J. Range Manage.
50:530–535

Cheatgrass and range science: 1930–1950

JAMES A. YOUNG AND FAY L. ALLEN

Authors are range scientist and research technician (oral history specialist), USDA-ARS, Conservation Biology of Rangelands Research Unit, 920 Valley Road, Reno, Nev. 89512.

Abstract

Cheatgrass (*Bromus tectorum* L.) is currently and historically has been a serious point of contention among a wide variety of people interested in sagebrush (*Artemisia*)/bunchgrass rangelands. Nowhere are these differences more apparent than in the scientific community. Our purpose is to provide a historical perspective of the influence of cheatgrass invasion on western rangelands (1930–1950). This was a period of awakening interest by range scientists. Range managers, the livestock industry, and scientists have always had a love-hate relationship with cheatgrass. It provides the bulk of the forage on many ranges, yet it is the symbol of environmental degradation. Trying to cope with the endless ramifications of cheatgrass invasion, dominance, persistence, and potential community decline keep forcing scientists to critically evaluate the ecological principles upon which range management is based.

Key Words: invasive weeds, secondary succession, historical perspective, plant ecology, rangeland health

Millions of hectares of rangelands in the Intermountain Area, Pacific Northwest, and northern Great Plains are characterized by the accidentally introduced annual cheatgrass (*Bromus tectorum* L.). Cheatgrass dominance influences virtually all aspects of rangeland environments. The conversion from native vegetation to cheatgrass dominance has occurred at an accelerated rate during the 20th century. Scientific range management has also largely evolved during the same period. Range science has to be a dynamic, ever progressing discipline, to meet the needs of an ever-changing world. The changing perspective of range scientists and managers during the increase in dominance of cheatgrass provides insight into the evolution of range science. Our purpose is to trace and interpret this interaction during the critical period from about 1930 to 1950.

Social, Ecological, and Economic Setting

The range livestock industry in western North America was deeply depressed by the economic downturn that gripped the entire world at the beginning of the 1930s. Additionally much of the west was experiencing a drought of historic intensity. After the drought of the year 1934, basal areas of perennial grasses on 140 permanent transects located in sagebrush (*Artemisia*)/bunchgrass plant communities on the Sheep Experiment Station, Dubois, Ida., decreased 38% (Pechanec et al. 1937). These communities were largely in good ecological condition under moderate or limited grazing. The effect of this very dry and unusually warm year (2.69° C above normal mean annual temperature at Dubois) on degraded, excessively grazed communities must have been extreme.

The biological results of this drought were amplified by abusive use of range and marginal agricultural lands. The era of uncontrolled grazing on open range was painfully drawing to a close. Proposals for dealing with grazing on vacant federal lands had been debated since the beginning of the century without a consensus being reached. Major factors blocking a consensus were multiple claims, for common grazing lands, obviously far in excess of sustainable production for these lands (Wooton 1932). The drought made it readily apparent that the vast areas of marginal farm land were not suitable for sustainable rain-fed cropping. The depth and intricacies of the problems of the western range were brilliantly captured by George Stewart (1936) in his testimony before a Committee of the U.S. Senate. Since 1898 a series of bills to regulate grazing had failed to pass Congress, but on 28 June 1934 the Taylor Grazing Act was signed into law (Buckman 1935). That November, President Franklin D. Roosevelt issued an Executive Order withdrawing almost 70 million hectares of public land in 12 western states (Buckman 1935). A little more than a century after the first trappers had ventured west of the Rocky Mountains, much of the big sagebrush (*Artemisia tridentata* Nutt.)/bunchgrass ranges of the Intermountain Area was markedly changed as a result of improperly timed, continuous, and often excessive grazing (Young and Sparks 1985).

Cheatgrass

Cheatgrass occurs in Europe and Asia in a broad band from the Central Asian former Soviet Republics, through the Mediterranean area to Spain and North Africa (Meusel et al. 1965). It may not be native to any of these areas in the same sense that we describe plants as native to North American rangelands. Cheatgrass apparently has become pre-evolved to fill niches created by humans through the concentrations of their domesticated large herbivores, and as such has grown in the shadow of herders wherever they have roamed (i.e. Young and Evans 1976). Cheatgrass is a weed of many grain crops, and as a contaminant

Manuscript accepted 12 Nov. 1996.

of crop-seed it was readily disseminated across North America (Mack 1981). It was often a contaminant of alfalfa (*Medicago sativa* L.) seed (Piemeisel 1938). Cheatgrass was collected in Pennsylvania in 1861, Washington in 1893, Utah in 1894, Colorado in 1895, and Wyoming in 1900 (Yensen 1981). The advent of the steam-powered grain thresher that moved from farm to farm probably aided in the dispersion of cheatgrass.

Initial Dispersal

There is considerable antidotal information from the period concerning the spread of cheatgrass. In Elko County, Nevada, it obviously was the fault of the itinerant Basque sheepmen (i.e. Kennedy 1903, Anon. 1966). Local newspaper editors, at the turn of the century, tended to blame every social, biological, or economic evil that could not be directly attributed to the Gold Standard on the itinerant shepherds. This may have some merit because long distant movement of nomad sheep bands would provide an excellent dispersal mechanism for the awned seeds (caryopses) of cheatgrass. Railroad right-of-ways became some of the most frequent areas where the conversion from a shrub steppe to an annual grassland occurred in the 1940s (Yensen 1981). This was usually due to the high frequency of wildfires associated with steam locomotives, and brake fires on steep grades. With a few notable exceptions, the actual mechanism of dispersal and colonization was not subject to scientific scrutiny.

During the first few years of the 20th century, cheatgrass was observed in Idaho by personnel of the U.S. Forest Service (Stewart and Hull 1949, quoting 1914 Forest Service report). It was positively identified in the background of a photograph taken in Ada County, Ida. in 1898 (Yensen 1981). The annual grass was strictly a weed of cultivated fields and roadsides. About 1915 cheatgrass started to colonize overgrazed rangelands. Many reports hailed the establishment of cheatgrass on badly degraded areas as a great positive event (Sawyer 1965). There is even evidence that cheatgrass, which was called the "100 day grass", was deliberately introduced to new areas (Hedrick 1965). Promiscuous burning to aid in the spread of cheatgrass and remove sagebrush was probably common (Yensen 1981). The severe agricultural depression that followed World War I resulted in the abandonment of considerable areas (estimated 0.75 million hectares in Idaho) that had been cropped for grain. These grain-fallowed fields were often badly infested with cheatgrass which probably contributed to their abandonment. Once abandoned, these areas became dense stands of cheatgrass with very limited re-establishment of native shrubs.

Ecological Status of Cheatgrass

The classic cheatgrass paper was written by G.D. Pickford (1932) in which he described for the foothills of Utah, a cycle of: a) cheatgrass invasion, b) excessive grazing, c) increase in cheatgrass, d) frequent wildfires, and e) continued dominance by cheatgrass. The model portrayed by Pickford has proven remarkedly resilient over time. Perhaps, the perception of this model by many observers has clouded over time. An overly simplistic summary of this model is given as: "grazing causes cheatgrass and wildfires."

Invasion

Pickford found that cheatgrass made up less than 1% of the vegetation of good and excellent condition plant communities protected from grazing. The painstaking research of R.F. Daubenmire (1940, 1942) clearly showed that minimal amounts of cheatgrass were capable of establishment and discontinuous persistence in good and excellent condition bunchgrass communities that had not been grazed for 50 years. Through development of large, persistent seedbanks, cheatgrass could persist on sites where it did not have sufficient environmental potential to reproduce every year. Tisdale (1947) reached a similar conclusion for grasslands of British Columbia.

The historical sequence shows that cheatgrass invaded degraded rangelands, but as the Pickford model points out, degradation was not necessary for cheatgrass invasion. The speed that cheatgrass spread was probably initially highly dependent on the level of degradation of the native herbaceous vegetation. Yet adaptation to equilibrium native communities is the first reason that the misrepresentation, "Remove livestock and cheatgrass disappears", is false.

Excessive Grazing

There are several references to the reduction of cheatgrass by spring grazing (Daubenmire 1940, Piemeisel 1938). Excessive grazing in the early spring, year after year weakens native cool-season perennial grasses and provides additional habitat for cheatgrass increase. The removal of livestock reduces grazing on cheatgrass and increases seed production, seedbanks, and the chances of destructive wildfires. All of these factors enhance the potential of cheatgrass to compete and persist. The fact that excessive spring grazing both enhances the presence and biologically suppresses the abundance of cheatgrass is one of the most misunderstood aspects of the biology of this grass.

Increase in Cheatgrass

Pickford, Stewart, and Piemeisel all recognized the tremendous phenotypic plasticity of cheatgrass (i.e. Piemeisel 1938). One plant m^{-2} can produce as many seeds as 10,000 plants m^{-2} (Young et al. 1969). This is the significance of a few cheatgrass plants being able to establish and persist in high ecological condition perennial grass communities. Most of the native perennial grasses of sagebrush/bunchgrass communities have irregular, limited seed production, the seeds have complex dormancies and/or low viability, and most species do not build seedbanks. In numbers of seeds produced per plant per unit of area, cheatgrass has the capability to overwhelm native perennials in competition at the seedling level even if the starting density of cheatgrass was extremely limited. The mechanisms through which cheatgrass out competes seedlings of native perennial species are varied and complex. However, it is important to maintain a perspective of the tremendous seed production and seedbank size, in addition to the persistence of cheatgrass.

Frequent Wildfires

That cheatgrass stands protected from grazing persisted if promiscuously burned is the more profound portion of Pickford's (1932) model. It was beyond the time period of this manuscript, before the close association of cheatgrass dominance and mineralizable nitrogen was recognized (i.e. Harris 1967). Cheatgrass thrives on nitrogen enrichment. Disturbances and wildfires bring accelerated mineralization of nitrogen. This is apparently the reason Pickford's observation that promiscuous burning favors ungrazed cheatgrass stands is valid.

Continued Dominance of Cheatgrass

One basic concept of range management is that responses are site specific. Certainly this is true in regard to the reaction of cheatgrass to management options. On some sites, that were in specific successional stages, reduced grazing pressure enhanced perennial grasses and reduced cheatgrass. What became adopted as cast-in-stone dogma by land management agencies during the 1930s and 1940s was that grazing management solved all cheatgrass problems. A frequent reaction of cheatgrass-dominated sites to grazing management, especially if the management system included deferment of grazing until after seed ripe and/or complete rest from grazing in rotation, has been the absolute persistence of the annual grass. Site potential, successional status, seedbanks, and the influence of fuel accumulations from the occurrence of wildfires all interact with the results of grazing cheatgrass. If we try to view the cheatgrass problem through the perspective available to scientists in the 1930s and 1940s, the concept that a lack of grazing management was the major factor in creating cheatgrass dominance, then the reciprocal that proper grazing management should solve the problem is an obvious conclusion.

Cheatgrass as a Forage Species

Cheatgrass was initially hailed by many involved with the range livestock industry as the greatest thing that could have happened to sagebrush rangelands. It produced abundant forage on areas that had been producing Russian thistle (*Salsola australis* R. Brown) and/or tumble mustard (*Sismybrium altissimum* L.) (Hull and Pechanec 1947). The original Range Plant Handbook (Anon. 1937) reported that cheatgrass provided the bulk of early spring grazing for all classes of livestock on millions of hectares in the Intermountain west. Hull and Pechanec (1947) estimated that during the 1940s cheatgrass was, in extent of area covered and volume of herbage produced, the most important forage plant in southern Idaho. In 1946 it was estimated that cheatgrass dominated 4 million hectares of rangeland in Oregon (Platt and Jackman 1946). They considered half of the forage consumed from rangelands to be cheatgrass. When green, cheatgrass provided a preferred forage for all classes of livestock. When it was dry, cattle and horses would consume the herbage. Draft horses were still important in agriculture during the 1930s and cheatgrass was found to serve as an adequate forage for non-working horses until fall (Hurtt 1939). The nutritive quality of cheatgrass when it is green was found to be excellent (McCall et al. 1943). When dry, the levels of digestible protein could be inadequate, depending on the class of animal using the forage.

Watershed Protection

Watershed studies on western rangelands developed out of necessity following a series of destructive floods (i.e. Sampson and Weyl 1918). Studies conducted on fragile soil derived from granite, on steep slopes in the Boise River watershed of Idaho, reported that cheatgrass provided much better protection against surface soil erosion than degraded rangeland communities or native needlegrass (*Stipa*) communities under moderate simulated precipitation (Craddock and Pearse 1938). The publication of these results created a storm of controversy among range managers and scientists. Hull and Pechanec (1949) cite a rebuttal manuscript by George Stewart as in preparation, but apparently it was never completed. The corner stone of range science was that the climax plant community was ideal, and departure from a pristine ideal represented degradation of the environment. F.E. Clements (1928), the father of grassland ecology and mentor of many range researchers of the era, wrote, "*Bromus tectorum* is a range plant of slight value, spreading over the Great Basin." He reported it was replacing desirable native dominant species. Actually, Craddock and Pearse (1938) went to considerable lengths to emphasize that they were not recommending cheatgrass as an alternative to native species (perhaps in response to peer review pressure).

Hazard of Basing Permanent Grazing on Cheatgrass

As senior forest ecologist with the Forest Service, Intermountain Forest and Range Experiment Station, George Stewart (Stewart and Young 1939) strove to explain the hazards of grazing cheatgrass. Some of the hazards of grazing cheatgrass enumerated in this paper are commonly repeated today, while others are no longer emphasized.

Variable Forage Production

The foremost hazard according to Stewart and Young (1939), was the great variability among years in herbage production of this annual. Perennial grass-dominated communities vary in herbage production among years in response to the amount and distribution of precipitation, but the amplitude of the variation is less than with cheatgrass. A 10 fold difference in herbage production of cheatgrass was measured in consecutive years (Hull and Pechanec 1947). In good years, on favorable sites, production of cheatgrass herbage exceeded most native and introduced perennial grasses. This probably was true for introduced forage species available at the time. The hazard of basing cow and calf production on cheatgrass forage is that during dry years forage production can be zero. A major factor controlling the amount of forage produced by cheatgrass was the timing of germination. During years when germination did not occur in the fall and was delayed until spring, production was greatly reduced (Stewart and Hull 1949). For the extremely dry years this is probably not a valid comparison because under such conditions the limited herbage production of perennial grasses should not be grazed during the growing season. The comparison is probably valid for marginally sub-average production years. In discussing the variability in cheatgrass forage production, the comparative danger of wildfires in cheatgrass versus native perennial grass stands deferred from grazing for forage conservation, as a hedge against future droughts, was not directly discussed.

Short Green Feed Period

Stewart and Young (1939) firmly insisted that cheatgrass was only eaten by livestock when green. Mature cheatgrass was consistently described as dry straw armed with noxious seeds. This was perpetuated in the truism that the caryopses were extremely injurious to livestock. Reid (1942) repeated the idea that cheatgrass was only eaten during the green feed period, but added that livestock did lick the mature seeds from the ground in the fall.

Livestock Injury

Perhaps the first scientific interest displayed toward cheatgrass concerned injuries to the eyes and mouths of livestock caused by the awned caryopses (Glover and Robbins 1915). Stewart and Young (1939) considered this to be a major hazard of basing grazing on this species. Such injuries are still common, but do not receive the elevated emphasis in livestock management imparted by 1930s authors. The awned seeds caused many injuries to sheep (Fleming et al. 1942). Perhaps, the treatment of secondary infections associated with cheatgrass injuries has improved.

Smut Infestations

Cheatgrass, under certain precipitation patterns is highly susceptible to a smut (*Ustilago bromivora* [Tul.] Frisch. von Waldh.) (Ruddy and Godkin 1923). Stewart and Young (1939) mention the occurrence of this smut, but did not emphasize the occurrence of the disease as a hazard to grazing, other than reducing forage production. The hazard of super abundant seed production and seedbank development serving as a reservoir of plant pathogens that could spread to other grasses was not discussed (Kreitlow and Bleak 1964).

Wildfires

Stewart and Young (1939) repeated the well established concept that cheatgrass contributed to the number and spread of wildfires, leading to ecological degradation. They did not consider mature, dry cheatgrass to be a suitable forage source and the general level of utilization on most non-National Forest sagebrush rangelands ensured there were no accumulations of dry cheatgrass (Emmerich et al. 1993). Leopold (1941) considered wildfires in cheatgrass stands virtually impossible to control. By the end of the 1940s, Stewart and Hull were both much more concerned with the wildfire hazard associated with cheatgrass.

Overgrazing Cheatgrass

One of the supposed advantages of cheatgrass, that was widely repeated during the 1930s, was its immunity to overgrazing. Hull and Pechanec (1947) disputed this and showed photographs of overgrazed cheatgrass ranges where accelerated erosion was occurring. If cheatgrass was grazed to the point of no longer protecting the surface soil, accelerated erosion occurred and loss of site potential was possible. To support this conclusion, they referred to the pioneering research of R.L. Piemeisel (1938) and R.F. Daubenmire (1940). Piemeisel described secondary successional stages from Russian thistle to cheatgrass dominance. This succession was reversible through excessive grazing. The significance of this to Intermountain intensive irrigated agriculture was that lower successional stages provided alternate habitat for the beet leafhopper (*Eutettix tenellus*), which served as a vector for the curly top virus. If you overgrazed cheatgrass, the lower seral communities provided increased habitat for the leafhopper and therefore more disease transmittal to susceptible crops.

Reality of Basing Grazing on Cheatgrass

The counterpoint to the articles by Intermountain Forest and Range Experiment Station scientists touting the hazard of cheatgrass was provided by the Nevada Experiment Station Bulletin, "Bronco Grass (*Bromus tectorum*) on Nevada Ranges" by Fleming et al. (1942). C.E. Fleming was one of the original range scientists conducting research on the western range. In the 1940s he was widely recognized as an authority on Intermountain ranges, probably at a level of experience and reputation equivalent with George Stewart. We have 2 copies of the above mentioned bulletin. One has margin notations apparently by J.H. Robertson, and the other came from the School of Forestry at the University of California at Berkeley and the margin notations have been attributed to Arthur W. Sampson. The margin notations agree with Fleming's conclusion that cheatgrass is a permanent source of forage and as such must be recognized by range managers. A statement by Fleming et al. (1942) on the variability in cheatgrass forage production was very interesting in that it dodged the major conclusion of Stewart and Young (1939). It stated, as long as spring moisture was adequate, the variability in cheatgrass production was no greater than with native perennial grasses. The data presented by Stewart and Young (1939) actually show this, but it also shows spring seasons when moisture is inadequate and there is virtually no cheatgrass forage production. The additional conclusion that cheatgrass can compete very well under heavy spring grazing with native perennials is in agreement with Stewart and Young (1939), but the value placed on the conclusion is exactly opposite! This dichotomy continues in the discussion of the relationship of cheatgrass to wildfires. Yes, cheatgrass allowed wildfires to spread in degraded big sagebrush stands, but by doing this the overly dense stands of sagebrush were removed and good stands of cheatgrass returned. The final conclusion of the Fleming et al. (1942) paper is most interesting: "Is there any assurance that perennial grasses would withstand the hard conditions of early spring grazing as well as bronco grass if they could be restored?"

Regrassing Sagebrush Rangelands

The subheading is paraphrasing A.C. Hull, Jr.'s (1944) title "Regrassing Southern Idaho Range Lands." Essentially, Hull and other scientists of the 1940s answered Fleming's question on alternatives to cheatgrass by planting crested wheatgrass (*Agropyron desertorum* [Fisher] Schultes). The story of restoring perennial grasses to sagebrush rangelands has been told in detail elsewhere (Young and McKenzie 1982). Crested wheatgrass was established on sites dominated by cheatgrass, but only if the topography and surface rock cover permitted tillage (Stark et al. 1946). A large percentage of the sagebrush rangelands that were seeded to crested wheatgrass were degraded big sagebrush stands. The perennial grass understory had been depleted (perhaps late in the 19th century), and subsequent excessive sagebrush seedling establishment had maintained the site as on herbaceously sterile community, and relatively fire free. These shrub sites were plowed and seeded without there ever being a period of cheatgrass dominance. Rehabilitation of areas burned in wildfires were a second type of environment where crested wheatgrass was established in avoidance of competition with cheatgrass. As long as degraded sagebrush stands were burning, there was sufficient fuel to keep temperatures high enough and long enough to kill cheatgrass seeds to markedly reduce competition. Failure to rehabilitate sagebrush burns allowed cheatgrass dominance and assured re-burning. Burns in cheatgrass, without woody fuel, do not significantly reduce cheatgrass seedbanks. Farve (1942) was the first to suggest seeding perennial grasses to reduce the incidence of wildfires on cheatgrass-dominated rangelands.

Hull (1949) reported that most introduced forage grasses adapted to sagebrush rangelands began growth in the spring before cheatgrass. Reitz and Morris (1939) concluded the opposite for introduced and native perennial grasses. This seemingly small point has great importance in interpreting the potential of using early spring grazing to biologically suppress cheatgrass versus deferment of grazing to favor native perennial grasses. It also has bearing on the justification for seeding exotic perennial grasses on the grounds that they can stand early spring grazing.

Closed Communities

Range scientists during the 1930s and 1940s had a hard time trying to define the relation between native perennial grasses and cheatgrass. Was cheatgrass replacing or displacing perennial grasses? Established perennial grasses easily suppressed cheatgrass. There was no evidence that cheatgrass was killing perennial grasses. The key was at the seedling stage. If the stand of perennial grasses was to fully occupy the site and suppress cheatgrass, the native perennial grasses had to produce, disperse, and germinate seeds and establish seedlings in the face of competition for moisture from cheatgrass seedlings. This was clearly shown in the landmark paper, "Artificial Reseeding and the Closed Community", published by Joseph H. Robertson and C.K. Pearse (1945). The initial emphasis was on cheatgrass closing stands to the establishment of seedlings of exotic perennial grasses. It soon became apparent that the closed community concept applied to native as well as exotic perennial seedlings (Rummell 1946).

Legacies

W.D. Billings was among the few scientists who conducted research during the 1930s and actively published on the subject. He chose the work of another living scientist of the era, J.H. Robertson, to illustrate the impact of cheatgrass on sagebrush/bunchgrass environments (Billings 1990). Robertson (Robertson and Kennedy 1954) repeated a survey of Elko County, Nevada ranges 50 years after the pioneering work of range botanist P.B. Kennedy (1903). The comparisons developed by J.H. Robertson and the 1990s perspective by Billings, one of America's most distinguished ecologists, need to be read by anyone concerned about cheatgrass.

The legacies passed on by the range scientists of the 1930s and 1940s contain many profound discoveries that have great theoretical and practical applications to the art and science of range management. At the same time, we must maintain the historical perspective that this research was conducted at the end of an era when demand for range forage greatly exceeded supply. Reading Fleming's publications, you have the feeling he could not conceive of the idea of reducing the number of livestock grazing degraded sagebrush ranges in order to improve the condition of such ranges. These research results were interpreted in such policies as failing to give any credit for cheatgrass as a forage species on public rangelands because it was not a native species. This was done for several decades since the 1940s when cheatgrass was providing the bulk of the forage on given allotments. Deferring grazing on cheatgrass ranges that lacked a residual population of native perennial grasses is another legacy of this era. Perhaps, it should be said that these interpretations were made in spite of, rather than as a result of, the research on cheatgrass conducted from 1930 through 1950. It is personified in the concept: "do not graze cheatgrass and it will go away".

A second perspective of the 1930 to 1950 period is provided by examining the scientific achievements in light of the current level of scientific understanding. The ecological concepts in use at the time were static. The concepts of climatic change were static. The cheatgrass itself was viewed as a static species not capable of rapidly evolving to changing environmental situations. In retrospect, this research may have been conducted while the environment of the sagebrush/bunchgrass ranges was crossing a threshold for which there is no return (Tausch et al. 1993).

Literature Cited

Anon. 1937. Range plant handbook. USDA, Forest Service, Washington, D.C.

Anon. 1966. Water and related land resources, Humboldt River Basin, Nevada. Bull. R12, USDA, SCS, Carson City, Nev.

Billings, W.D. 1990. *Bromus tectorum*, a biotic cause of ecosystem impoverishment in the Great Basin. pp. 301–322. *In*: G.M. Woodwell (ed) Patterns and processes of biotic impoverishment. Cambridge Univ. Press, N.Y.

Buckman, T.E. 1935. The Taylor Grazing Act in Nevada. Bull 76 Nevada Agr. Exp. Sta., Reno, Nev.

Clements, F.E. 1928. Plant Succession and Indicators. Wilson, New York, N.Y.

Craddock, G.W. and C.K. Pearse. 1938. Surface run-off and erosion on granitic mountain soils of Idaho as influenced by range cover, soil disturbance, slope, and precipitation intensity. Cir. 428, USDA, Washington, D.C.

Daubenmire, R.F. 1940. Plant succession due to overgrazing in the *Agropyron* bunchgrass prairie of southern Washington. Ecology 21:55–64.

Daubenmire, R.F. 1942. An ecological study of the vegetation of southeastern Washington and adjacent Washington. Ecol. Monogr. 12:53–79.

Emmerich, F.L., F.H. Tipton, and J.A. Young. 1993. Cheatgrass: changing perspectives and management strategies. Rangelands 15:37–40.

Farve, C.E. 1942. Cheatgrass and fire. National Wool Grower 32(12):30–31.

Fleming, C.E., M.A. Shipley, and M.R. Miller. 1942. Bronco grass (*Bromus tectorum*) on Nevada ranges. Bull. 158, Nevada Agr. Exp. Sta., Reno, Nev.

Glover, G.H. and W.W. Robbins. 1915. Colorado plants injurious to livestock. Bull. 211, Colorado Agric. Expt. Sta., Fort Collins, Colo.

Harris, G.A. 1967. Some competitive relationships between *Agropyron spicatum* and *Bromus tectorum*. Ecol. Monogr. 37:89–111.

Hedrick, D.W. 1965. History of cheatgrass—present importance of cheatgrass in management of rangelands, pp. 13–16. *In*: Proc. cheatgrass symposium. USDI, BLM, Portland, Ore.

Hull, A.C., Jr. 1944. Regrassing southern Idaho rangelands. Bull 146. Idaho Agric. Expt. Sta., Moscow, Ida.

Hull, A.C., Jr. 1949. Growth periods and herbage production of cheatgrass and reseeded grasses in southwestern Idaho. J. Range Manage. 2:183–186.

Hull, A.C., Jr. and J.F. Pechanec. 1947. Cheatgrass-A challenge to range research. J. Forestry 45:555–564.

Hull, A.C., Jr. and J.F. Pechanec. 1949. Growth periods and herbage production of cheatgrass and reseeded grasses in southwestern Idaho. J. Range Manage. 2:183–186.

Hurtt, L.C. 1939. Downy brome (cheatgrass) range for horses. Applied Forestry Note 89. USDA, Forest Service, Missoula, Mont.

Kennedy, P.B. 1903. Summer ranges of eastern Nevada, Bull 55. Nevada Agr. Exp. Sta., Reno, Nev.

Kreitlow, L.W. and A.T. Bleak. 1964. *Podosporiella verticillata*, a soil-borne pathogen of some western Gramineae. Phytopathology 54:353–357.

Leopold, Aldo. 1941. Cheatgrass takes over. The Land 1:310–313.

Mack, R.N. 1981. Invasion of *Bromus tectorum* L. into western North America: an ecological chronicle. Agro-Ecosystems 7:145–165.

McCall, R., R.T. Clark, and A.R. Patton. 1943. The apparent digestibility and nutritive value of several native and introduced grasses. Tech. Bull. 418, Montana Agr. Exp. Sta., Missoula, Mont.

Meusel, H., E. Jager, and E. Weinert. 1965. Vergleichende Chorologie der Zentreleurofsaischen Flora. Bd. 1. (2 vols.) Gustav Fischen Verlag, Jena.

Pechanec, J.F., G.D. Pickford, and George Stewart. 1937. Effects of the 1934 drought on native vegetation of the upper Snake River Plains, Idaho. Ecol. 18:490–505.

Pickford, G.D. 1932. The influence of continued heavy grazing and the promiscuous burning on spring-fall ranges in Utah. Ecol. 13:159–171.

Piemeisel, R.L. 1938. Changes in weedy plant cover on cleared sagebrush land and their probable causes. Tech. Bull. 654. USDA, Washington, D.C.

Platt, K. and E.R. Jackman. 1946. The cheatgrass problem in Oregon. Bull. 668. Oregon Agr. Exp. Sta., Corvallis, Ore.

Reid, E.H. 1942. Important plants on national forest ranges of eastern Oregon and eastern Washington. Res. Report 1. USDA, Forest Service, Portland, Ore.

Reitz, L.P. and A.E. Morris. 1939. Important grasses and other plants on Montana ranges. Bull. 375, Montana Agr. Exp. Sta., Bozeman, Mont.

Robertson, J.H. and P. B. Kennedy. 1954. Half-century change on northern Nevada ranges. J. Range Manage. 7:117–121.

Robertson, J.H. and C.K. Pearse. 1945. Artificial reseeding and the closed community. Northwest Sci. 19:58–68.

Ruddy, C.S. and J.A. Godkin. 1923. Bacterial diseases of brome grasses. Phytopathology 13:75–86.

Rummell, R.S. 1946. Some effects of competition from cheatgrass brome on crested wheatgrass and bluestem wheatgrass. Ecol. 27:159–167.

Sampson, A.W. and L.H. Weyl. 1918. Range preservation and its relation to erosion control on western grazing lands. Bull. 675, USDA, Washington, D.C.

Sawyer, W.A. 1965. Management of cheatgrass on rangelands, pp. 11–13. *In*: Proc. Cheatgrass symposium. USDI, Bureau Land Management, Portland, Ore.

Stark, R.H., J.L. Toeus, and A.L. Hafenrichter. 1946. Grasses and cultural methods of reseeding abandoned farm lands in southern Idaho. Bull. 267. Idaho Agric. Expt. Sta., Moscow, Ida.

Stewart, George. 1936. History of Range Use. pp. 119–133. *In*: The Western Range. Senate Doc. No. 199, 74th Congress, 2nd Session, GPO, Washington, D.C.

Stewart, George and A.C. Hull, Jr. 1949. Cheatgrass (*Bromus tectorum* L.)-an ecologic intruder in southern Idaho. Ecol. 30:58–74.

Stewart, George and A.E. Young. 1939. The hazard of basing permanent grazing on *Bromus tectorum*. Agron. J. 31:1003–1015.

Tausch, R.J., P.E. Wigand, and J.W. Burkhardt. 1993. Viewpoint: Plant community thresholds, multiple steady states, and multiple successional pathways: legacy of the Quaternary? J. Range Manage. 46:439–447.

Tisdale, E.W. 1947. The grasslands of the southern interior of British Columbia. Ecol. 28:346–382.

Wooton, E.O. 1932. The public domain of Nevada and factors affecting its use. Tech. Bull. 301, USDA, Washington, D.C.

Yensen, D.L. 1981. The 1900 invasion of alien plants in southern Idaho. Great Basin Natur. 41:176–183.

Young, J.A. and R.A. Evans. 1976. Responses of weed populations to human manipulations of the natural environment. Weed Sci. 24:189–190.

Young, J.A. and D. Mckenzie. 1982. Rangeland drill. Rangelands 4:108–113.

Young, J.A. and B.A. Sparks. 1985. Cattle in the cold desert. Univer. Press, Utah State Univ., Logan, Ut.

Young, J.A., R.A. Evans, and R.E. Eckert, Jr. 1969. Population dynamics of downy brome. Weed Sci. 17:20–26.