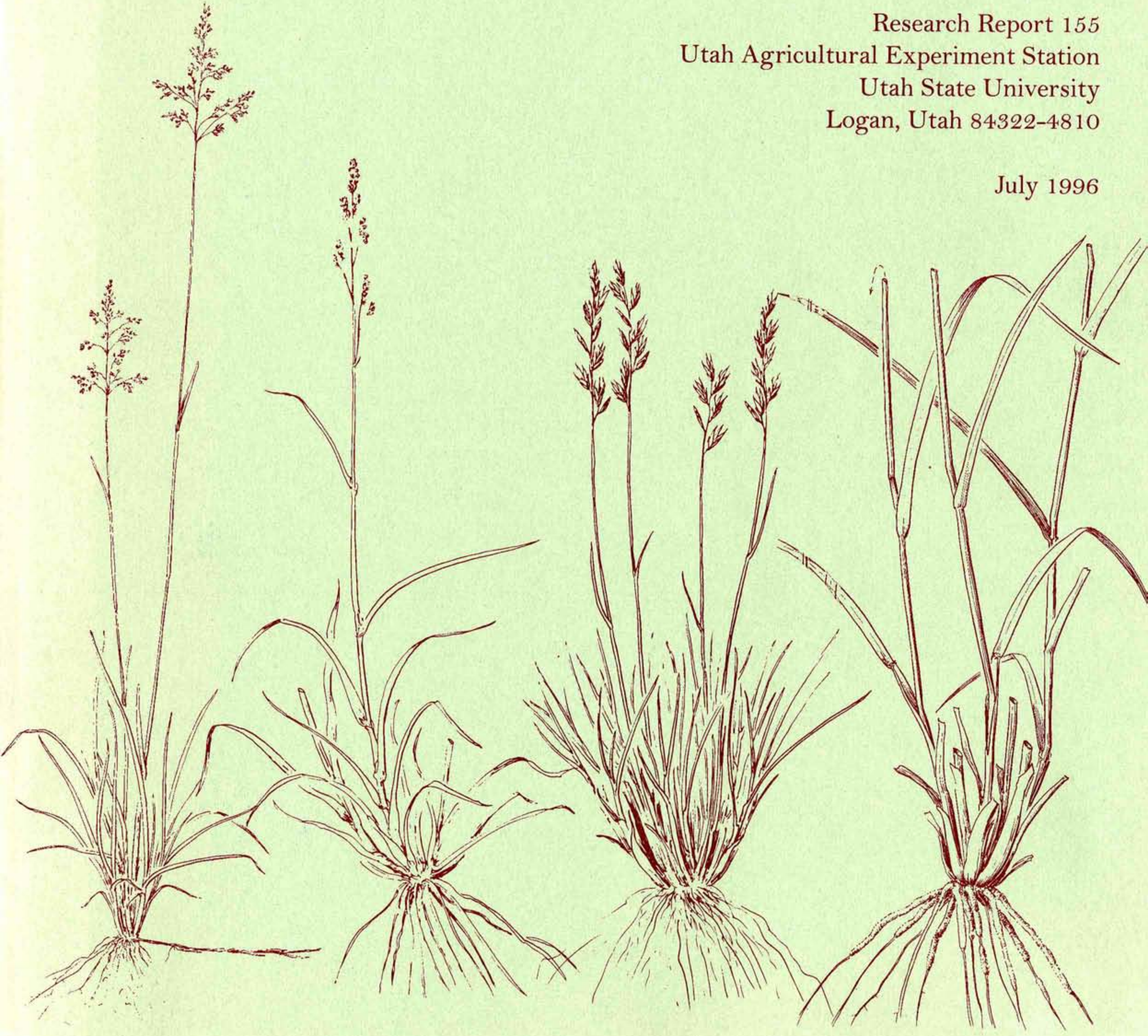
July 1996



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(Second Printing)

This literature review was partially funded on a contract as part of the Interior Columbia River Basin Assessment Project to the USDA-Agricultural Research Service/Utah State University, Logan, Utah 84322-6300 in cooperation with the Utah Agricultural Experiment Station, Logan, Utah

Illustrations from *Intermountain Flora: Vascular Plants of the Intermountain West, U.S.A.* Vol. 6., Columbia Univ. Press, N.Y. 1977.

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summary

Environmental and site conditions temper a plant species' ability to grow and compete with other species. These conditions include geomorphology, slope, aspect, soil types, climate, salinity, human impacts or management, seed sources, and existing vegetation. Jointly they determine how successful each plant species will be on a site. All plants (native and introduced) are most competitive or "aggressive" in environments where they are best adapted and where soils are most suitable for their establishment and growth. All species establish most readily if there is little or no competition from other species. A species' competitiveness declines as the environment becomes less favorable relative to other species in the population. Therefore, even the most "aggressive" plants only grow where their tolerance limits are not exceeded.

The impacts of both native and introduced grasses in the Columbia River drainage and the Great Basin are governed by the same factors. Removing all vegetation by fire, grazing and/or cultural practices prior to seedling establishment favors the creation of a monoculture of the seeded species whether native or introduced in origin. It is often difficult to establish a monoculture without removing existing vegetation. Generally, the nine species or species complexes discussed in this review (bulbous and Kentucky bluegrass, crested/Siberian wheatgrass complex and intermediate/pubescent wheatgrass complexes, hard and sheep fescue, orchard grass, reed canarygrass, and tall wheatgrass) can be established as monocultures only if indigenous vegetation is removed prior to seeding. In several instances, adapted species have become established in monocultures of introduced grasses. Except for reed canarygrass and bulbous bluegrass, movement or spread of these introduced grasses usually occurs mainly in disturbed areas.

Both native and nonnative grass species now contribute to genetic diversity and biodiversity and their use is consistent with important management goals. Thus, if native and introduced species are well adapted to a site, both will contribute to biodiversity regardless of the origin of their genetic variation. Biodiversity is a function of the variety or number and relative abundance of different species or ecotypes in an ecosystem.

In several instances, introduced grasses have been preferred in the Columbia River drainage and the Great Basin. They stabilize soils, reduce erosion, and improve forage availability and persistence for both livestock and wildlife use. The lack of native species adapted to man-altered environments or degraded rangelands and the spread of weeds, poisonous plants and fires have been important factors in decisions to use introduced plant materials.

The mere presence of selected plant species (native or introduced) in an ecosystem is less important than the stabilization of soils and the maintenance of ecosystem processes. To attain worthy multiple use management goals on western ecosystems, the potential benefits of all available species must be considered while protecting and maintaining both biotic and abiotic resources.

In some instances rangelands are sufficiently disturbed, both in vegetation composition and in soil condition, that they must be readily stabilized. Microsites are sometimes irreversibly modified by changes in climate, fires, and grazing. Introduced grasses may be best suited for stabilization of such sites. Successful establishment of plants, either by intentional seeding or by natural means, requires the presence of many factors including viable seeds, favorable microsites for the target species, and an acceptable (low) level of competition by existing plants. Environmental thresholds must be satisfied for successful establishment and growth whether a plant is classified as native or introduced.

Finally, an evaluation of biodiversity must consider the scope or size of the area involved. Within a seeded area where indigenous vegetation has been removed and one or a few species have been established, biodiversity is reduced. But when considered on a larger scale, biodiversity is increased with the addition of the new genetic material (species).

purpose

This report examines the competitive ability, invasiveness, wildlife use, and known effects on overall biodiversity within the Columbia and Great Basins of nine seeded grass species or species complexes: crested, intermediate and tall wheatgrasses; bulbous and Kentucky bluegrass; hard and sheep fescues; orchardgrass, and reed canarygrass.

introduction

Much of the literature on biodiversity concerns either general ecological principles or specific characteristics of a grass, such as interspecific competition among grass species. Few biodiversity studies are specific to the Columbia and Great Basins. As a result, this report relies heavily on general ecological theory and on case studies in regions of North America whose physiography, climate, and biota are similar to the regions under consideration. Appendix I lists the moisture requirements (Appendix Ia), soil adaptations (Appendix Ib), and fire tolerance (Appendix Ic) of the species included in this review.

1) competition

Competition for resources generally determines the presence, abundance, and special arrangement of species within a plant community (Pyke and Archer 1991). It generally regulates the growth of plants in arid and semiarid communities (Fowler 1986) and often reduces the biomass of individual plants (Harper 1977).

Researchers have not always agreed on the importance of competition on the composition of plant communities (Reichenberger and Pyke 1990, Tilman 1982, Roughgarden 1983, Schoener 1983, Strong 1983, Call and Roundy 1991, Roché, personal communication, 1994). However, an accurate assessment requires a thorough understanding of the processes and interactions of competition and population stabilization, including the relationships among plants, animals, microorganisms, soil processes and climatic factors (Call and Roundy 1991).

Studies of competition between introduced and native species include those by: Douglas et al. (1960), Harris (1977), Harris and Wilson (1970), Heady (1988), Hull and Klomp (1966), Hyder and Sneva (1963), Monsen and

Anderson (1993), Rittenhouse and Sneva (1976; 1977), Rumple (personal communication, 1994), Sneva and Hyder (1965), Stannard (1994), and Zamora (personal communication, 1994). Root competition was shown to affect seedlings of *Artemisia tridentata* Nutt, *A. desertorum* (Fischer ex Link) Schultes, and *A. spicatum* (Pursh) Scribn. & Smith and *Bromus tectorum* L. (Reichenberger and Pyke 1990). Even though the response of a single fitness component may vary among species, interspecific and intraspecific competition play major roles in determining the relative abundance of individuals in populations within semiarid ecosystems (Reichenberger and Pyke 1990).

2) biodiversity

Noss (1991) and Walker (1992) note that the term "biodiversity" is so vague and generally misunderstood as to be meaningless. West (1993) has since defined biological diversity as the variety of life and its processes, including all living organisms, the genetic differences among them, the communities, ecosystems, and landscapes in which they occur, plus their various interactions. Fundamentally, biodiversity includes the composition and function of all processes present in any ecological (abiotic-biotic) system. Biodiversity can be viewed from ecological and political perceptives, global ecological complexity, and anthropocentric-anthropomorphic values (Table 1). Biodiversity may also involve cultural, religious, and individual values, and beliefs concerning the role of humans in global ecology.

Public attention concerning diminishing biodiversity tends to emphasize an anthropocentric, commodity-based view, e.g., the foods (e.g., Prescott-Allen and Prescott-Allen 1990) and drugs (Ehrlich and Wilson 1991) obtained from natural sources. The less comprehensible, yet more critical, global ecosystem processes that sustain all life receive less attention. Biodiversity can encompass ecosystems consisting of native and introduced species. As noted below, sites can be stabilized by seeding introduced species, thereby enhancing the establishment of native species. Such seedings may or may not alter biodiversity.

Detailed reviews of biodiversity, landscape ecology, and the maintenance of ecological complexity include: Council on Environmental Quality (1991, 1993), Ehrlich and Wilson (1991), Erwin (1991), Franklin (1993), Klijn and Udo de Haes (1994), Lacy (1987), McArthur and Tausch (1995), Noss (1991), Soulé (1991), Thomas and Salwasser (1989), Walker (1992), Waller (1988), West (1993), and Wilson (1988, 1992).

Table 1. **Primary non-human centered and human-centered layers involved in biodiversity. Adapted and modified from Ehrlich and Wilson (1991), Walker (1992), and West (1993).**

global ecological complexity

ecosystem/landscape

- pattern
  - -patch types and heterogeneity
  - -collective species distribution
  - -fragmentation
  - -perimeter-to-area ratio
- process
  - -nutrient cycling
  - -carbon storage
  - -energy flow
  - -soil development
  - -soil erosion control
  - -human disturbance rate
  - -non-human disturbance rate

community

- pattern
  - -physiognomic heterogeneity
  - -structural heterogeneity
  - -species heterogeneity
  - -species endemism
  - -biological invasions
- process
  - -colonization rate
  - -extinction rate
  - -patch dynamics
  - -nutrient cycling rate
  - -human disturbance rate

population

- pattern
  - -relative abundance, frequency, and biomass
  - -structure: sex and age ratios
  - -morphological and genetic variation
  - -karyotypic variants
- process
  - -recruitment
  - -survivorship
  - -adaptation
  - -genetic drift
  - -selection

individual

- pattern
  - -heterozygosity
  - -rare alleles
- process
  - -genetic
- gene flow
- mutation
- selection
  - -physiological
- phenology
- acclimation

Table 1 continued. Primary non-human centered and human-centered layers involved in biodiversity. Adapted and modified from Ehrlich and Wilson (1991), Walker (1992), and West (1993).

anthropocentric/anthropomorphic values		
economic	*moral*	*aesthetic*
● commodities -food plants ● domesticated crops ● wild-gathered -livestock -clothing fabrics -energy sources ● services -nutrient cycling -carbon storage -energy flow -soil development -soil erosion control	● obligation to preserve life ● obligation to not interfere with evolution of other species ● obligation to pass on a livable and diverse planet to future generations of all species so as not to limit their opportunities and options	● need for appreciation of non-human created landscapes ● need for appreciation of non-human life forms ● need for animal companionship

3) exotic plant invasion

Biological invasion, specifically by introduced plants, is a controversial topic. Much of the current discussion is framed in Clementsian concepts of plant communities and plant succession (Clements 1916, 1928), although some concern the Gleasonian individualistic concept (Gleason 1917, 1926, 1939) and "state-and-transition" models (Westoby et al. 1989). Westoby et al. (1989) note that plant associations are not "organismal entities," but function as individual populations with differing physiological tolerances and life histories that are shaped by local, regional, and global environmental dynamics. Only recently have climatic changes been recognized as having a significant role in plant genetic diversity.

No combination of vegetation associations or landscapes (e.g., North America just prior to European occupation) have more intrinsic value than any other combinations or landscapes. Fossil records clearly show that vegetation associations are both plastic and dynamic. Arid regions of western North America experienced significant climatic changes with major vegetation expansions and contractions during the Holocene period, and even greater fluctuations during the inclusive Quaternary Period (Tausch et al. 1993). For example, creosote bush expanded in the southwest (Miller and Wigand, 1994). Humans have influenced the structure and composition of North American vegetation for several thousand years (Delcourt 1987). On the "protected" Hanford, Washington, site in the Columbia Basin, unintentionally introduced plants (cheatgrass, *Bromus tectorum* L., and Russian thistle, *Salsola kali* L.) have invaded and persisted on areas undisturbed by humans or livestock since 1944 (Brandt and Richard 1994) and have invaded Glacier National Park (Tyser and Worley 1992) and other areas of the Columbia and Great Basins (Ogle, personal communication 1994).

Walker (1992) and West (1993) view the preservation of ecosystem processes as more important than the maintenance of any temporal association of species or of "ecologically redundant" species. In many instances we lack the knowledge to classify organisms as ecologically redundant (e.g., an introduced grass may or may not be the ecological equivalent of an indigenous grass). Orr (1990) and others believe we will never fully understand the complexity of our global ecology; if that is so, the concept of ecological "management" will remain extremely challenging. This viewpoint illustrates the arrogance that may be associated with attempts to evaluate "ecological importance" of any one organism.

The introduction of nonnative grasses involves two major issues related to biodiversity: 1) those concerning an individual grass species or species complex and 2) those concerning vegetation type-conversion. Although some authors, e.g., Temple (1990), treated introduced plants as inherently "evil organisms," others view them as relatively benign additions (e.g., Lugo 1990, 1992), and others (e.g., Johnson and Mayeux 1992) think they "increased species richness and probably diversity." We agree with Lodge (1993) who notes that the "truth" depends on the specific situation. A successful invasion requires the coincidence of numerous ecological factors and no single model is likely to fit all circumstances, making it difficult to predict the "invasion potential" of a species. The introduction of some species has dramatically changed local habitats, e.g., the introduction of *Andropogon virginicus* C. von Linné, *Paspalum conjugatum* Bergius, and *Pennisetum setaceum* (Forskål) Chiovenda into Hawaii (Vitousek et al. 1987). Some believe that each introduction should be accompanied by proof that a given plant will not adversely affect local biodiversity. A parallel world would be required to demonstrate all possible effects. No model or experimental plot can ever accommodate all ecological factors. Thus, assessments of the invasive potential and possible adverse effects on biodiversity of a species are often "educated guesses." Nevertheless, the nine grasses reviewed here have not been found to cross with native species (Gibbs, personal communication, 1994). Even though some introduced grasses possess advantageous traits e.g., high germination, strong seedling vigor, overall robustness, salt, drought or grazing tolerance and abundant seed production, "pre-adaptation" is not automatically associated with invasive characteristics. Any estimate of the negative and positive ecological influence of introduced species must be based on scientific monitoring.

Establishment of nonindigenous grasses may effect biodiversity but the size of the area (scope) must always be a consideration in evaluating biodiversity effects. Concern is often focused on removal of existing vegetation and on the reseeding of cleared areas. Less consideration is given to the ability of introduced plants to invade relatively intact indigenous vegetation. Type-conversion involves the alteration and simplification of local ecosystems, which may markedly alter food sources, and the numbers and species of animals or fauna. In an 11-year study, Minnesota grasslands with many species were more resilient after drought than were grasslands with four or fewer species (Tilman and Downing 1994). Maintaining many species with varying tolerances to drought, frost, fire, herbivory, and fungal pathogens helps ensure the persistence of some species on a site.

Rangeland degradation, expanding desertification, and ecosystem fragmentation are interrelated issues (e.g., Allen and Jackson 1992, Lord and Norton 1990, Milton et al. 1994, Saunders et al. 1991, West 1993). The removal of vegetative cover in arid regions increases insolation, alters the hydrology, facilitates soil erosion, impairs functional processes, and often accelerates desertification. Accordingly, land managers in arid regions must examine the ecological consequences of each type-conversion and, if necessary, attempt to restore fragmented landscapes (Hobbs and Saunders 1993) which may require planting suitable introduced grasses that are adapted to the altered environments.

Exotic plant invasion, habitat fragmentation, population fragmentation, and revegetation are further discussed by Call and Roundy (1991), Coblentz (1990), Johnstone (1986), Fowler (1986, 1990), Lacy (1987), Pyke and Archer (1991), Soulé (1990, 1991), Westman (1990), and Wilson and Belcher (1989).

Each of nine species or species complexes of introduced grasses is discussed in the following sections.

bulbous bluegrass

1) taxonomy and origin

Bulbous bluegrass, which is indigenous to Eurasia, is the only *Poa* in the United States that manifests corm-like basal internodes with bulblet or bulbous spikelets. It reproduces by underground bulblets, seeds, and bulblets produced from the stem (Winward, personal communication, 1994).

1.1) scientific names

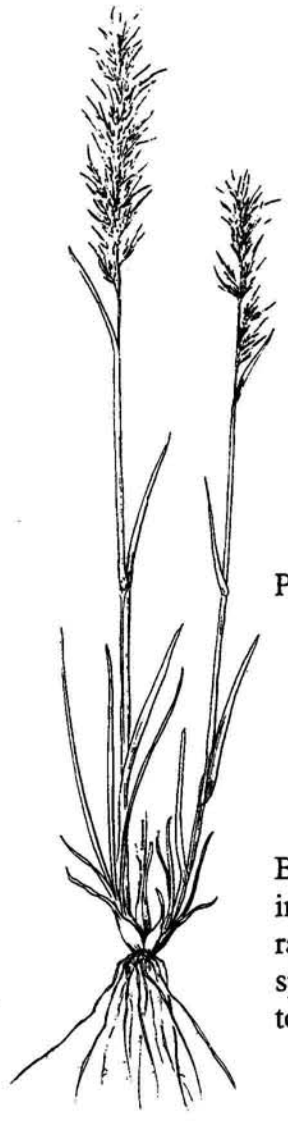
Poa bulbosa C. von Linné, Sp. Pl. ed. 1:70. 1753.
Poa bulbosa C. von Linné var. *vivipara* Koeler, Descr. Gram. 189. 1802.

1.2) other common names

Bulbous bluestem, bulbous meadowgrass, bulbous poa, black grass

1.3) cultivar names

BULBOUS BLUEGRASS



2) common uses

Pasture and soil erosion control.

3) effects on regional biodiversity

3.1) competitive ability and invasiveness

Bulbous bluegrass was introduced in the eastern United States from Russia in 1906. In 1915 it was accidentally distributed in alfalfa seed and spread rapidly throughout the western United States. Bulbous bluegrass is widespread in the Columbia River drainage and Great Basin and is well adapted to winter-rainfall zones, although stands fluctuate from year to year. Bulbous bluegrass often persists in mixtures on established bunchgrass sites. It moves into disturbed areas, can be a problem on croplands and has many of the weedy characteristics of cheatgrass (USDA-NRCS PPMC files, Pullman, Washington, examined in 1994).

Competition/invasion

In western Montana, only very small amounts of bulbous bluegrass remained on ungrazed areas the second year after planting (Gomm 1974). Hoag (personal communication, 1994) reported that bulbous bluegrass is not aggressive on the Snake River Plains at Aberdeen, Idaho. However, it spread and was competitive, especially in degraded alfalfa stands, at sites near Baker, Oregon and Fairfield, Idaho (W. C. Krueger and D. Ogle, personal communication).

Bulbous bluegrass did well east of the Cascade Mountains in the valleys and foothills of Oregon and Washington, and spread rapidly to roadsides, waste places, bench lands, foothills, and rocky slopes, in Idaho near Boise, Pocatello, Mayfield, and in Gem County (Hull, 1940). When bulbous bluegrass was seeded into a cheatgrass stand in 1937 and 1938 along with crested wheatgrass (*Agropyron cristatum (*L.) Gaertner), and bluebunch wheatgrass (*Pseudoroegneria spicata (*Pursh) A. Löve), only the bluegrass survived. It is aggressive and readily invades disturbed areas and occasionally moves into established stands of some species. Bulbous bluegrass produces abundant seed even in dry years and is well adapted to the granitic foothills of the Boise River drainage, Snake River plains, and northern Nevada and Utah. It grows aggressively in areas where spring and fall precipitation totals more than 10 inches and at elevations from 2,000 to 6,000 feet. It does well on dry gravelly soils that are low in organic matter (Hull 1940).

Competition/native plants

On a site south of Rupert, Idaho, native species replaced seeded bulbous bluegrass (Hull and Klomp 1967). We and other plant-material scientists (Carlson, Gibbs, Harris, and Ogle, personal communication, 1994) have observed that bulbous bluegrass serves as an early successional species and invades disturbed sites, but is replaced by longer-lived native perennials in eastern Oregon and Washington, northern and central Idaho, and northern Utah. Bulbous bluegrass plants may coexist with other natives but seldom dominates unless a disturbance such as overgrazing occurs. It may give way to squirreltail (*Elymus elymoides (*Raf.) Swezey), Sandberg bluegrass (*Poa secunda* Presl), and bluebunch wheatgrass, but persists with grazing pressure at Baker, Oregon, northern Utah and southern Idaho. Bulbous bluegrass invaded valleys and foothills of the Curlew National Grasslands in south central Idaho (Winward, personal communication, 1994). It is especially competitive in areas where soil dries in July and August and that receive 10 to 18 inches of annual precipitation. Some 30- to 40-year-old stands of crested wheatgrass dominated by sagebrush and rubber rabbitbrush (*Chrysothamnus nauseosus* (Pall.) Britt.) also contain bulbous bluegrass. Sandberg bluegrass, big sagebrush and yellow rabbitbrush often coexist with bulbous bluegrass (Winward, personal communication, 1994).

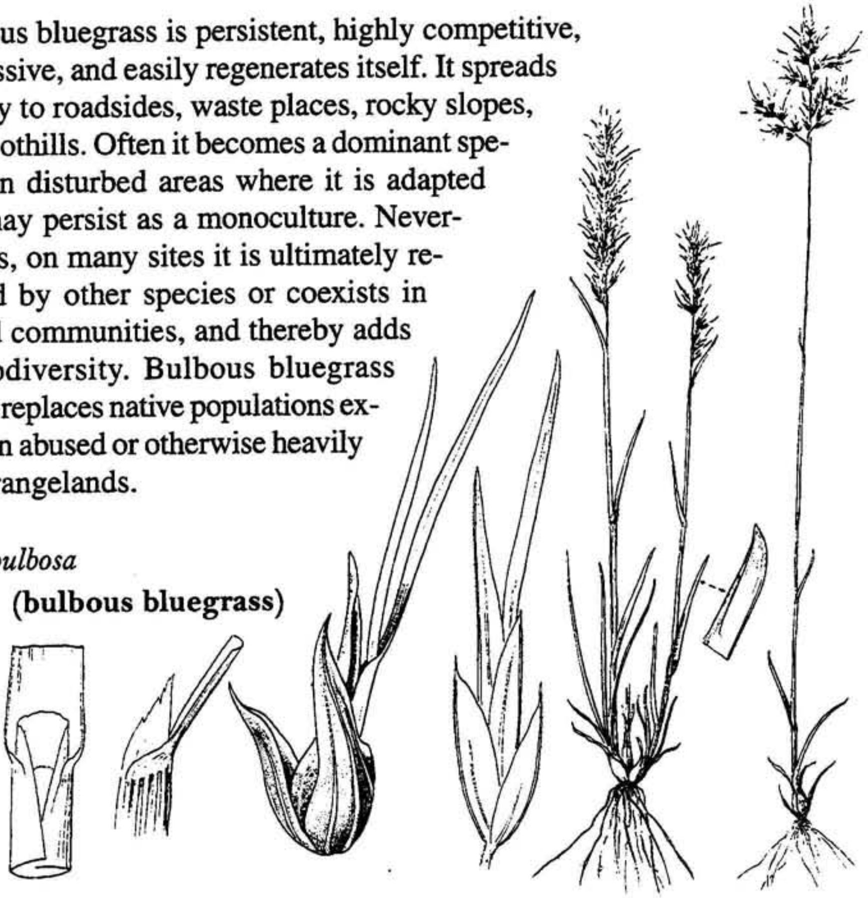
Bulbous bluegrass, seeded in plots at several locations in Washington (Republic, 1948 and 1949; Riverside, 1950 and 1951; Yakima Training Center, 1962) did not persist and by 1968 it was replaced with other seeded and native species at Republic, Riverside (Harris, unpublished report, 1994) and the Yakima Training Center (Nissen, personal communication, 1994).

3.2) wildlife usage

Mule deer have been observed by Harrison and others (McArthur and Winward, personal communications, 1994) to graze bulbous bluegrass during early spring and late fall in northern Utah and southern Idaho.

3.3) summary

Bulbous bluegrass is persistent, highly competitive, aggressive, and easily regenerates itself. It spreads rapidly to roadsides, waste places, rocky slopes, and foothills. Often it becomes a dominant species on disturbed areas where it is adapted and may persist as a monoculture. Nevertheless, on many sites it is ultimately replaced by other species or coexists in mixed communities, and thereby adds to biodiversity. Bulbous bluegrass rarely replaces native populations except on abused or otherwise heavily used rangelands.



Poa bulbosa
(bulbous bluegrass)

crested wheatgrass complex

1) taxonomy and origin

According to the taxonomic proposals of Dewey (1984) and Löve (1984), the genus *Agropyron* is restricted to those taxa comprised of the "P" genome. Species previously treated in *Agropyron* are dispersed into the following genera: *Australopyrum, Elymus, Elytrigia, Eremopyrum, Festucopsis, Pascopyrum, Pseudoroegneria, Thinopyrum,* and *Agropyron. Agropyron* is now comprised of over 100 taxa worldwide. It is defined by the following characteristics: continuous variation in rhizome elongation, culm width, leaf-blade width, spike width, spike rachis length, spike rachis internode lengths, spikelet number and attitude, spikelet length, spikelet floret number, glume length and width, glume awn length, lemma length and width, lemma awn length, palea length, and palea keel trichome number, together with the presence or absence of trichomes or purple pigmentation on various structures.

As accessions from the indigenous Eurasian range of this complex were distributed, the misapplication of scientific names has caused considerable confusion regarding the taxonomy of crested wheatgrasses. For example, in North America, the name *A. cristatum* Gaertner was traditionally applied to the "Fairway-type" cultivar morphology following Beetle's (1961) treatment; however the true *A. cristatum sensu stricto,* as circumscribed by Eurasian taxonomists, includes only those plants with oblong-ovoid spikes and ascending and pilose spikelets. The "Fairway-type" morphology actually corresponds most closely to *A. pectiniforme* Römer *et* J.A. Schultes.

The confusion surrounding the taxonomy of crested wheatgrass could be resolved by the following actions: 1) a re-examination, and where necessary, reclassification of all accessions housed in North America to conform with Eurasian treatments or 2) placement of all *Agropyron sensu stricto* into a single polymorphic, panmictic species, *A. cristatum sensu amplo,* while retaining cultivar names. The latter option may prove the most biologically realistic and workable alternative. Following is a list of taxonomic treatments of the crested wheatgrass complex.

1.1) scientific names

Agropyron cimmericum Nevski, Tr. Sredneaz. Univ. ser. 8B, 17:56. 1934.

Agropyron cristatiforme Sarkar, Can. J. Bot. 34:333. 1956.

Agropyron cristatum (L.) Gaertner, Nov. Comm. Acad. Sci. Petrop. 14:540. 1770, *sensu amplo*.

Agropyron cristatum (C. von Linné) Gaertner ssp. *dasyanthum* (Ledebour) Á. Löve, Feddes Rept. 95(7/8):431. 1984.

Agropyron cristatum (C. von Linné) Gaertner ssp. *desertorum* (Fischer *ex* Link) Á. Löve, Feddes Rept. 95(7/8):431. 1984.

Agropyron cristatum (C. von Linné) Gaertner ssp. *fragile* (Roth) Á. Löve, Feddes Rept. 95(7/8):431. 1984.

Agropyron cristatum (C. von Linné) Gaertner ssp. *imbricatum* (Bieberstein) Á. Löve, Feddes Rept. 95(7/8):431. 1984.

Agropyron cristatum (C. von Linné) Gaertner ssp. *michnoi* (Roshevitz) Á. Löve, Feddes Rept. 95(7/8):432. 1984.

Agropyron cristatum (C. von Linné) Gaertner ssp. *mongolicum* (Keng) Á. Löve, Feddes Rept. 95(7/8):432. 1984.

Agropyron cristatum (C. von Linné) Gaertner ssp. *pectinatum* (Bieberstein) Tzvelev, Sched. Herb. Fl. URSS 18:25. 1970.

Agropyron cristatum (C. von Linné) Gaertner ssp. *tarbagataicum* (Plotnikov) Tzvelev, Nov. Sist. Vyssch. Rast. 9:58. 1972.

Agropyron dasyanthum Ledebour, Ind. Sem. Horti Dorpat. 3. 1820.

Agropyron desertorum (Fischer *ex* Link) J.A. Schultes *in* J.A. *et* J.H. Schultes, Mantissa 2:412. 1824.

Agropyron deweyii Á. Löve, Feddes Rept. 95(7/8):432. 1984.

Agropyron fragile (Roth) Candargy, Arch. Biol. Vég. (Athènes) 1:58. 1901.

Agropyron fragile (Roth) Candargy ssp. sibiricum (Willdenow) Melderis, Bot. J. Linn. Soc. 76:384. 1978.

Agropyron imbricatum Römer *et* J.A. Schultes, Syst. Veg. ed. 15, 2:757. 1817.

Agropyron michnoi Roshevitz, Izv. Glavn. Bot. Sada SSSR 28:384. 1929.

Agropyron mongolicum Keng, J. Wash. Acad. Sci. 28:305. 1938.

Agropyron pectiniforme Römer *et* J.A. Schultes, Syst. Veg. ed. 15, 2:758. 1817.

Agropyron sibericum (Willdenow) Palisot de Beauvois, Essai Agrost. 102,146, 181. 1812.

Agropyron sibericum (Willdenow) Palisot de Beauvois var. *desertorum* (Fischer *ex* Link) Boissier, Fl. Orientalis 5:667. 1884.

Agropyron tanaiticum Nevski, Tr. Sredneaz. Univ. ser. 8B, 17:56. 1934.

Agropyron tarbagataicum Plotnikov, Tr. Omsk. Sel'sk. Inst. 20:131, 143. 1941-1946.

Elymus pectinatus (Bieberstein) Laínz, Bol. Inst. Estud. Astur., Suppl. Cienc. 15:44. 1970.

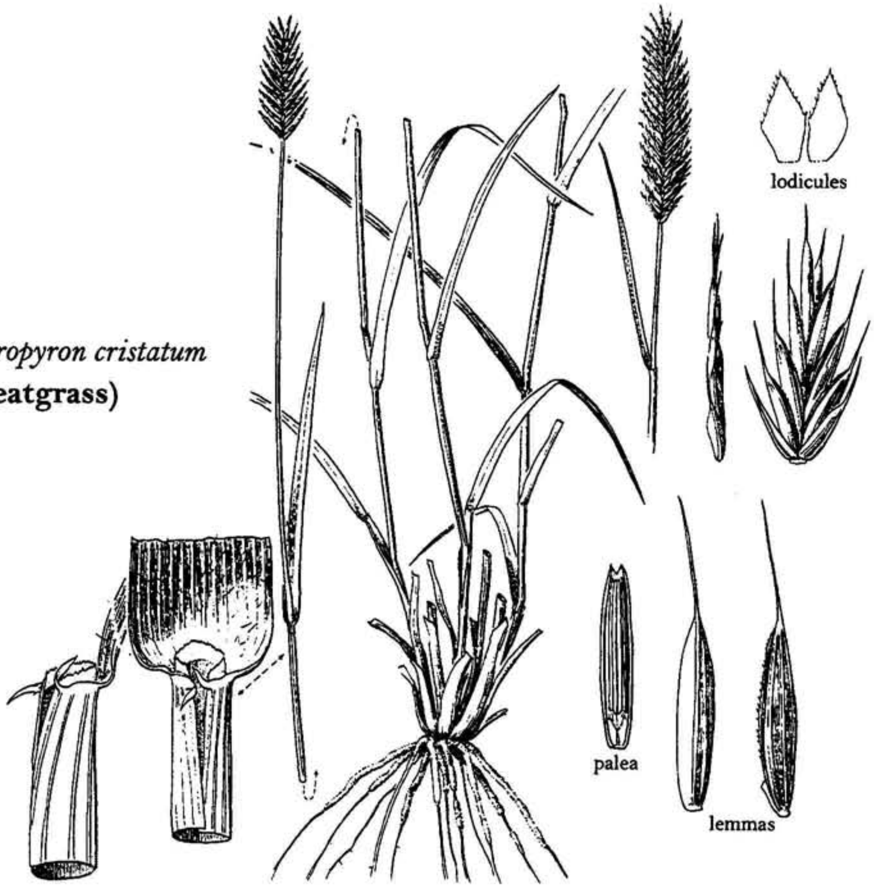
1.2) other common names

Desert crested wheatgrass, desert wheatgrass, Fairway crested wheatgrass, Siberian wheatgrass, Siberian crested wheatgrass, Mongolian wheatgrass, Standard crested wheatgrass, Transbaikal wheatgrass

1.3) cultivar names

EPHRAIM, FAIRWAY, HYCREST, KIRK, NORDAN, PARKWAY, P-27, RUFF, SUMMIT, DOUGLAS, VAVILOV

Agropyron cristatum
(crested wheatgrass)



2) common uses

Pasture, hay, soil conservation practices, turf, wildlife

3) effects on regional biodiversity

3.1) competitive ability and invasiveness

Crested wheatgrass is one of the most successful grasses introduced into the sagebrush-grass ecosystem of the Columbia and Great Basins. It was the first species successfully seeded into sagebrush-grass sites in southern Idaho, and continues to be one of the best adapted species (Hull and Klomp 1966). It has wide adaptation, long life, drought and cold resistance, relative freedom from disease, good productivity and palatability, persistence under abuse, good competitive ability, high seed production, ease of establishment and excellent seedling vigor (Hull and Klomp 1966). Standard and Fairway crested wheatgrass were first introduced around 1900 and have been important in range revegetation since the 1930's (Sharp 1986).

Dwyer (1986) stated that crested wheatgrass may be the single most economically and biologically important range plant in North America. This grass was introduced from Siberia where it evolved with intensive grazing. An accurate estimate of the acreage seeded to crested wheatgrass in North America is not available. It has been used to revegetate depleted bluebunch wheatgrass sites.

> Economically and ecologically astounding by most measures, crested wheatgrass produces from 3 to 20 times the grazing capacity of the native plants it has replaced. It sustains heavy and long or even continual grazing, much to the surprise of most early range ecologists who predicted it would easily succumb to the pressures of grazing or to its new environment or a combination of both. Not only has it not succumbed, but crested wheatgrass has survived three of the century's worst droughts.
>
> After 50 years I believe this plant has gained its ecological credentials and is now subject to our vegetative classification schemes. Therefore I am declaring it is a range plant. We have decided here at Utah State University that crested wheatgrass deserves to receive its papers—at least a permanent work visa if we cannot grant it a citizenship based on naturalization (Dwyer 1986).

Seedling competition

Johnson (1986) reviewed seedling establishment of crested wheatgrass and focused on competition with cheatgrass. Cheatgrass is a strong competitor with seedlings of crested wheatgrass because cheatgrass has high seed production, highly viable seeds that germinate rapidly and emerge aggressively, excellent seedling competition, rapid and extensive root penetration and development. Johnson (1986) concludes that early seedling root development and seedling ability to tolerate widely fluctuating moisture and temperature conditions undoubtedly contribute to the ease of establishment of crested wheatgrass.

Species such as crested wheatgrass resist cheatgrass competition better than does western or bluebunch wheatgrass (Rummell 1946). Crested wheatgrass germinates earlier and grows more rapidly than western wheatgrass. Bluebunch wheatgrass is also characterized by rapid germination and growth, but cheatgrass extends its roots more rapidly during the winter, thus gaining control of the site before bluebunch seedlings become established (Harris 1965). Cheatgrass matures 4 to 6 weeks earlier and utilizes the limited moisture supply prior to use by bluebunch. Whitmar bluebunch wheatgrass is slower to establish than crested wheatgrass and requires 7 or more years to produce the same amount of vegetation (Douglas et al. 1960). Roots of crested wheatgrass grow at colder temperatures than do roots of bluebunch wheatgrass (Harris and Wilson 1970, Eissenstat 1986, Eissenstat and Caldwell 1988a), which appears to impart an important competitive advantage.

Competition/native plants

Big bluegrass (*Poa amplaMerr*) successfully competed with crested wheatgrass at Burns, Oregon (Sneva and Hyder 1965). Sherman big bluegrass may produce as much or more drymatter yield than Nordan crested wheatgrass (Douglas et al. 1960, Hyder and Sneva 1963, Rittenhouse and Sneva 1976, and Sneva and Hyder 1965). However, Douglas et al. (1960) found that the stand density of crested wheatgrass was superior to that of Sherman big bluegrass. Nordan crested wheatgrass and P-27 Siberian wheatgrass did not persist after 15 years at Lind, Washington, and were replaced by over-seeded species of Sherman big bluegrass and Secar bluebunch wheatgrass (Stannard 1994).

Crested wheatgrass stands at Vale, Oregon, and elsewhere (Hull and Klomp 1966, Blaisdell et al. 1982, Johnson 1986,USDA-ARS 1992) have persisted for 30-50 years. Big sagebrush (*Artemisia tridentata* Nutt.) repopulated the crested wheatgrass plantings at Vale and provided about 15% of the cover in plowed and seeded areas during a 20-year period (Heady 1988). However, in areas sprayed with herbicide and then seeded with a mixture of crested and bluebunch wheatgrass, sagebrush returned to pretreatment levels in about 10 years. In both sprayed and seeded mixture areas at Vale, bluebunch wheatgrass (which is less tolerant of grazing than crested wheatgrass) has decreased and crested wheatgrass has increased. Palatability differences account for differences in use by livestock of the two species. In an area protected from grazing, bluebunch wheatgrass and other native species are unchanged or have increased moderately (Heady 1988, Rumple, personal communication, 1994). Hyder and Sneva (1963) attributed the grazing tolerance of crested wheatgrass to early root-growth activity, early accumulation of leaf tissue, and early accumulation of carbohydrate reserves in underground parts.

Eighteen years after crested wheatgrass was planted in a native grass mixture dominated by green needlegrass (*Stipa viridula* Trin.) and western wheatgrass herbage yield of the native grasses exceeded that of crested wheatgrass. Green needlegrass increased and encroached on the adjoining crested wheatgrass strips under management that included spring and winter grazing (McWilliams and Van Cleave 1960).

Crested wheatgrass is better as a monoculture rather than as a successional species that is replaced by native species (Anderson and Marlette 1986). At four crested wheatgrass sites, two were essentially monocultures and two had been re-invaded by native species (primarily *Artemisia tridentata*) 24-30 years after planting (Marlette and Anderson 1986). However, crested wheatgrass was abundant in surrounding native communities well beyond the original seeding. They conclude that "crested wheatgrass retards development of a diverse plant community," and should be reduced or eliminated before other species are planted to enhance biodiversity.

Near Cheyenne, Wyoming, use of crested wheatgrass doubled the cattle stocking rate of native range (Hart et al. 1983). The native range was dominated by bluegrama (*Bouteloua gracilis* (H. B. K.) Lag. ex Griffiths), western wheatgrass, sedges (*Carex* spp.), and needle-and-threadgrass (*Stipa comata* Trin. and Rupt.). Crested wheatgrass effectively reduced livestock pressure on the native range and promoted more rapid recovery. Although some native species invade crested wheatgrass, many stands have remained productive for 20 to 45 years (Asay and Knowles 1985, Dillman 1946, Hull and Klomp 1966, Cook 1966).

Although planting various wheatgrasses, particularly crested wheatgrass, can effectively control annual weeds like cheatgrass (Asay and Johnson

1983), others believe that introduced perennials are not compatible with most native species and may hinder native plant recovery (Monsen and Shaw 1983, Walker et al. 1993, Marlette and Anderson 1986). Crested wheatgrass effectively competes with ponderosa pine seedlings (*Pinus ponderosa* Laws) for moisture and available nitrogen near Flagstaff, Arizona (Eliot and White 1987).

Invasion by crested wheatgrass

Over a 30-year period at the Vale project, crested wheatgrass plants invaded stands with poor bluebunch wheatgrass condition/vigor (areas where livestock were concentrated, areas recovering from drought, etc.)†(Rumple, personal communication, 1994). The density of crested wheatgrass was never associated with an increase in the density of bluebunch wheatgrass. Mortality of both wheatgrasses increased during some periods of drought and plant recruitment ceased. Big sagebrush and rabbitbrush were the only native species to invade stands of crested wheatgrass, and tended to invade less vigorous stands. Established stands of Nomad alfalfa persist in crested wheatgrass stands at Vale, Oregon.

In nine 20- to 30-year-old crested wheatgrass seedings in southern Idaho, consisting mostly of Fairway and Standard crested wheatgrass, threetip sagebrush (*Artemisia tripartita* Pydh.) and big sagebrush reinvaded some areas, depending on the initial elimination of sagebrush, seedbed preparation, and availability of sagebrush seed (Hull and Klomp 1966). In contrast, bluebunch wheatgrass declined in density and was replaced by sagebrush.

There are sites in the Great Basin where crested wheatgrass has not spread, including some 40-year-old crested wheatgrass plants with no evidence of progeny established around the original plants (USDA-ARS 1992). Nissen and Pudney (personal communication, 1994) noted that Nordan and Siberian wheatgrasses coexist with natives such as bluebunch wheatgrass, Sandberg bluegrass, bottlebrush squirreltail and others after fire (some stands are 15 years old). On the Yakima Training Center in Washington, crested wheatgrass did not appear to spread or compete with native species.

Brush invasion of crested wheatgrass

Big sagebrush, with its 5- to 11-foot taproot and highly branched roots (Weaver and Clements 1938), effectively competes with crested wheatgrass (Cook and Lewis 1963). Sagebrush roots tend to concentrate at depths of 6-7 inches (Robertson 1943). Big sagebrush reinvades stands of crested wheatgrass subjected to livestock grazing (Cook and Lewis 1963, Robertson 1943). Crested wheatgrass ranks 7th of 17 grass species in resistance to sagebrush invasion/competition (Robertson 1947). Sagebrush is likely to reinvade seeded areas despite control efforts (Hyder 1954), even when managed to minimize encroachment by sagebrush (Sneva 1971). Sagebrush and rubber rabbitbrush invaded excellent 6-year-old stands of crested wheatgrass in a conservation reserve planting in the Twin Falls, Idaho area, from seed sources more than 1/2 mile away (Ogle, personal communication, 1994).

In northeastern Nevada, sagebrush invades seedings of grass immediately after brush is removed (Frischknecht and Bleak 1957). Moreover, big sagebrush recruitment is more likely to occur in bluebunch wheatgrass than in crested wheatgrass. However, bluebunch wheatgrass appears to be a stronger competitor against big sagebrush invasion on a mountain site in Wyoming (Reichenberger and Pyke 1990).

Mountain big sagebrush competes more successfully with bluebunch wheatgrass than with Standard crested wheatgrass, as evidenced by the fact that the roots of Artemisia were generally two to three times more abundant in areas with *Pseudoroegneria* than in those with *Agropyron* (Caldwell et al. 1991).

When Wyoming big sagebrush transplants were used as indicator plants, Standard crested wheatgrass was more competitive than bluebunch wheatgrass (Eissenstat and Caldwell 1988b). Survival, growth, reproduction, and late-season water potential of big sagebrush were lower when growing in stands of crested wheatgrass than in stands of bluebunch wheatgrass. Crested wheatgrass, which has thinner roots, has approximately twice the root length and exhibits greater root growth in winter and early spring than bluebunch wheatgrass (Eissenstat 1986). Eissenstat and Caldwell (1988a, 1988b) conclude that rapid water extraction by crested wheatgrass relative to bluebunch wheatgrass aids its ability to compete with big sagebrush. In greenhouse tests, greater root branching densities, lateral root lengths, and external link lengths enabled Hycrest crested wheatgrass to grow faster than Whitmar
Many crested wheatgrass seedings evaluated by Evans et al. (1986) were infested with sagebrush and rabbitbrush within 5 to 10 years of establishment. Brush infestations, with 20 to 25% crown cover, drastically reduce growth of associated grasses. Each 1% increase of sagebrush crown cover may decrease forage production by 5% (Rittenhouse and Sneva 1976).

On foothill rangelands in Utah it required only 2 years for big sagebrush to reinvade 70% of the stands of crested, intermediate, and tall wheatgrass (Cook and Lewis 1963). Big sagebrush densities ranged from 15 to 30 plants per 100 square feet. Removal of big sagebrush with herbicide increased soil moisture, grass height, and leaf length.

Spread/reseeding

Early researchers recognized the potential for crested wheatgrass to spread. Reitz et al. (1936) recommended drilling crested wheatgrass in 4-row strips, 30-meters apart across the prevailing wind, and deferring grazing for 2 or 3 years to help young plants become established, produce seed and spread. Stewart (1938) recommended drilling weedy land in strips across the prevailing wind to cover one-fifth to one-third of the total area.

In southern Idaho, Fairway crested wheatgrass became more dense and plants spread to adjacent areas (Hull and Klomp 1967). Weintraub (1953) also found that crested wheatgrass reseeds itself on western rangelands. Crested wheatgrass spread to rocky areas and waste places on sagebrush ranges at Blackfoot and American Falls, Idaho (Hull and Klomp 1967). At Dubois, Idaho, it spread 120 feet in 17 years. Standard, Fairway, and Siberian crested wheatgrasses spread from small seeded plots to areas 169, 438, and 131% of the original seedings, respectively. However, the spread of Siberian wheatgrass was erratic.

Crested wheatgrass produces many more seeds than bluebunch wheatgrass, and its seed production decreases little in dry years, unlike bluebunch wheatgrass, which produces no seed in dry years (Pyke 1990). Further, bluebunch wheatgrass seeds disperse when mature, while crested wheatgrass retains some seeds and disperses them slowly throughout the year, thus escaping peak periods of seed predation. Seeds are carried beyond 1 year on crested wheatgrass but not on bluebunch wheatgrass plants. Demographic factors associated with seeds of crested wheatgrass seem to favor maintenance and spread into native stands formerly dominated by bluebunch wheatgrass (Pyke 1990). In established stands in eastern Washington, crested wheatgrass outcompetes bluebunch wheatgrass (Roché and Pudney, personal communication, 1994).

Water Relations/Seed Production

Western wheatgrass (*Pascopyrum smithii* (Rudd) A. Löve) maintains a higher leaf water potential than crested wheatgrass and its reduced growth rate during drought allows it to remain green longer than crested wheatgrass (Frank 1981). Crested wheatgrass begins growth earlier in the spring than either western or beardless wheatgrass, and its seed matures sooner (Cook and Harris 1968). The roots of crested wheatgrass invade disturbed soil more rapidly and grow more quickly in early spring than do the roots of bluebunch wheatgrass (Eissenstat and Caldwell 1989, 1988a).

Crested wheatgrass and bluebunch wheatgrass extract phosphorus and water at similar rates in the early spring, but crested wheatgrass extracts more phosphorous later in the spring (Eissenstat 1986, Eissenstat and Caldwell 1988b). Furthermore, compared to bluebunch wheatgrass, crested wheatgrass may reduce the uptake of phosphorus by neighboring Wyoming big sagebrush plants (Eissenstat and Caldwell 1989).

Defoliation Tolerance

The ability of crested wheatgrass to recover from defoliation better than bluebunch wheatgrass appears to be related to rapid growth of new tillers in crested wheatgrass (Caldwell et al. 1981). Crested wheatgrass uses less nitrogen and produces less biomass per unit area of photosynthetic tissues than bluebunch wheatgrass. It produces more tillers and leaves per bunch and shorter stems than bluebunch wheatgrass, factors that may increase its tolerance of defoliation. After 6 years, crested wheatgrass had declined in a mixture planted with Whitmar bluebunch wheatgrass and numerous natives including snowberry (*Symphoricarpos* spp. Juss), balsam root (*Balsamorhiza sagittata* Pursh), western yarrow (*Achillea lanulosa* Nutt.), penstemon (*Penstemon* spp. Mitch), blue elderberry (*Sambucus coerulea* Raf Juss), and annuals (Zamora, personal communication, 1994).

Squirreltail competes vigorously with crested wheatgrass and also invades both cheatgrass and medusahead stands (*Taeniatherum caput medusae* L.) Nevski spp. *asperum,* formerly *Elymus caput-medusae* L.) (Keller 1979).

3.2) wildlife usage

Deer, antelope, elk, bighorn sheep and livestock

Mule deer prefer Fairway crested wheatgrass in spring and fall to several other grasses, including various natives (Austin et al. 1994). Spring livestock grazing on crested wheatgrass reduces subsequent winter use by mule deer (Austin et al. 1983). In British Columbia, green crested wheatgrass ranks below Sandberg bluegrass in mule deer diets during 6 March to 5 May and was the most important plant in their diet from 6 to 31 May (Willms and McLean 1978).

Crested wheatgrass seedings provide a high-quality forage that helps wildlife rapidly recover body condition after the stressful winter period. Seeded species supply green herbage on many sagebrush winter ranges where native species are either dormant or produce little foliage. Crested wheatgrass supplies quality forage in the fall and during snow-free periods of the winter, thereby extending the availability of browse. Seeding crested wheatgrass on spring-fall range reduces both browse use by livestock and livestock competition with wildlife (Lamb 1966, Vale 1974) (Appendix II).

Both use of crested wheatgrass and its nutritional value to deer and antelope vary by region and locality (Urness et al. 1983, Urness 1986). Green growth of crested wheatgrass from fall to mid-spring supplements browse diets, and plantings have ameliorated conflicts between use by deer and livestock on foothill ranges. Antelope depend more on forbs and derive less direct benefit from crested wheatgrass seedings than livestock or deer. Crested wheatgrass seedings are heavily used by elk and bighorn sheep (Urness 1986).

In a rehabilitation effort at Vale, Oregon, crested wheatgrass establishment did not help or harm wildlife and may have improved wildlife habitat overall (Heady 1988). The number of deer and antelope seem to have increased in response to the reduction of tall brush and the increase of winter forage made available by fall growth of crested wheatgrass.

Jackrabbits

Black-tailed jackrabbits in southern Curlew Valley (on the Utah-Idaho border) removed approximately 70% of total forage from the crested wheatgrass seeding. Most use occurred in a 300 meter-wide band around the perimeters (Westoby and Wagner 1973). Even when jackrabbit densities are high, they may not seriously damage established crested wheatgrass seedings.

Black-tailed rabbits used nearly twice as much Nordan crested wheatgrass and Hycrest crested wheatgrass as Magnar and Trailhead basin wildrye (*Leymus cinereus* (Scribner and Merr) A. Löve), Secar and Goldar bluebunch wheatgrass, #9021076 thickspike wheatgrass (*Elymus lanceolatus (*Scribn. and Smith) Gould), and Bozoisky Russian wildrye (*Psathyrostachys juncea* (Fisch) Nevski) (Ganskopp et al. 1993). Seeding unpalatable cultivars might: (1) discourage jackrabbits from using highway right-of-ways, (2) reduce competition between jackrabbits and livestock for forage, and (3) reduce potential damage to ground cover or forage resources in critical areas during jackrabbit population peaks. Conversely, seeding palatable cultivars might lure jackrabbits from less palatable but more valuable crops or forages.

Birds

Shrub-dependent nongame bird species are displaced by the establishment of crested wheatgrass seedings in sagebrush communities (McAdoo et al. 1986, Reynolds and Tract 1981). However, ground-nesting species increase when herbaceous cover improves. The total number of birds in the seeding may be similar to that of unconverted sagebrush habitat, but there are fewer bird species and relative abundance of species is much different in the monoculture seeding. As sagebrush invades crested wheatgrass, the number of shrub-nesting bird species increase. Changes in the populations of prey species resulting from changes in shrub and herbaceous cover may affect raptor distribution, nesting success, etc. Prey abundance and vulnerability may also change after conversion. Eagle numbers increase with the conversion from sagebrush to grass.

The relative abundance of nongame birds nesting in either shrubs or grass (shrub and grass-nesters) in central Nevada was 18 and 82% in a monoculture crested wheatgrass seedings, 48 and 52% in sagebrush-invaded seedings, and 80 and 20% in unconverted sagebrush (McAdoo et al. 1986).

Rodents and Small Mammals

Habitat use and food selection of four types of rodent were determined near a sagebrush/crested wheatgrass interface in southeastern Idaho (Koehler and Anderson 1991). Thirty-seven percent of the rodents were captured in the native sagebrush, 33% in disturbed/unseeded sites, and 30% in crested wheatgrass. Montane voles were almost exclusively associated with crested wheatgrass. The Ord's kangaroo rat made substantial use of crested wheatgrass (82% and 91% in July and August, respectively). Crested wheatgrass use by deer mice was highest at seed set, and made up the bulk of the diet of the ground squirrel. These four mammal species are uncommon in the native sagebrush type, but comprise a large part of the mammal community on seeded sites.

On 21 crested wheatgrass pastures (100 acres each) on the Benmore Experiment Station south of Tooele, Utah, deer mice or nests were found on one-half of the plots where grass utilization was less than 50% and on one-third of the plots where grass utilization exceeded 50% (Frishknecht 1965). Food in caches consists mainly of mature heads of crested wheatgrass and small bulbs of bulbous bluegrass. Johnson (1961) studied the food habits of western harvest mice in sagebrush and shadscale associations in southern Idaho. The mice frequently consume seeds and vegetative parts of crested wheatgrass during August and were most common in stands of crested wheatgrass. Ground squirrels and their predators benefited from an increase in crested wheatgrass at Vale, Oregon (Heady 1988).

Small mammal densities on crested wheatgrass seedings at Surface Disposal Areas (SDA) in southeast Idaho equaled or exceeded densities in the adjoining sagebrush (Boone and Keller 1993). Densities were highest along the SDA edge where an earthen dike separates the seeded SDA from the native sagebrush, and varied more in the adjoining native sagebrush.

3.3) summary

Crested wheatgrass is well adapted to much of the western United States. The crested wheatgrass taxa are generally long-lived on adapted sites in both the Columbia River drainage and Great Basin. Some plantings in the Great Basin have persisted for more than 50 years, while other well established stands have died out after 5 to 15 years. Full, properly managed stands of crested wheatgrass withstand encroachment by native grasses and forbs. However, some natives (big sagebrush and rabbitbrush) often invade the stands, especially if seed sources are nearby.

Researchers differ in their views of the invasiveness, spread, and the effects on biodiversity of crested wheatgrass. However, most agree that it moved slowly where it has spread or invaded native sites. Some conclude that it persists as a monoculture, with little or no biodiversity, while others report it coexists with native species and improves biodiversity. In its native habitat it occurs in association with many other species. Many birds and small rodents eat crested wheatgrass seeds; mule deer and elk graze it, especially in early spring and fall. Many taxa in the crested wheatgrass complex originated in Eurasia and compete well with undesirable weedy species from the same region, such as cheatgrass and Russian thistle.

hard and sheep fescue

1.1) taxonomy and origin for hard fescue

Hard fescue is not native but commercial seedings and naturalization have extended its distribution through most of North America (Aiken and Darbyshire 1990). Older taxonomic treatments (e.g., Hitchcock 1935, 1951; Piper 1906) of the genus *Festuca* in North America included early introductions of hard fescue in *Festuca ovina* C. von Linné var. *duriuscula* (C. von Linné) Koch as did most subsequent regional floras and other works. As discussed by McNeill and Dore (1976), the type specimen of *F. ovina* var. *duriuscula* is actually a plant of the *F. rubra* complex; consequently, the names *F. duriuscula* and *F. ovina* var. *duriuscula* have been misapplied to hard fescue.

The assigned name for hard fescue depends on the approach of individual taxonomists. Within the Flora Europeae, Markgraf-Dannenberg (1980) recognized 115 species and numerous additional infraspecific taxa in the *F. ovina/F. rubra* aggregate employing putatively diagnostic combinations of ploidy level, rhizome elongation, degree of sheath margin connation, and spikelet bract variation, together with such esoteric character-states as position and amount of leaf-blade sclerenchyma or percentage of leaf-blade epidermal stomata with accompanying silica cells. As a consequence, *F. ovina* C. von Linné *sensu stricto* is applied exclusively to diploid ($2n = 2x = 14$) plants of northern and central Europe, only weakly differentiated from diploid plants of Asia and North America, which are arbitrarily segregated as different species.

More recent treatments of the *F. ovina/F. rubra* aggregate in North America (e.g., Aiken and Darbyshire 1990; Dore and McNeill 1980; Gleason and Cronquist 1991) accept the narrower, vague Eurasian definitions, and relegate *F. ovina sensu stricto* species to alien status. As a consequence, there is the misconception that no portion of the *F. ovina/F. rubra* aggregate is indigenous to North America. Although the *F. ovina/F. rubra* aggregate is circumboreal, some taxonomists treat the indigenous populations of North America as a single polymorphic species. Others split them into the 10 native species recognized by Aiken and Darbyshire (1990).

In Europe, the common name hard fescue is loosely applied to a group of hexaploid ($2n = 6x = 42$) *F. ovina* segregates, primarily *F. brevifolia* Tracey, *F. guestfalica* Bönninghausen *ex* Reichenbach, and *F. lemanii* Bastard. Hard fescue introductions to North America may be treated as alien material of

F. ovina sensu amplissimo, or as one of five or more segregate species, depending upon the subtle morphological differences exhibited by individual plants. Appropriate valid scientific names are listed below:

1.11) scientific names

Festuca brevifolia Tracey, Plant Syst. Evol. 128: 287. 1977.
Festuca carnuntina Tracey, Plant Syst. Evol. 128: 289. 1977.
Festuca glauca Villars, Hist. Pl. Dauph. 2: 99. 1787.
Festuca guestfalica Bönninghausen *ex* Reichenbach, Fl. Germ. Excurs.140. 1831.
Festuca lemanii Bastard, Essai Fl. Maine et Loire. 36. 1809.
Festuca ovina C. von Linné var. *trachyphylla* (Hackel) Druce, List Brit. Pl. 83. 1908.
Festuca ovina C. von Linné subvar. *trachyphylla* Hackel, Monogr. Festuc. Eur. 91. 1882.
Festuca duriuscula auctorum non C. von Linné [= *F. rubra* C. von Linné *sensu amplo*]
Festuca ovina C. von Linné var. *duriuscula auctorum non* (C. von Linné) Koch [= *F. rubra* C. von Linné *sensu amplo*]
Festuca trachyphylla Hackel *ex* Druce, Rep. Bot. Exch. Cl. Brit. Isles 1914(4): 30. 1915. [= *F. dumetorum* Philippi, Linnaea 33: 297. 1864, *non* C. von Linné, Sp. Pl. ed. 2: 109. 1762.]
Festuca trachyphylla (Hackel) Krajina, Acta Bot. Bohem. 9:191. 1930, *non* Hackel *ex* Druce, Rep. Bot. Exch. Cl. Brit. Isles 1914(4): 30. 1915.

1.12) other common names

Hard sheep fescue, sheep fescue

1.13) cultivar names

DURAR

1.2) taxonomy and origin for covar sheep fescue

Covar sheep fescue, a native of Konya, Turkey, was introduced to the United States in 1934.

1.21) scientific names

Festuca ovina C. von Linné, Sp. Pl. ed. 1:73, 1753
sensu amplissimo

1.22) other common names

sheep fescue

1.23) cultivar names

COVAR

2) common uses for hard and sheep fescue

Soil erosion control, pasture, turf, watershed protection, roadside beautification, airports, dams sites, terraces, diversions, ditchbanks, mine spoils, ski slopes.

3) effects on regional biodiversity for hard and covar sheep fescue

3.1) competitive ability and invasiveness

Both hard fescue and sheep fescue are very competitive and may become monocultures. Covar, a cultivar of sheep fescue adapted to the 10 to 18 inch rainfall areas in the Columbia Basin, is more drought tolerant than the hard fescue cultivar Durar (*Festuca trachyphylla* (Hackel) Krayina). Rows of the two cultivars planted 35 years ago by the Soil Conservation Service are still visible. Other plants seldom encroach into established seedings of Durar or Covar fescue.

Hard fescue readily invades disturbed sites. Its early successional habitats were recognized as valuable traits in turf and pasture plant development. The extensive root production of Durar is a valuable trait in soil stabilization and watershed protection projects. Durar is well adapted in the 15-24 inch precipitation zone (Ensign 1985).

In a planting at Pullman,Washington, (5 lbs. of crested wheatgrass and 5 lbs. of hard fescue) Durar completely suppressed crested wheatgrass after 6 years (Schwendiman et al. 1964). Several plantings have demonstrated Durar's ability to outcompete cheatgrass and other annuals, due in part to its massive root system (7,500-15,000 pounds per acre) (Pullman, Washington, NRCS, PPMC files researched 1994). Hard fescue persists at Smoot, Wyoming after 14 years, but does not compete well with natives (Gomm, personal communication, 1994).

Several decades after Durar hard fescue was seeded alone or with 61 other species and cultivars at three locations in Washington, it occupied almost half of the seeded areas (Harris and Dobrowolski 1986). However, after 20 years, plots seeded to Durar were completely taken over by pinegrass and elk sedge on Grand and Douglas fir sites (Roché, personal communication, 1994).

Covar sheep fescue, a selection from Turkey, has massive root production and is very competitive as an understory grass on sites favorable to many native species. It suppresses brush invasion when chaparral communities are burned (Ensign 1985). In a 45-year-old seeding Covar sheep fescue stopped encroachment by deer brush (*Ceanothus* sp.) south of Baker, Oregon (Carlson, personal communication, 1994). *F. ovina longifolia* was established in the lodgepole pine-Douglas fir forest-grasslands of western Montana that were dominated by Idaho fescue (Gomm 1974).

Covar and Durar compete with spotted knapweed (*Centaurea maculosa* Lam.) in northern Idaho. However, Covar generally spreads very slowly by seed and has not replaced native stands (Carlson, Gibbs, Krueger, and Ogle, personal communication, 1994). Cascade trefoil (*Lotus* sp L.), Canadian thistle (*Cirsium arvense* (L.) Scop) and smooth brome (*Bromus inermis* Leyss.) invade Covar sites. After 20 years Covar had spread from seeded plots at some sites (Kelly, personal communication, 1994). Sheep fescue and other introduced grass species have little or no effect on stands of dalmatian toadflax (Gates and Robocker 1960). *Festuca ovina* ssp. *sulcata* persisted for 52 years on a big sagebrush site in south-central Idaho but three other ecotypes failed to survive for 10 years (Monsen and Anderson 1993).

3.2) wildlife usage

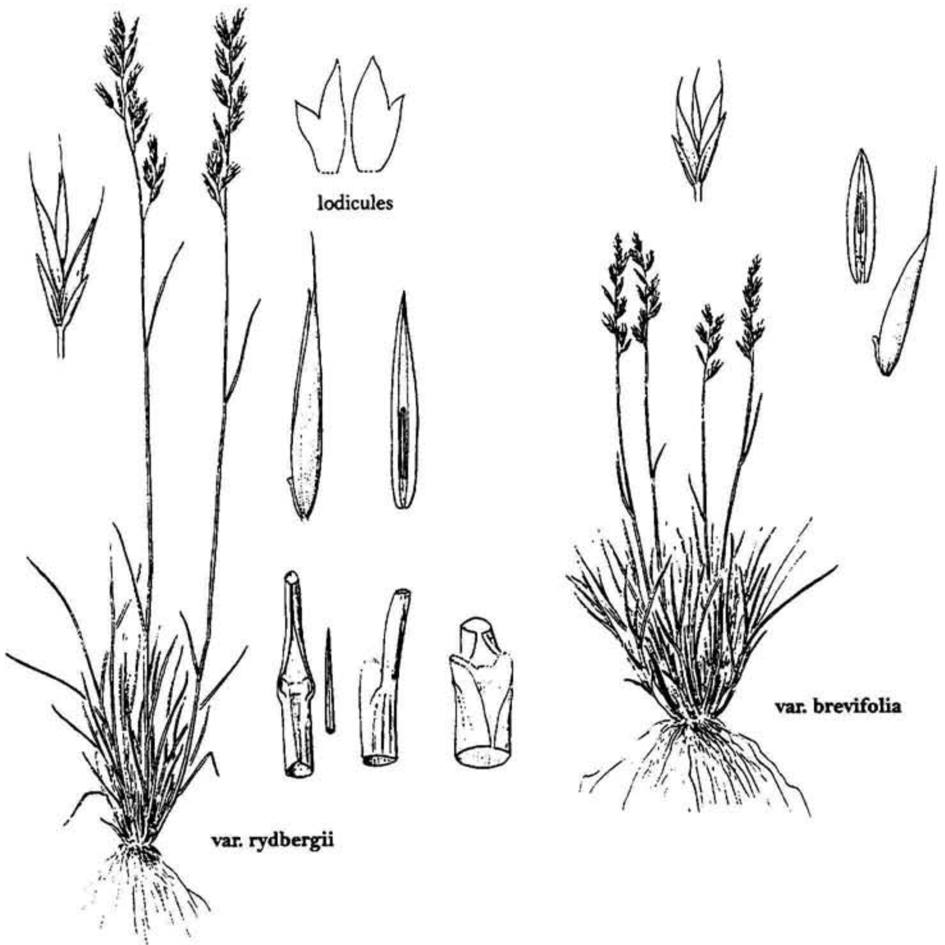
Wild birds prefer the small seeds of sheep fescue to the large seeds of perennials such as intermediate and pubescent wheatgrass (Goebel and Berry 1970). Durar hard fescue appears to encourage rodent activity. Although, herbivores do not prefer Durar and Covar fescues, mule deer and elk graze them in early spring (Gibbs and Ogle, personal communication, 1994).

3.3) summary

Within their areas of adaptation both Durar and Covar often develop monocultures and persist as long as 50 years. Their dense spreading root systems exclude most invader plants. The spread of hard and sheep fescues into adjacent areas appears to be site-specific. Rodents often inhabit areas covered by Durar. Elk and mule deer graze sheep fescue in the early spring, and wild birds often eat its seeds.

Festuca ovina

(hard and sheep fescue)



intermediate wheatgrass/ pubescent wheatgrass complex

1) taxonomy and origin

Because taxonomic treatments of the Triticeae tribe differ radically, the nomenclature history of most wheatgrass species reflects assignment to several genera, e.g., the Eurasian intermediate wheatgrass/pubescent wheatgrass complex has been assigned to six different genera. Mariam and Ross (1972) and Dewey (1978) believe the presence of copious trichomes on the leaf, spike, and spikelet bract surfaces, which supposedly separates pubescent wheatgrass from intermediate wheatgrass, is too variable in wild populations to serve as the basis for classification. Consequently, most recent treatments, including those of Tzvelev (1976), Dewey (1984), and Löve (1984), treat pubescent wheatgrass as a subspecies of intermediate wheatgrass. Following is a list of scientific names and of the most commonly used cultivars.

1.1) intermediate wheatgrass

1.11) scientific names

Agropyron intermedium (Host) Palisot de Beauvois, Essai Agrost. 102, 146. 1812.
Elymus hispidus (Opiz) Melderis, Bot. J. Linn. Soc. 76:379. 1978.
Elytrigia intermedia (Host) Nevski, Trudy Bot. Inst. AN SSSR, ser. 1,1:14. 1933.
Thinopyrum intermedium (Host) Barkworth *et* D.R. Dewey, Am. J. Bot. 72:772. 1985.
Trichopyrum intermedium (Host) Á. Löve, Veröff. Geobot. Inst. Zürich 87:49. 1986.
Triticum intermedium Host, Gram. Austr. 3: 23. 1805.

1.12) cultivar names

AMUR, CLARKE, CHIEF, GREENAR, OAHE, SLATE, TEGMAR, RELIANT, MANSKA, REE, RUSH

1.2) pubescent wheatgrass

1.21) scientific names

Agropyron barbulatum Schur, Verh. Siebenb. Ver. Naturw. 4:91. 1853.

Agropyron intermedium (Host) Palisot de Beauvois ssp. *trichophorum* (Link) Ascherson *et* Graebner, Syn. Fl. Mitteleur. 2:658. 1901.

Agropyron intermedium (Host) Palisot de Beauvois var. *trichophorum* (Link) Halácsy, Conspectus Fl. Græcæ 3:437. 1904.

Agropyron trichophorum (Link) K. Richter, Pl. Eur. 1:124. 1890.

Elymus hispidus (Opiz) Melderis ssp. *barbulatus* (Schur) Melderis, Bot. J. Linn. Soc. 76:381. 1978.

Elytrigia intermedia (Host) Nevski ssp. *trichophora* (Link) Á. Löve *et* D. Löve, Bot. Not. 114:50. 1961.; Tzvelev, Novit. Syst. Pl. Vasc. 10:31. 1973, *nomen superfluum*

Elytrigia trichophora (Link) Nevski, Tr. Sredneaz. Univ. ser. 8B,17:61. 934.

Thinopyrum intermedium (Host) Barkworth *et* D.R. Dewey ssp. *barbulatum* (Schur) Barkworth *et* D.R. Dewey, Am. J. Bot. 72:772. 1985.

Trichopyrum intermedium (Host) Á. Löve ssp. *barbulatum* (Schur) Á. Löve,Veröff. Geobot. Inst.

Triticum trichophorum Link, Linnaea 17: 395. 1843.

1.22) cultivar names

GREENLEAF, LUNA, TOPAR, MANSKA

2) common uses

Pasture, hay, soil erosion control, turf, wildlife forage and habitat

3) effects on regional biodiversity

3.1) competitive ability and invasiveness

Genotypes in the intermediate wheatgrass complex are generally long-lived and often outlive associated native species. In a 52-year-old planting of 132 accessions of native and introduced grasses in central Idaho, intermediate wheatgrass maintained the best stand (Monsen and Anderson, 1993).

Longevity

Intermediate wheatgrass is very productive during early years of a stand (Asay and Knowles 1985), and although the newer varieties of intermediate wheatgrass are better, they are criticized for their lack of longevity when mismanaged or subjected to environmental stress. Greenar intermediate, Topar, and Luna pubescent wheatgrasses were replaced when overseeded with Sherman big bluegrass and Secar bluebunch wheatgrass at Lind, Washington. Greenar intermediate and Topar pubescent did not survive in single-species seedings. Luna pubescent developed only 2% ground cover (Stannard 1994).

Spread

Twenty years after seeding at the U.S. Sheep Experiment Station near Dubois, Idaho, intermediate and pubescent wheatgrass was 155% and 210%, respectively, of the initial area. There was also considerable spread of intermediate and pubescent wheatgrass seeded at other sites in Idaho (Hull and Klomp, 1966). Intermediate wheatgrass did not spread into native range from a seeding at Star Valley, Wyoming (Gomm, personal communication, 1994).

Thirty-two-years after Whitmar bluebunch wheatgrass was seeded in individual plots with 10 other species, including pubescent wheatgrass, it had encroached into several other plots and was the dominant species on adjoining plots of pubescent wheatgrass (Nissen, personal communication, 1994).

Competition With Weeds/Native Grass

As a density of pubescent wheatgrass and yellow starthistle increase, interspecific competition exceeds intraspecific competition (Prather and Callihan 1991). Moreover, at equal densities, pubescent wheatgrass does not exclude yellow starthistle.

Based on weekly leaf counts, the effects of intra- and interspecific competition on the growth of yellow starthistle and pubescent wheatgrass are noticeable 6 to 7 weeks after emergence. Controlling yellow starthistle and a substantial increase in seedling rates facilitates the establishment of pubescent wheatgrass on yellow starthistle-infested sites. The longevity of pubescent wheatgrass may allow it to outcompete yellow starthistle seedlings where pubescent wheatgrass is well established (Prather and Callihan 1991). Competition from Oahe intermediate, Luna pubescent and Nordan crested wheatgrass produced weaker and more spindly yellow starthistle plants (Roché et al. 1994).

Intermediate wheatgrass initiates spring growth about the same time as western and beardless wheatgrass, but matures more rapidly than beardless (Cook and Harris 1968). On a site in central Utah, western wheatgrass was competitively superior to intermediate wheatgrass when managed with short-duration grazing or when protected from grazing (Bartels 1992). Removing the competition of western wheatgrass from rangelands on the Great Plains improved the performance of intermediate wheatgrass on sites protected from grazing. Western wheatgrass will outcompete and eventually eliminate intermediate wheatgrass. The competitive superiority of western wheatgrass is attributed to: leaf rolling (Latas and Nicholson 1976), glaucousness, rapid conditioning to drought (Frank 1981), significant allocation of photosynthates to growth and maintenance of roots (Power 1985), extraction of water from deep soil depths (Frank et al. 1985), and deeper root penetration. Dissimilar tiller dynamics may also contribute to the superiority of western wheatgrass. The spatial segregation of individual plants of intermediate and western wheatgrass suggests a process of competitive exclusion between these species with similar resource demands (Bartels 1992). Native western wheatgrass may be more competitive than intermediate wheatgrass within the Great Basin and on the Great Plains. In some instances intermediate is crowded out.

3.2) wildlife usage

Deer

Mule deer highly prefer Luna pubescent wheatgrass in spring and fall (Austin et al. 1994). Seeding of introduced grass species, such as intermediate wheatgrass, on spring-fall ranges reduce browse use by livestock, thus reducing livestock competition with wildlife (Appendix II).

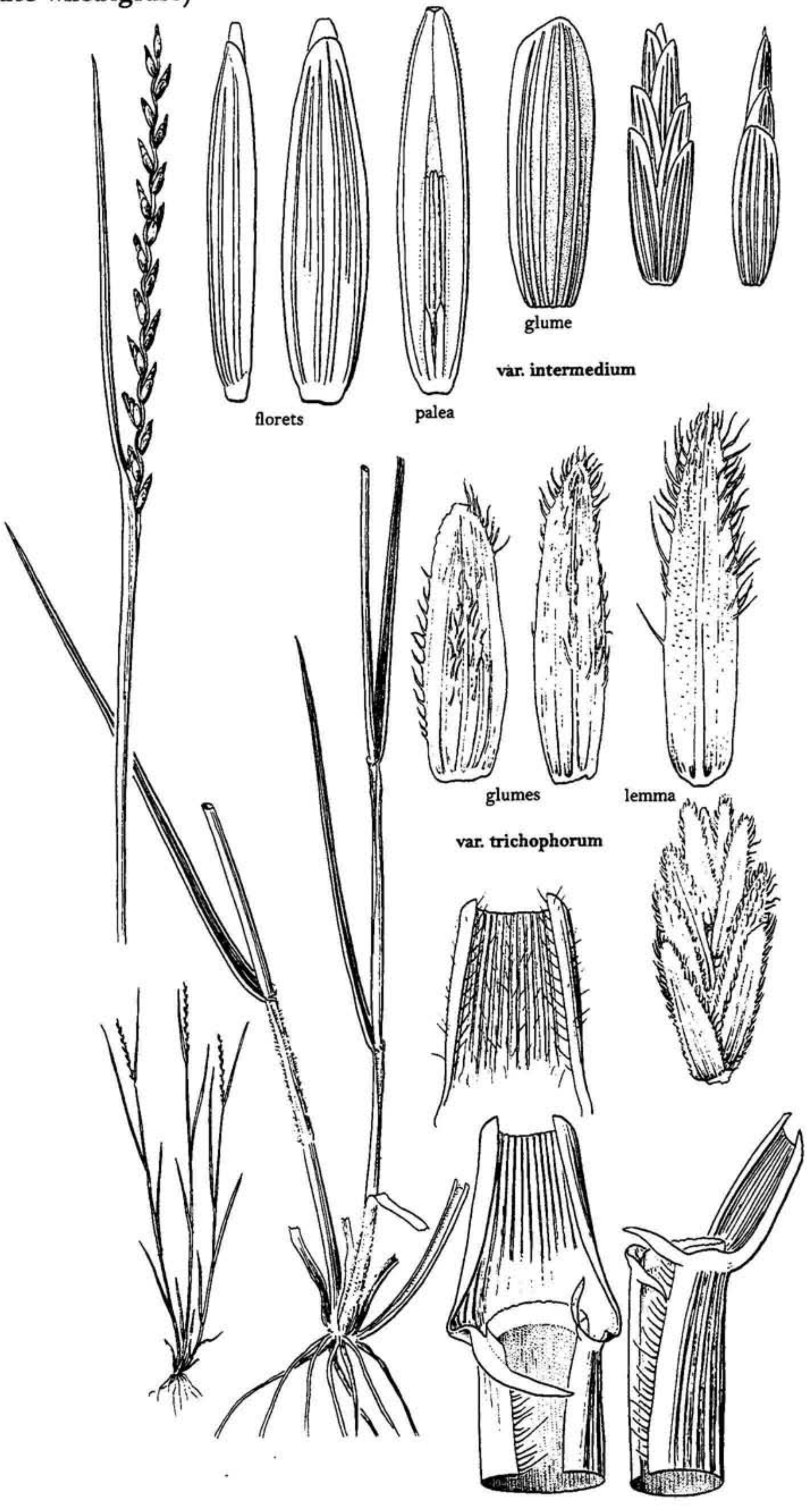
Rabbits/Birds

Kangaroo rats and black-tailed jackrabbits prefer Greenar intermediate and Luna and Topar pubescent wheatgrass to other grasses near Aberdeen, Idaho (C. Hoag, personal communication, 1994). Of the wheatgrasses tested, wild birds prefer intermediate wheatgrass. In some instances seed consumption by birds precludes seedling establishment (Goebel and Berry 1976) (see Appendix II).

Rodents

Captive deer mice from pinyon-juniper, sagebrush-bitterbrush (*Purshia tridentata* (Pursh) DC), and Jeffrey pine-ceanothus plant associations ate

Agropyron intermedium
(intermediate wheatgrass)



or destroyed seed equivalent to approximately one-third of their body weight each day (Everett et al. 1978). Four introduced grasses (pubescent wheatgrass, Fairway crested wheatgrass, sheep fescue, and bulbous bluegrass) ranked 10th, 19th, 23rd and 24th, respectively, in preference by mice. Of the 28 native and introduced plant species evaluated (including eight grass species), only stiffhair (pubescent) wheatgrass was ranked relatively high. Seed consumption varies with field conditions. Seed consumption maybe so severe that it is advantageous to plant seed not preferred by deer mice.

3.3) summary

Intermediate pubescent wheatgrass is a long-lived grass (50+ years) that may outlive other introduced and associated native species. The competitive ability and invasiveness of grasses in the intermediate wheatgrass complex depend on environmental conditions and management practices. Natives such as Sherman big bluegrass and western wheatgrass out-compete some of the introduced species in this complex. At high densities, these introduced species can successfully compete with yellow starthistle. Competition from big sagebrush reduces the grass height and leaf length of intermediate wheatgrass. Intermediate wheatgrass may spread into adjoining vegetative communities, but it coexists with native taxa and adds to the biodiversity in some situations. On favorable sites where it is well adapted, it can become dominant and exist as a monoculture.

kentucky bluegrass

1) taxonomy and origin

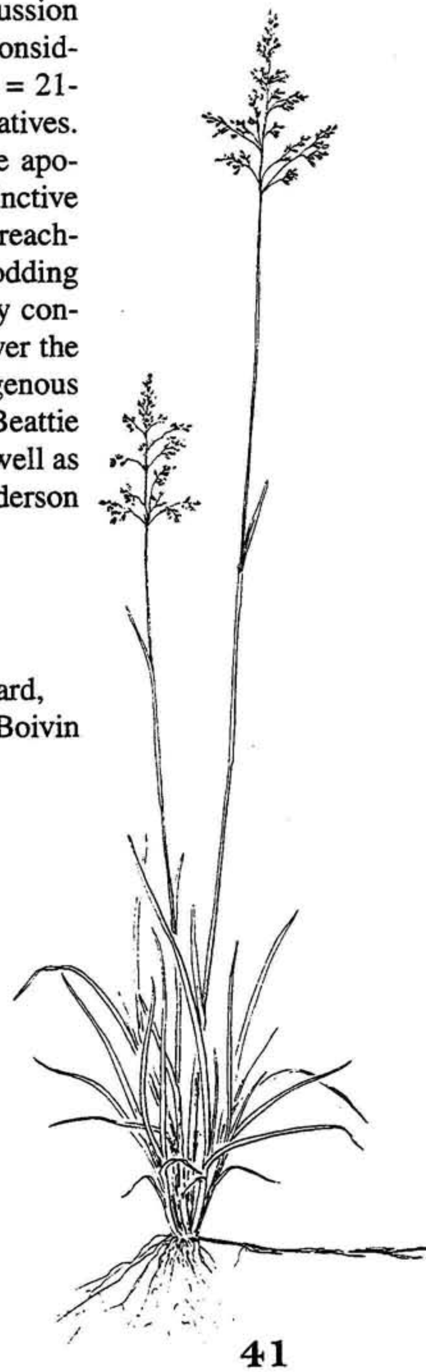
Debate continues concerning the origins of populations of Kentucky bluegrass, *Poa pratensis* C. von Linné. Some believe native populations (segregated as *P. agassizensis* Boivin & Löve) existed along the Cascade-Sierra Nevada Cordillera, the Rocky Mountain Cordillera, and northern Canada, prior to the spread of European cultivars (see Duell 1985, for a discussion of North American populations). The *P. pratensis* complex exhibits considerable phenotypic plasticity, probably the result of polyploidy ($2n$ = 21-147; x = 7) through repeated introgressions with various close relatives. Resultant morphs are maintained through pseudogamic, facultative apomixis, with infrequent allogamy (Clausen 1961). Two rather distinctive morphs commonly occur in western North America: one has culms reaching a height of 3 feet and panicles openly pyramidal, ultimately nodding and tawny; the other has culms 1 foot or less, and panicles densely contracted, oblongly linear, erect, and purplish to some degree. Whatever the origin of Kentucky bluegrass, this species seems foreign to the indigenous Columbia Basin flora. Early floras of the Palouse Region (Piper and Beattie 1901) and of southeastern Washington (Piper and Beattie 1914), as well as early bulletins of the Idaho Agricultural Experiment Station (Henderson 1903), list Kentucky bluegrass as "everywhere introduced."

1.1) scientific names

Poa agassizensis Boivin *et* D. Löve *in* D. Löve *et* Bernard, Svensk Bot. Tidskr. 53:371. 1959, *nomen nudum*; Boivin *et* D. Löve, Nat. Canad. 87:176, *fig. 1*.1960.
Poa pratensis C. von Linné, Sp. Pl. ed. 1:67. 1753.

1.2) other common names

Meadow grass, smooth meadow grass, June grass, speargrass,bluegrass



1.3) cultivar names

COLUMBIA, KENBLUE, MERION, PARK, RUGBY, SOUTH DAKOTA CERTIFIED,WABASH, WARREN'S A-34, MONOPOLY, ADELPHI, AMENLLA BONNIEBLOE, BRISTOL, CHALLENGER, ECLIPSE, MAJESTIC, MID NIGHT (Note: these are only the more common cultivars used in the western U.S.)

2) common uses

Turf, pasture, hay, wildlife, habitat, soil erosion control

3) effects on regional biodiversity

3.1) competitive ability and invasiveness

Kentucky bluegrass is a highly rhizomatous perennial species thought to be introduced from Europe by early settlers (Vinall and Hein 1937). It is a common increaser on disturbed sites in the steppe region (Bates 1935, Burden and Randerson 1972). Kentucky bluegrass colonizes microsites in disturbed areas more readily than species with relatively narrow microsite requirements (Harper et al. 1965). It is not as conspicuous as bluebunch wheatgrass, but it can become dominant in the *Festuca -Symphoricarpos* habitat type (Daubenmire 1970). A daily flux in soil temperature from 13° to 27°C favors germination (Brown 1902). Germination may occur in the autumn and significant root growth occurs during the winter (Hansen and Jaska 1961). These characteristics provided an advantage over such natives as bluebunch wheatgrass, which grows very little in the winter (Harris 1965). Growth and flowering phenology are similar to that of cheatgrass.

Exclusion of Natives

Kentucky bluegrass is competitive, persistent, and restricts the entry of native herbs and shrubs into their sward-like stands at the Grand Teton National Park near Jackson Hole, Wyoming (McArthur et al. 1994). They note that del Moral (1985) and Goldberg and Gross (1988) describe similar findings. Kentucky bluegrass was present on more study areas (14 of 16) than any other taxa except common dandelion (*Taraxacum officinale* Weber). Kentucky bluegrass, timothy (*Phleum pratense* L.), and smooth brome dominated a meadow area and a severely disturbed sagebrush-grass sites (McArthur et al. 1994).

Kentucky bluegrass does not compete with Douglas fir (*Pseudotsuga taxifolia* Britton) once the tree roots are lower than roots of Kentucky bluegrass (Winward, personal communication, 1994). There is little competition between Kentucky bluegrass and pinegrass (*Calamagrostis rubescens* Buckl.) or elk sedge (*Carex geyeri* L.), but Kentucky bluegrass competes well with Idaho fescue (*Festuca idahoensis* Elmer) and bluebunch wheatgrass. Kentucky bluegrass is compatible with fescue and bluebunch wheatgrass (Winward, personal communication, 1994). However, Zamora (personal communication, 1994) found that Kentucky bluegrass is unable to compete with elk sedge and pinegrass and other native species on Douglas and Grand fir sites in western Washington, where velvetgrass, (*Holcus lanatus* L.), red top (*Agrostis alba* L.), trailing blackberry (*Rubus macropetalus* L.), and mountain ash (*Fraxinus* L.) replace Kentucky bluegrass stands.

Kentucky bluegrass readily competes with and often dominates native species on disturbed sites. On a dry meadow site near LaGrande, Oregon, Kentucky bluegrass dominates native species including *Deschampsia* spp. (Krueger, personal communication, 1994). After 11 years of non-livestock grazing, tufted hairgrass (*Deschampsia caespitosa* C. von Linné) had not advanced toward dominance in a Kentucky bluegrass meadow in central Oregon (Uchytil 1993). In a livestock enclosure in the Douglas fir-ninebark habitat type (*Physocarpus malvaceus* (Greene), Kuntze) (Daubenmire 1970), elk sedge, pinegrass, blue wildrye (*Elymus glaucus* Beubl) and western needlegrass (*Stipa occidentalis* Thunb.) withstood competition from Kentucky bluegrass (Krueger and Winward 1974). At the livestock-big game exclosure, ninebark and red stem ceanothus (*Ceanothus sanguineu* L.) dominated the site. After 29 years, there were five times as many "foliage cones" of bluebunch wheatgrass and Kentucky bluegrass inside livestock exclosures (McLean and Tisdale 1971). Kentucky bluegrass is very competitive in western Montana where it spread to several other seeded plots after 5 to 9 years, and "nearly covered" some plots (Gomm 1974).

Competition With Other Introduced Species

In southwest Oregon, Kentucky bluegrass prevents the lateral spread of cheatgrass roots (Bookman 1980). Established Kentucky bluegrass root systems usurp both space and associated resources in the soil matrix. Early establishment of Kentucky bluegrass enables it to capture a disproportionate share of resources and determines the final position of cheatgrass (Harper 1977). As with orchardgrass, timing of seedling emergence determines the amount of soil resources usurped by the seedlings before there is significant neighbor-to-neighbor interference (Ross and Harper 1972).

Water Relations/Grazing Resistance

Kentucky bluegrass cannot tolerate a high water table, but is very aggressive and strongly competitive on dry meadow sites in areas receiving 18 to 25 inches of precipitation (Krueger and Winward, personal communication, 1994). They and others (Carlson, Gibbs, Harris and Ogle, personal communication, 1994) note that it withstands grazing pressure from livestock and wildlife. Kentucky bluegrass is highly resistant to grazing because its growing points remain near the ground throughout the growing season and has a low ratio of reproductive to vegetative stems (Uchytil 1993).

3.2) wildlife usage

Herbivores

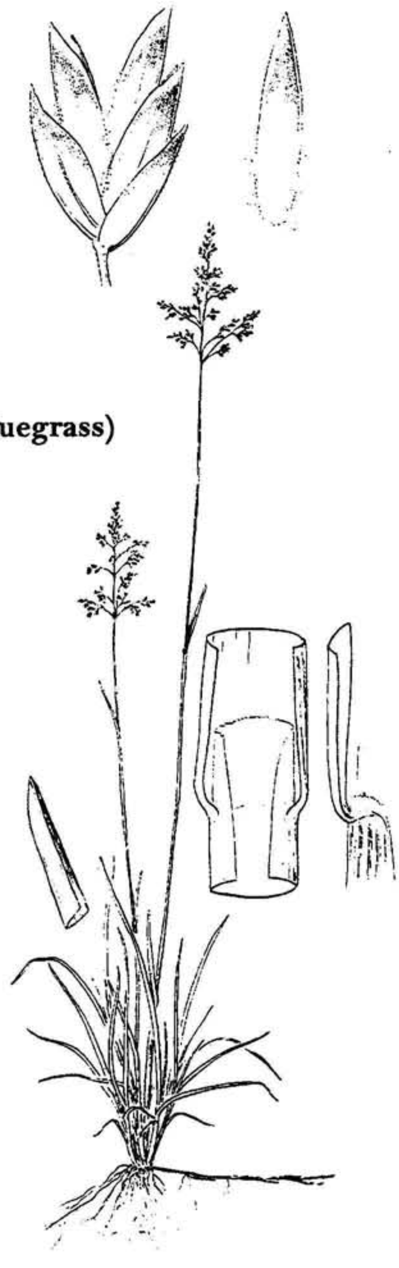
Kentucky bluegrass is heavily grazed (depending on the season, phenological stage and kind of wildlife) by mule deer, elk, antelope, and moose (Carlson, Gibbs, Harris, Krueger, and Winward, personal communication, 1994). Grazing by big game (mule deer and elk) on a Douglas fir-ponderosa pine-Kentucky bluegrass community in Oregon does not harm Kentucky bluegrass (Krueger and Winward 1974). Kentucky bluegrass makes up a relatively small portion of the diet of bighorn sheep (*Ovis canadensis*) in British Columbia (Krueger and Winward 1974).

Rodents

In Kentuky bluegrass-dominated mountain meadows in Oregon, the northern pocket gopher, Columbian ground squirrel, and mice are prevalent (Uchytil 1993).

3.3) summary

There is some disagreement as to whether Kentucky bluegrass is indigenous to parts of the western United States. Everyone does agree that it is an aggressive spreader on moist and dry meadows receiving more than 18 inches of annual precipitation and is very competitive on favorable sites. Root growth during the winter gives bluegrass an advantage over many natives. Swards of Kentucky bluegrass restrict entry of native herbs and shrubs. It competes with cheatgrass, but not with established Douglas fir seedlings and it is compatible with bluebunch wheatgrass and Idaho fescue, but does not successfully compete with elk sedge, pine grass, velvet grass, red top, trailing blackberry and mountain ash (in western Washington). At other locations Kentucky bluegrass may dominate some native species such as *Deschampsia* spp. but coexists with blue wildrye and western needlegrass. Thus the competitive nature of Kentucky bluegrass is highly dependent upon environmental conditions. It withstands livestock and big game grazing and may become a monoculture under heavy grazing pressures that eliminate less tolerant species. Kentucky bluegrass is highly desired by livestock and a variety of wild herbivores.



Poa pratensis
(Kentucky bluegrass)

orchardgrass

1) taxonomy and origin

Although numerous taxa of orchardgrass are recognized within its indigenous Eurasian distribution, most variants are classified in one polymorphic species. Piper and Beattie (1901) listed orchardgrass as an escape from cultivation on the Palouse.

1.1) scientific names

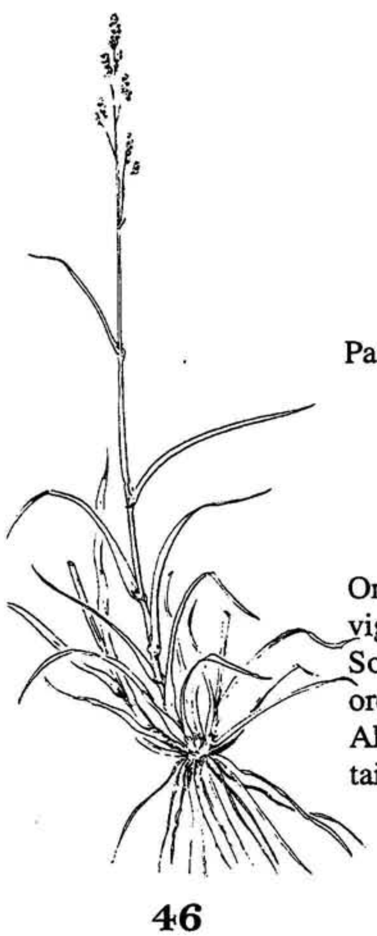
Dactylis glomerata C. von Linné, Sp. Pl. ed. 1:71. 1753.

1.2) other common names

Cocksfoot

1.3) cultivar names

AKOROA, BERBER, BRAGE, COMET, CROWN, DWARF, HALLMARK, HAWK, INA, JUNO, KAY, LATAR, NAPIER, ORCHARD, ORION, PAIUTE, PALESTINE, PENNLATE, POMAR, POTOMAC, RIDEAU, SUMAS, S-143
(This is a list of more common orchardgrass cultivars used in the western U.S.)



2) common uses

Pasture, hay, green chop, silage, orchard ground cover

3) effects on regional biodiversity

3.1) competitive ability and invasiveness

Orchardgrass, a long-lived, shade-tolerant bunchgrass with good seedling vigor, readily establishes when there is little competition from other plants. Some orchardgrass cultivars are more competitive than others. Latar orchardgrass is winterhardy and more competitive in colder areas than Akaroa, which winter-kills east of the Cascade and Sierra Nevada mountain ranges. Paiute orchardgrass is more competitive than Latar and most other orchardgrass cultivars in lower precipitation areas—about 2 inches below the precipitation zone for other orchardgrass cultivars (Pullman, Washington, NRCS, PMC annual reports and species files).

Competition/Native Plants

Although Ponderosa pine seedlings apparently utilize ammoniun while orchardgrass absorbs nitrate (Elliott and White 1987), orchardgrass may have alleopathy effects on pine seedings (Rice 1974, 1979). Orchardgrass competes with lodgepole pine (*Pinus contorta* var. *latifolia* Engelm) seedlings, especially at higher orchardgrass seeding rates (Powell et al. 1994). The survival, height, and plant mass of 6-month-old lodgepole pine seedings declines when they are grown with orchardgrass (Clark and McLean 1975). After 4 years, however, lodgepole pine survival was not affected by density of orchardgrass (Clark and McLean 1979). Under other conditions, orchardgrass reduces conifer tree seedling survival and growth (Baron 1962, Crane and Habeck 1982, and Eissenstat and Mitchell 1983).

In southwest Oregon, the biomass of orchardgrass exceeded that of wheatgrasses and was similar to that of perennial grasses during a relatively mild winter; however, biomass production of orchardgrass decreased following a cold winter (Borman et al. 1990). The survival of perennial grasses with annuals in these areas requires the early initiation of growth, continued growth through the winter, and maturation before soil moisture is depleted, characteristics possessed by Berber orchardgrass.

Orchardgrass is noncompetitive with native species in western Washington on a Douglas and Grand fir site (Zamora, personal communication, 1994), and is non competitive with native plants in western Montana and Wyoming (Gomm 1974, 1994, personal communication). Others (Carlson, Gibbs, Harris, Krueger, Winward, and Ogle, personal communication, 1994) have found orchardgrass to be noncompetitive in areas of the Columbia River and Great Basins.

Near LaGrande, Oregon, elk sedge invades orchardgrass stands where orchardgrass can spread and coexist with some native species (Krueger, personal communication, 1994). However, orchardgrass is competitive and when a solid sward is formed it restricts the entry of native herbs and shrubs (McArthur et al. 1994).

Competition/Introduced Plants

The biomass of five introduced species including intermediate wheatgrass and orchardgrass in the Uinta Mountains of Utah increased with seeding rate. A similar increase did not occur with four native grass species (Chambers 1989). Orchardgrass ranked second in biomass production. The seeded grasses showed no negative associations among themselves.

Orchardgrass is unable to compete with cheatgrass and annual Lotus on noncultivated plots. On cultivated sites, orchardgrass has little effect on the weedy species St. Johnswort (*Hypericum scouleri* Hook) and dalmation toadflax (Gates and Rohocker 1960).

3.2) wildlife usage

Herbivores

In its early phenological stages, orchardgrass is highly palatable to mule deer and elk. Elk have eliminated some orchardgrass seedlings by heavy grazing (Gibbs and Pudney, personal communication). Mule deer in central Utah prefer Paiute orchardgrass in the spring and summer over 15 other grasses (Austin et al. 1994).

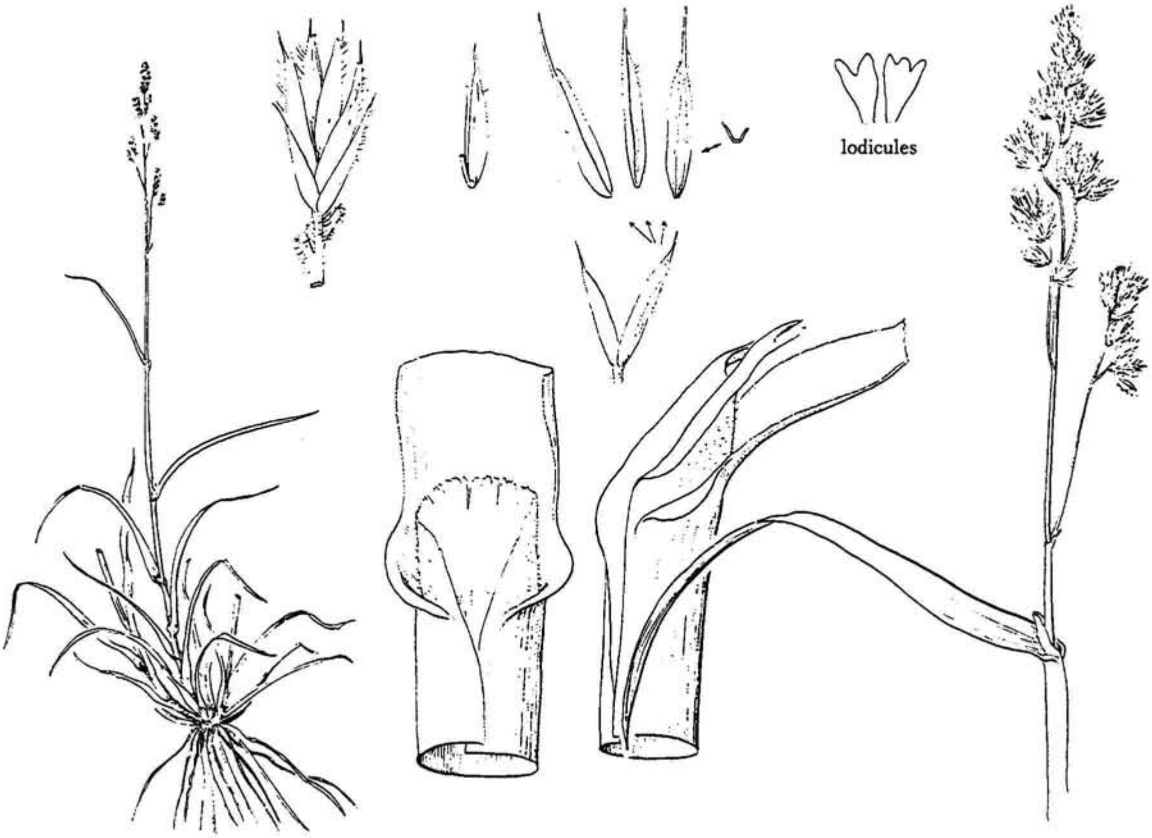
Birds/Rodents

Upland game birds use orchardgrass for cover and nesting and small birds eat its seed (Gibbs, personal communication, 1994). At Burns, Oregon, there was more pocket gopher activity on Piute orchardgrass plants than on other grass species (Haferkamp 1995).

3.3) summary

In the Columbia River drainage and Great Basin, orchardgrass is somewhat shade tolerant, has good seedling vigor and spreads by seed in open and shaded areas where precipitation exceeds 14-18 inches. This bunchgrass is generally considered noninvasive, compatible with native species, and does not outcompete natives in most ecosystems. Although orchardgrass may have little or no adverse effects on weedy species, it reduces the growth of pine seedlings but does not affect survival of lodgepole pine stands after several years. Orchardgrass may spread, but frequently coexists with natives, thus increasing biodiversity except when it is purposely established as a pure sward. It is highly palatable to livestock and wildlife herbivores.

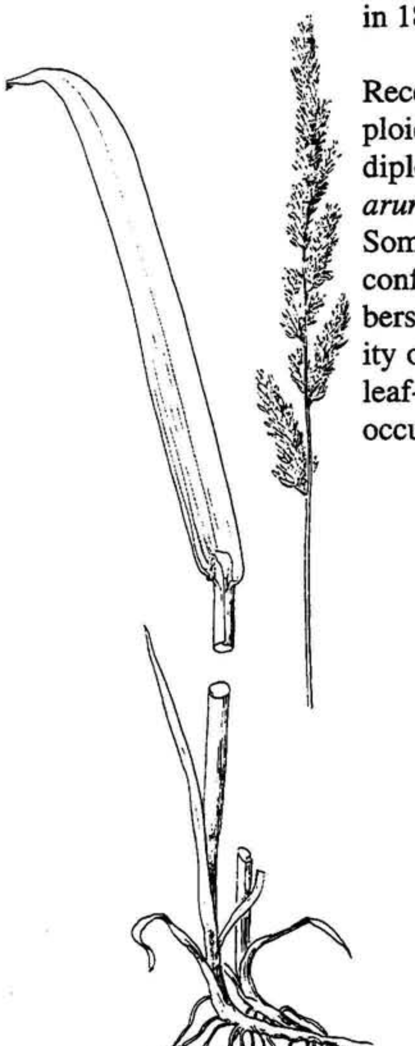
Dactylis glomerata
(orchardgrass)



reed canarygrass

1) taxonomy and origin

There is some question as to whether reed canarygrass, *Phalaris arundinacea* C. von Linné, is indigenous to North America. As with many other apparently circumboreal grasses, such as *Deschampsia caespitosa* (C. von Linné) P. Beauv. and *Festuca ovina*, many stands are probably indigenous while others were introduced from European populations. Both Anderson (1961) and Baldini (1993) treated reed canarygrass as a circumboreal species, and Piper and Beattie (1901, 1914) listed this species as native and common in wet places, including those covered with shallow water. Schoth (1929) traced most of the reed canarygrass fields in the Pacific region to a seeding made in 1895 in Coos County, Oregon.



Recently, Baldini (1993) divided *P. arundinacea* into two species based on ploidy level and inflorescence morphology: *P. rotgesii* (Husnot) Baldini, a diploid ($2n = 2x = 14$) putatively endemic to southern Europe, and *P. arundinacea*, a tetraploid ($2n = 2x = 28$) with cosmopolitan distribution. Some herbarium specimens of reed canarygrass from western North America conform morphologically to *P. rotgesii*; however, their chromosome numbers are unknown. Further investigations are needed to ascertain the validity of Baldini's classification system. Additionally, plants with variegated leaf-blades, formally recognized as the variety or form *picta*, occasionally occur in stands of reed canarygrass.

1.1) scientific names

Phalaris arundinacea C. von Linné, Sp. Pl. ed. 1:55. 1753.
Phalaris arundinacea C. von Linné var. picta C. von Linné, Sp. Pl. ed.1:55. 1753.
Phalaris arundinacea C. von Linné f. picta (C. von Linné) Ascherson *et* Graebner, Syn. Mitt. Eur. Fl. 24. 1898.
Phalaris rotgesii (Husnot) Baldini, Webbia 47(1): 13. 1993.

1.2) other common names

Reed grass, ribbon grass, speargrass

1.3) cultivar names

AUBURN, CASTOR, FLARE, FRONTIER, GROVE, IOREED, PALATON, RISE, SUPERIOR, VANTAGE, VENTURE

2) common uses

Pasture, hay, stream and channel ditch bank stabilization and other soil conservation practices, water pollution control from sewage effluent.

3) effects on regional biodiversity

3.1) competitive ability and invasiveness

Reed canarygrass is a very aggressive rhizomatous grass that persists between the aquatic and upland zones in Washington (Zamora, personal communication, 1994). It is widely distributed in Idaho, Oregon, Nevada, Utah, and Washington. Reed canarygrass is extremely competitive (Comes 1971) and it grows vigorously on several thousand miles of ditch banks and waterways in the Columbia and Great Basins. Rootlets develop at each node as they contact water or moist soil along banks. Reed canarygrass will completely eliminate legumes from a community in 2 or 3 years (Bonin and Tomlin 1968, Heath and Hughes 1953).

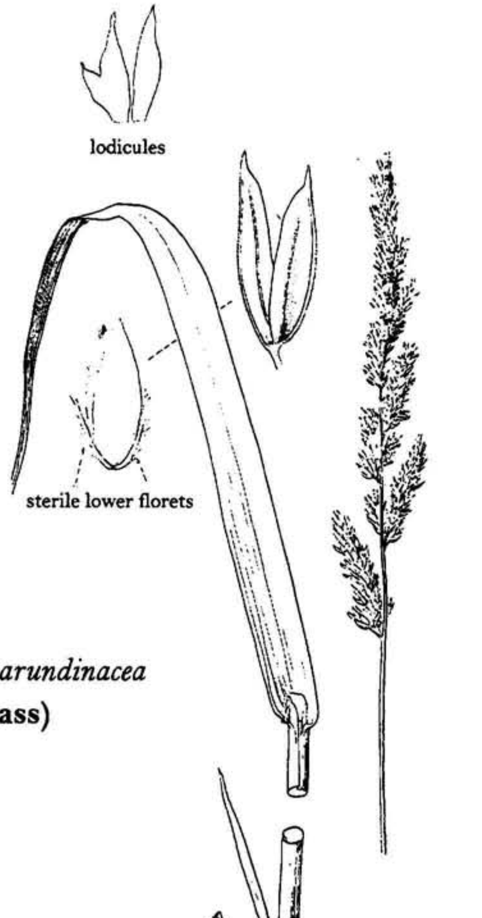
Although the natural habitat of reed canarygrass is poorly drained wet areas, it grows quite well on some upland sites. With favorable conditions both quackgrass (*Elytrigia repens* (L.) Nevski) and redtop (*Agrostis gigantea* Roth) have difficulty in competing with reed canarygrass. Reed canarygrass is intolerant of shade and in shade gives way to willow (*Salix* sp. L.), red-osier dogwood (*Cornus stolonifera* Michx.), and chokecherry (*Prunus virginiana* L.). Sedges (*Carex* sp. L.) and rushes (*Juncus* sp. L.) replace reed canarygrass in central Washington (Zamora, personal communication, 1994). We have found that under heavy grazing pressure reed canarygrass gives way to other irrigated pasture species.

3.2) wildlife usage

We have observed the use of reed canarygrass as a habitat for pheasants and ducks in upland and wetlands, respectively. Small birds eat the seed. It provides habitat for small mammals in upland areas.

3.3) summary

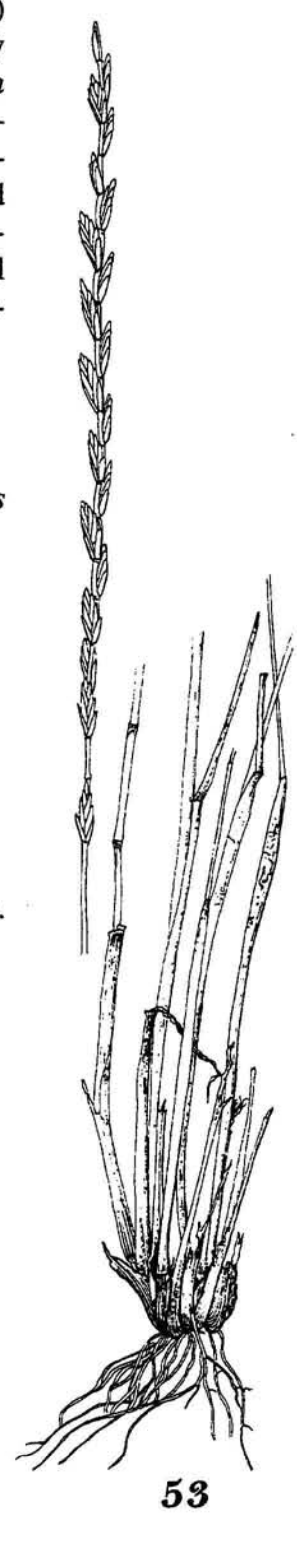
Reed canarygrass is generally a highly aggressive, competitive, persistent and vigorous perennial grass that grows in poorly drained wet areas and along stream and canal banks in the Columbia and Great Basins. It usually dominates and grows as a monoculture and thus reduces biodiversity. Even quackgrass and redtop have difficulty competing with Reed canarygrass. It is intolerant of shade where it is often replaced by sedges, rushes, willow, red osier dogwood, and chokecherry.



Phalaris arundinacea
(reed canary grass)

1) taxonomy and origin

Historically, tall wheatgrass has been treated as *Agropyron elongatum* (Host) Palisot de Beauvois in most North American grass treatments. As noted by Dewey (1984), Löve (1984), and Moustakas (1993), true *Agropyron elongatum*, now generally excluded from *Agropyron sensu stricto*, is a diminutive diploid ($2n = 2x = 14$), while the robust grass known as tall wheatgrass is a decaploid ($2n = 10x = 70$). Differences in plant stature, spike and spikelet morphology, as well as genomic constitution, warrant the segregation of tall wheatgrass as a distinct species. The generic assignment of tall wheatgrass varies with the grouping criteria emphasized. The valid combinations are listed below.



1.1) scientific names

Agropyron elongatum auctorum non (Host) Palisot de Beauvois
Elymus elongatus auctorum non (Host) Runemark
Elymus elongatus (Host) Runemark ssp. *ponticus* (Podpera) Melderis, Bot. J. Linn. Soc.76:377. 1978.
Elytrigia pontica (Podpera) Holub, Folia Geobot. Phytotax. Praha 8:171. 1973.
Lophopyrum ponticum (Podpera) Á. Löve, Feddes Repert. 95(7/8):489. 1984.
Thinopyrum ponticum (Podpera) Barkworth *et* D.R. Dewey, Great Basin Nat. 43(4):570.1983, *comb. inval.*; Barkworth *et* D.R. Dewey, Am. J. Bot. 72:772. 1985; Liu *et* Wang, Genome 36:648. 1993, *nomen superfluum*.

1.2) other common names

Salt wheatgrass

1.3) cultivar names

ALKAR, JOSE, LARGO, ORBIT, PLATTE, TYRELL

2) common uses

Pasture, hay, alkaline or saline soil reclamation, wildlife habitat

3) effects on regional biodiversity

3.1) competitive ability and invasiveness

Tall wheatgrass is a bunchgrass that spreads by seed. Spring growth commences at the same time as western and beardless wheatgrass but tall wheatgrass is slower to mature (Cook and Harris 1968).

Competition/Native Plants

Alkar tall wheatgrass was replaced after 15 years under semiarid conditions at Lind, Washington by overseeding with species of Sherman big bluegrass and Secar Snake River wheatgrass (Stannard 1994).

Tall wheatgrass has not spread or replaced native plants after 45 years in Star Valley, Wyoming, or in a planting made in Bozeman, Montana (Gomm, personal communication, 1994) and persists on adapted sites in Idaho, Oregon, Utah, and Washington (Gibbs, Carlson, and Harris, personal communication, 1994). It is a strong dominant and develops into a monoculture under favorable conditions. Tall wheatgrass is short-lived in low rainfall conditions at Aberdeen, Idaho (Douglas et al. 1960). In southwest Oregon, tall wheatgrass yields are high in years of above-average precipitation, but stands do not persist nor does tall wheatgrass compete well with Idaho fescue and many annuals (Borman et al. 1990).

On rangelands near Eureka, Utah, roots of tall wheatgrass and other grasses grew to similar depths and densities (Cook and Lewis 1963). Competition from sagebrush reduces grass height, leaf length, and soil moisture. In contrast, competition from tall wheatgrass and other grass species only slightly affected growth of the weedy dalmatian toadflax (*Linaria dalmatica.*(L.) Miller) and St. Johnswort (Gates and Robacker 1960).

Water Relations/Salt Tolerance

Tall wheatgrass establishes well on some saline soils but does not persist on dry saline soils (Roundy 1983). It is more salt tolerant and less drought tolerant than Basin wildrye or slender wheatgrass (Young and Evans 1981). Many of the sites where Basin wildrye occurs naturally in the Columbia and Great Basins are too dry for tall wheatgrass (Gibbs and Carlson, personal communication, 1994). However, others (Asay and Horton) note that tall wheat is more drought tolerant on some sites in the Great Basin than Basin wildrye. A combination of factors, not just soil moisture, may determine their relative tolerances.

Seed/Seedling Vigor

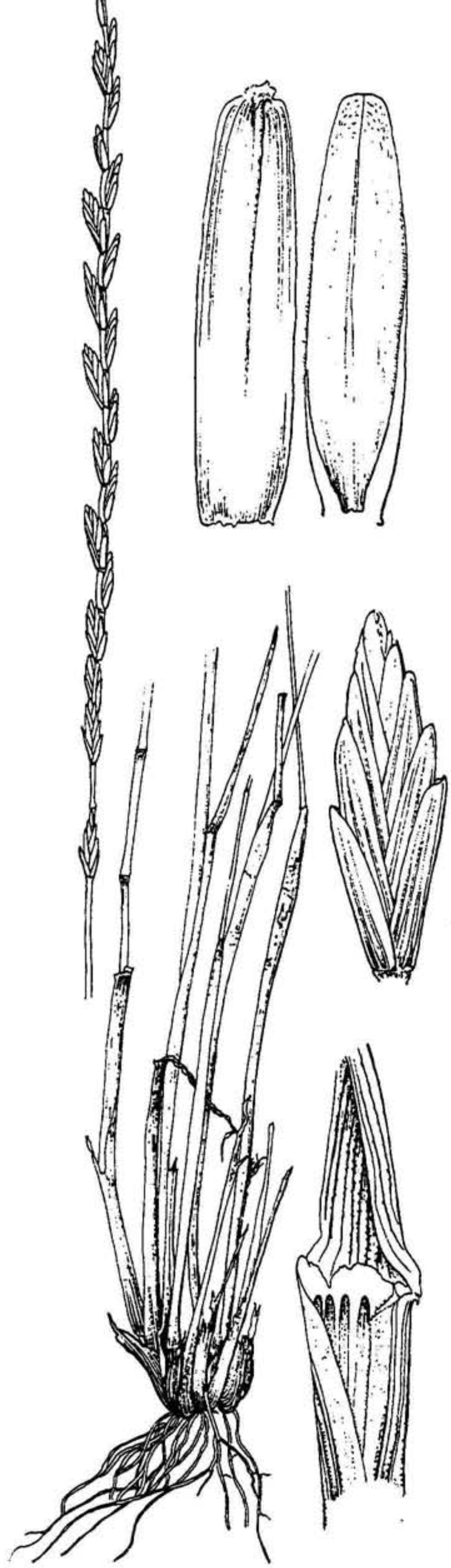
Jose tall wheatgrass germinates more rapidly and has higher seedling emergence than Magnar Basin wildrye. It achieved a greater density than Magnar on both irrigated and nonirrigated nonsaline and moderately saline plots in Utah (Roundy 1983). Tall wheatgrass seedlings emerge better through a hard soil crust and root elongation is greater and more rapid than in Magnar (Roundy 1983).

3.2) wildlife usage

We have noted along with Gibbs (personal communication, 1994) that tall wheatgrass seeds are eaten by birds and rodents. Its abundant foliage furnishes habitats for nesting and cover for upland game birds and mule deer.

3.3) summary

Tall wheatgrass is a perennial bunchgrass that may persist for a long time on adapted sites. On less favorable sites, e.g., saline and low-moisture, it is short-lived unless there is a water table below the dry surface. Generally, it does not spread. In the Columbia River drainage and Great Basin it competes well with natives such as Basin wildrye on saline soils. It is usually limited by its inability to establish as a seedling in dry conditions, although under droughty conditions in Utah, some seedings have been successful. Once established, its well-developed root system seeks out deeper water. Tall wheatgrass produces large amounts of foliage on heavy salty soils where subsurface water is available. Under favorable conditions, it establishes as a dominant and may form a monoculture, thereby reducing biodiversity.



Agropyron elongatum
(tall wheatgrass)

appendix

appendix I

appendix Ia

moisture adaptations
precipitation requirements-inches

species	states			
	Idaho[1]	*Oregon*[2]	*Utah*[3] *Western Wyoming Eastern Nevada*	*Washington*[4]
bulbous bluegrass[5]	10+	10+	10+	10+
crested wheatgrass complex[6]	10-16	8-12	8-20	9-18
hard fescue	14-18	14-18+	14-30	15-25+
sheep fescue		8-25	12-14	9-18
intermediate wheatgrass complex[7]	12-18	10-18+	14+	12-24
Kentucky bluegrass[8]	18+	18+	18+	18+
orchardgrass[9]	17+	14+	14+	18+
reed canarygrass[10]	18+	18+	18+	18+
tall wheatgrass	15+	10-25	12+	15+

[1]USDA-NRCS, 1994
[2]USDA-SCS, 1988
[3]Horton (editor), 1994
[4]WSU, 1983
[5]Winward, 1994, personal communication

[6]Siberian is generally more drought tolerant than other crested wheatgrass cultivars.

[7]Pubescent is generally more drought tolerant than other forms of intermediate.

[8]Based on Idaho's seeding guide (Ogle, 1994).

[9]Piute is generally more drought tolerant than other forms of orchardgrass and may tolerate as low as 14 inches while others require 16 inches or more.

[10]Based on Washington State Seeding Guide (WSU, 1983).

soil adaptations

species	soil characteristics[1,2]					
	deep to moderately deep loamy	*clay*	*shallow, sandy and/or very gravely*	*water table* *wet surface shallow*	*water table* *dry surface deep*	*relative salt tolerance rating*
bulbous bluegrass	✔	✔	✔			poor
crested wheatgrass complex[3]	✔	✔	✔		✔	fair
hard and sheep fescue	✔	✔				poor
intermediate wheatgrass complex	✔	✔	✔[4]			poor to fair
Kentucky bluegrass	✔	✔	✔[4]		✔	poor
orchardgrass	✔	✔				poor
reed canarygrass	✔	✔		✔	✔[4]	poor
tall wheatgrass	✔	✔			✔	good

[1]USDA-SCS, 1994
[2]USDA-SCS, 1988
[3]Crested wheatgrass best adapted on deep to moderately deep well-drained loamy soils, but will grow on a wide range of soils.
[4]In higher moisture areas (USDA-SCS, 1994; USDA-SCS, 1988).

appendix Ic

responses to fire[1,2]

species	*favored*	*no effect*	*negative effects*		
			slight	*moderate*	*severe*
bulbous bluegrass[3]	✔	✔	✔		
crested wheatgrass complex[4]	✔(fall)	✔	✔(spring)		
hard fescue[5]		✔	✔(spring)		
sheep fescue[5]		✔(fall)		✔(spring)	
intermediate wheatgrass complex	✔				
Kentucky bluegrass[6]	✔				
orchardgrass	✔	✔			
reed canarygrass[7]		✔	✔		
tall wheatgrass		✔			

[1]USDA, FS Intermountain Research Station, 1994.

[2]Wright et al., 1979.

[3]Based on burning studies of sandberg bluegrass. Different studies show it to be favored, no effect, slight negative effect.

[4]Negative effect by burning in spring and may reduce growth for two years; however studies show growth favored by late summer fires.

[5]Zamora, 1995, personal communication.

[6]Fire appears to favor Kentucky blue grass in the Columbia and Great Basins.

[7]Negative effect by burning every two to three years during dry period.

appendix II

general wildlife use of introduced taxa

Planting of introduced grasses and other plants on portions of an area can result in earlier green up in spring, a critical time for most wildlife (Ammann et al. 1973). Such seedlings often provide high-quality plant foods that aid in more rapid recovery of body condition lost in the stressful winter period. Seeded (introduced) species can supply significant amounts of green herbage on many sagebrush winter ranges where native species are either dormant or produce little forage. Fall green up of crested wheatgrass may supply palatable and nutritional forage in fall and snow-free periods in winter and extend the availability of the limited amount of browse. Seeding of introduced species on spring-fall range reduced the livestock use of browse species and thus reduced competition with wildlife (Lamb 1966, Vale 1974). Literature pertaining to wildlife food habits on mid-successional sites indicate that deer, antelope, sage grouse, other birds, and small mammals use seeds and foliage from introduced plants in the west (Urness 1979).

Seed predation by deer mouse and other rodents causes or contributes to the failure of several seedings (Howard 1950, Spencer 1954, Nord 1965). The deer mouse is a major consumer of planted seed (Kverno 1954, Nelson et al. 1970, Everett et al. 1978).

Seeds are an important part of the deer mice diet, especially in the fall and winter when insects and green vegetation are not available (Fitch 1954, Williams 1959, Whitaker 1966). Seeds of forbs (Johnson 1961), grasses (Frischknecht 1965), and shrubs (Jameson 1952) are consumed at different times of the year, depending on seed availability and floristic composition. Seed size, odor, and nutrient content play an important role in food preference (Howard and Cole 1967, Lockard and Lockard 1971), but when food is scarce deer mice will take almost any food available. Deer mice are opportunistic in their feeding habits and readily consume available foods (for example, planted seed) that appear on the site (Johnson 1961, Everett et al. 1978).

Goebel and Berry (1976) and Nelson et al. (1970) report that birds can consume significant amounts of the applied seed and reduce seedling establishment in an otherwise potentially successful reseeding. These authors cite Spencer (1954, 1958, and 1959), who has worked extensively on bird and mammal seed protectants for range and forest seeding, and have concluded damage by birds, rodents, and insects can be so extensive as to result in failures.

Goebel and Berry (1976) conducted feeding trials for seed preference by 25 different wild birds in an annual-dominated *Agropyron-Poa* habitat type near Asotin, Washington. Six perennial and two annual species were tested. Based on cafeteria-type feeding stations observed during the spring of 1969 they found that the small-seeded sheep fescue was removed more frequently than larger-seeded species such as intermediate and pubescent wheatgrass. Intermediate wheatgrass was the most highly preferred wheatgrass used in these trials. The authors concluded that birds may inhibit improvement of range sites by their use of the seed of various species.

appendix III

contacts

Numerous natural resource research scientists, retired research scientists, plant material specialists and range management field people were contacted. These individuals represent several experiment and research stations, universities, and plant material centers. Many visits were made to their respective locations. The following is a list of people and institutions contacted during the preparation of this report:

A. people contacted

Jay Anderson, ISU, Pocatello, Idaho
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Jacy Gibbs, Regional Plant Materials Specialist USDA-NRCS,
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Spokane, Washington
Durrant McArthur, Project Leader and Geneticist, USDA-FS,
Shrub Sciences Laboratory, Provo, Utah
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Dan Ogle, Plant Materials Specialist for Idaho, Utah, and parts of Nevada.
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Richard Pudney, Area Range Conservationist USDA-NRCS,
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Ben Roché, Extension Range Specialist, WSU, Pullman, Washington
Phil Rumple, Rangeland Management Specialist, USDI-BLM,
Vale District, Vale, Oregon
Ken Sanders, Professor of Range Resources, UI, Twin Falls, Idaho
Mark Stannard, Plant Materials Center Manager, USDA-NRCS,
Pullman, Washington
Lorin St.John, Asst. Plant Materials Center Manager, USDA-NRCS,
Bridger, Montana
Forrest Sneva, Retired, Range Scientist, USDA-ARS, Burns, Oregon
Tony Svejcar, Research Leader, USDA-ARS, Burns, Oregon
Ross Wight, Range Scientist, Northwest Watershed Research, USDA-ARS,
Boise, Idaho
Neil West, Professor of Rangeland Resources, USU, Logan, Utah
Alma Winward, Riparian Specialist, USDA-FS, Ogden, Utah
Gary Young, USDA-NRCS Plant Materials Center, Aberdeen, Idaho
Ben Zamora, Professor of Ecology, WSU, Pullman, Washington

B. institutions, stations, and centers contacted

1) Universities:

University of Idaho
Idaho State University
Utah State University
Washington State University
Oregon State University
Brigham Young University

2) Research Stations:

Forage and Range Research USDA-ARS, Logan, Utah
Intermountain Research Station USDA-FS, Ogden, Utah
Shrub Science Laboratory USDA-FS, Provo, Utah
Squaw Butte Experiment Station USDA-ARS, Burns, Oregon

3) NRCS Plant Material Centers:

Aberdeen, Idaho
Pullman, Washington
Corvallis, Oregon
Bridger, Montana

C. The following data bases were electronically searched using key words that included all scientific and common names of species be ing reviewed plus approximately 30 additional terms such as competition, invasion, biodiversity, etc.)

Journal of Range Management (1948-1993)
Dissertation Abstracts
National Agricultural Library - AGRICOLA, BIOSIS
USDA-Forest Service INFO Database

appendix IV

literature cited

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