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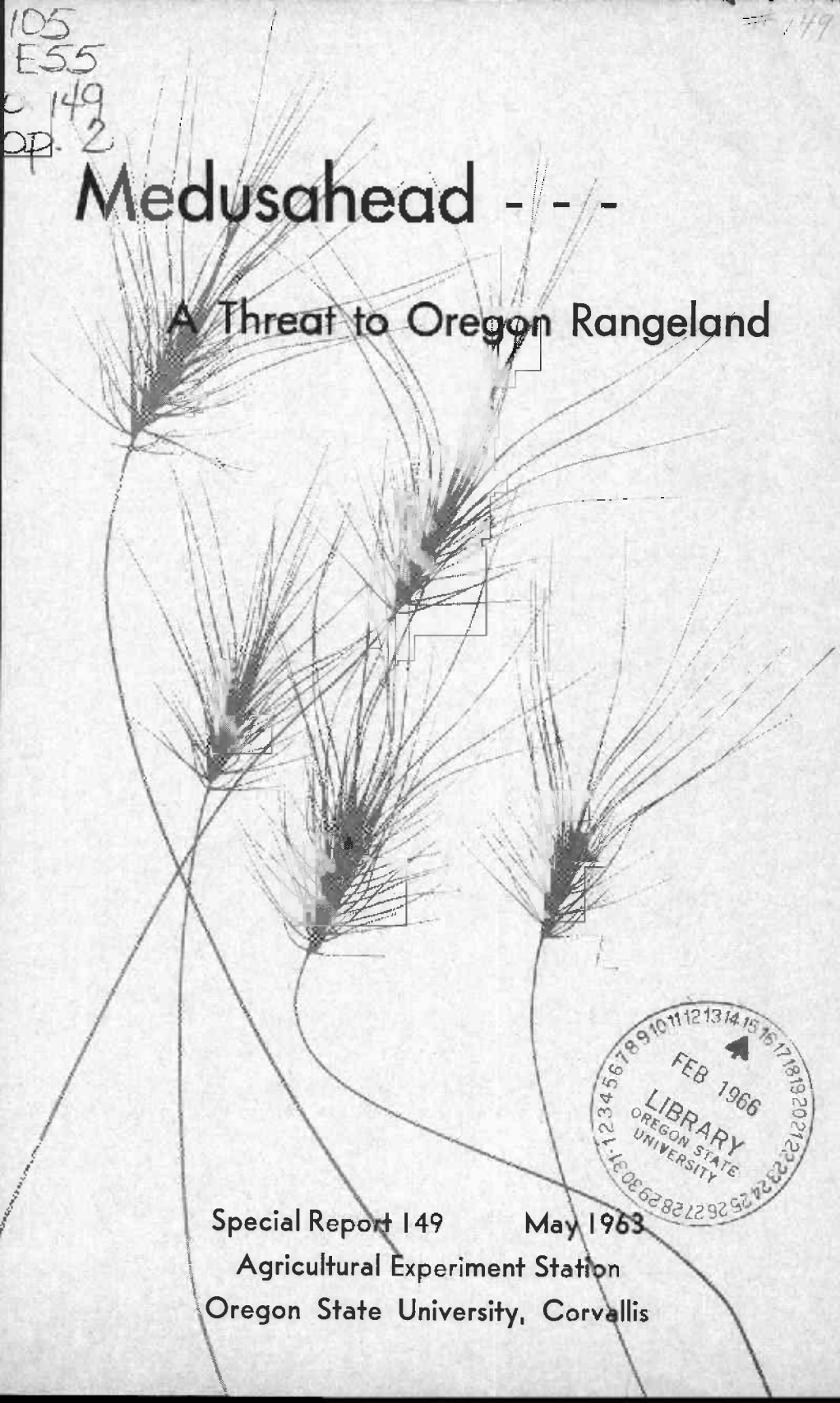
# Medusahead - - -

## A Threat to Oregon Rangeland



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# Medusahead---

## A Threat to Oregon Rangeland

ROBERT B. TURNER, CHARLES E. POULTON, AND WALTER L. GOULD

### Introduction

Medusahead,[1] a winter-annual weedy grass native to the Mediterranean region, is currently one of the primary range weed problems in Oregon. This weed has also been given the distinction by Torell et al. (1961) of being "the worst range weed in Idaho." Likewise, Murphy and Turner (1959) reported that medusahead ranks close to first as an undesirable range plant of California; and the western directors of the state experiment stations rank it among the 10 most serious range weeds.

Medusahead is a serious threat to the range livestock industry because of its aggressiveness in competition with cheatgrass (*Bromus tectorum* L.) and its practically worthless value as forage for both cattle and sheep. This weed has spread alarmingly in recent years in Oregon, California, Idaho, and Washington, and currently threatens to invade thousands of additional acres of overgrazed range, much of which now supports cheatgrass as the main forage plant. Sharp and Tisdale (1952) noted that within a period of three years medusahead became the dominant species on an area in Idaho which was formerly dominated by cheatgrass and other annuals.

It is of great importance that means are found quickly to arrest the rate of spread, to control and replace, and to manage for minimizing the risk of future outbreaks of this serious range weed.

### Geographic Distribution

The exact time and mode of introduction of medusahead into the United States is unknown. The first recorded collection of the plant was made by Thomas Howell in the Umpqua Valley in southwestern Oregon in 1884.[2] Other early collections were made near Roseburg, Oregon, by Howell in 1887,[2] and near Steptoe, Washington, by G. R. Vassey in 1901 (St. John, 1937).

According to Murphy and Turner (1959) medusahead has spread 600

[1] The scientific name of the species of medusahead found in the United States has been widely accepted as *Elymus caput-medusae* L. There is evidence that this is not the species we have in the United States. *Elymus caput-medusae* L. subs. *asper* (Sim.) Degen. seems more appropriate; however, the validity of naming the species *Taeniatherum asperum* (Sim.) Nevski is indicated from the European literature.

[2] Recorded in the University of Oregon herbarium.

miles south from the Oregon border since its initial foothold in California about 1900. Likewise in Idaho, the weed has an alarming history of rapid migration. The first official record made at the University of Idaho was in 1945, although ranchers claim to have noticed the plant during the 1930's. Hironaka (1961) reported this weed has spread, in about 15 years, from a few isolated patches to more than 750,000 acres in Idaho. Medusahead is also on the increase in Washington, with infestations reported by ranchers and Extension agents, from the southeastern border of the state to the area north of Spokane and well out into the Columbia Basin.

Current estimates indicate that medusahead occurs throughout an area in excess of 2,000,000 acres in Oregon.[3] This figure is much too high for the total infested acreage in this state because it encompasses both clean cropland and uninfested areas which could not be accurately separated in an extensive, rapid survey. Conversely, a more intensive survey would undoubtedly reveal infested areas which are unknown and not reported in the present estimate.

Half of Oregon's 36 counties are known to have medusahead infestations—5 west of the Cascades in southwestern Oregon and 13 in eastern Oregon (Figure 1). Southwestern Oregon has the largest geographical area of medusahead with over 1,500,000 acres included within the periphery of known infestations. These are mainly in Lane, Douglas, Jackson, and Josephine counties, with small amounts as far north as Benton County. Since the original center of known invasion into the United States is in Douglas County, medusahead is no recent stranger in this section of the state. In 1948, Peck (1948) described the occurrence of the weed, "In southern Oregon, in the high hills east of Ashland, thousands of acres are covered, almost to the submergence of other forms of herbaceous vegetation, with a continuous mantle of *Elymus caput-medusae,* the medusahead grass."

East of the Cascades, the presently known extent of infestation is approximately 500,000 acres. The history of medusahead is obscure for this region, but alarm has been expressed by many ranchers and range administrators over the high rate of spread evident in recent years. It is apparent that the rate of increase is comparable to that of Idaho. Counties with the largest acreages of medusahead include Wasco, Grant, Union, Baker, Malheur, and Klamath. Others with lesser amounts include Sherman, Gilliam, Morrow, Umatilla, Jefferson, Wheeler, and Lake counties.

Medusahead is not known to occur on the high, sagebrush-dominated plateau of southeastern Oregon, locally known as the "high desert." Whether or not it will seriously infest this physiographic province remains to be seen.

[3] Compiled from reports of county Extension agents, the Bureau of Land Management, and the Bureau of Indian Affairs.

# INFESTATION of MEDUSAHEAD

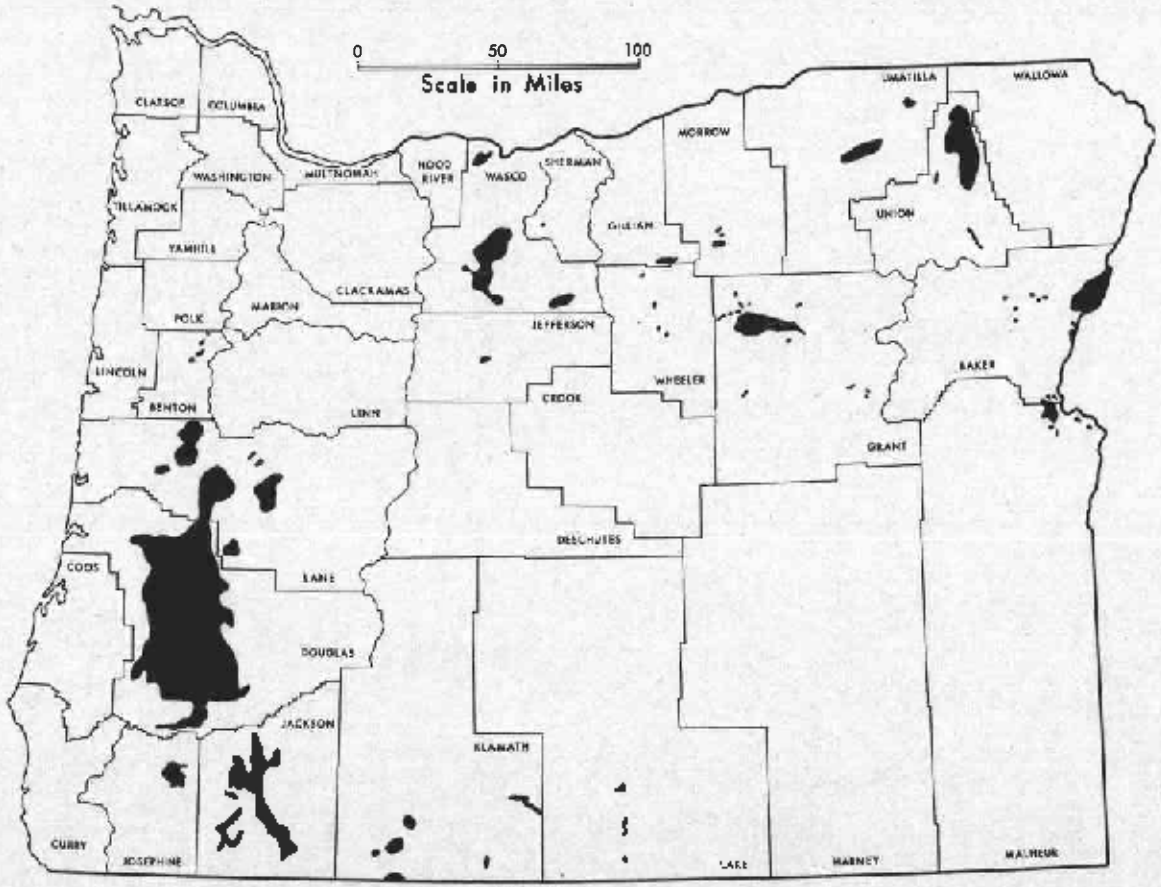


**FIGURE 1. Medusahead infestations in Oregon, January 1962.**

## Description of Medusahead

Medusahead has been appropriately named because of its resemblance to the mythical, Greek goddess, Medusa, with her snake-like hair (Figure 2). The large, bristly seed head with its long, somewhat twisted and wavy awns serves as a good means of identification (Figure 3, a). However, the head may be confused by the casual observer with other long-awned grasses such as the foxtails (*Hordeum spp.*) and squirreltail (*Sitanion spp.*). The following characteristics of mature medusahead will serve to separate it from similar grasses:

1. The life form is annual.
2. Height varies from 8 to 20 inches. Wiry, slender stems contain but few short, narrow leaves. The leaves dry and wither soon after mature size is reached, giving the plant an unusually heavy-headed appearance.
3. Two (occasionally three) spikelets, each containing one seed, are located at each node (Figure 3, c).
4. The plant has two kinds of flat awns. The longest awns arise from the tip of a $\frac{1}{4}$-inch seed and are from 2 to 4 inches long (Figure 3; a, d). The shorter awns, $\frac{1}{4}$ to 1 inch in length, arise below the seed at the nodes of the central axis (rachis) of the spike and remain attached after the seed shatters (Figure 3; a, b, c). These short awns represent the two glumes of each spikelet which arise below each seed.
5. The rachis is continuous rather than jointed (articulate), allowing the spike and its short, empty glumes to remain intact after the seed shatters (Figure 3, b). In addition, these plants are slow to decompose and identification of heads from the previous year's growth permits recognition of patches of medusahead at any time of the year, including early spring before the new heads emerge from the young plants.
6. The seed and its awn contain barbs which point upward and can be easily felt by rubbing the fingers backward down the awn and over the seed.
7. The seed head is disproportionately large in relation to the slender stems.

During the seedling stage in late fall or early spring, medusahead may be easily recognized by pulling up the young plants and observing the long awn and lemma which remains attached to the developing seedling.

In late spring, patches of medusahead are bright green, while cheatgrass, which matures two to three weeks earlier, will have turned to a reddish-tan color. About mid-August, on the other hand, medusahead is lighter yellow than cheatgrass, more the color of clean straw. The contrast in color, at these times, serves as an excellent means of spotting patches of medusahead. During both these periods, an airplane would be most useful for this purpose.

At maturity in early summer, medusahead turns a dark tan color touched with shades of purple. Later, it fades to a light straw color. Because of variable maturation, large stands frequently appear mottled with these two colors in late June and early July. Also noticeable, at this time, is a tendency for small areas within a dense stand of medusahead to lodge—

giving, in addition to the variable color, a rather wavy aspect to the whole stand.

In dense stands of medusahead, little or no tillering occurs, and each plant tends to be single stemmed. Growing in sparse stands, however, the plants usually tiller profusely. In dense stands, slow decomposition of litter is especially noticeable because it tends to build up a dense mat that seems to smother, shade out, or other-

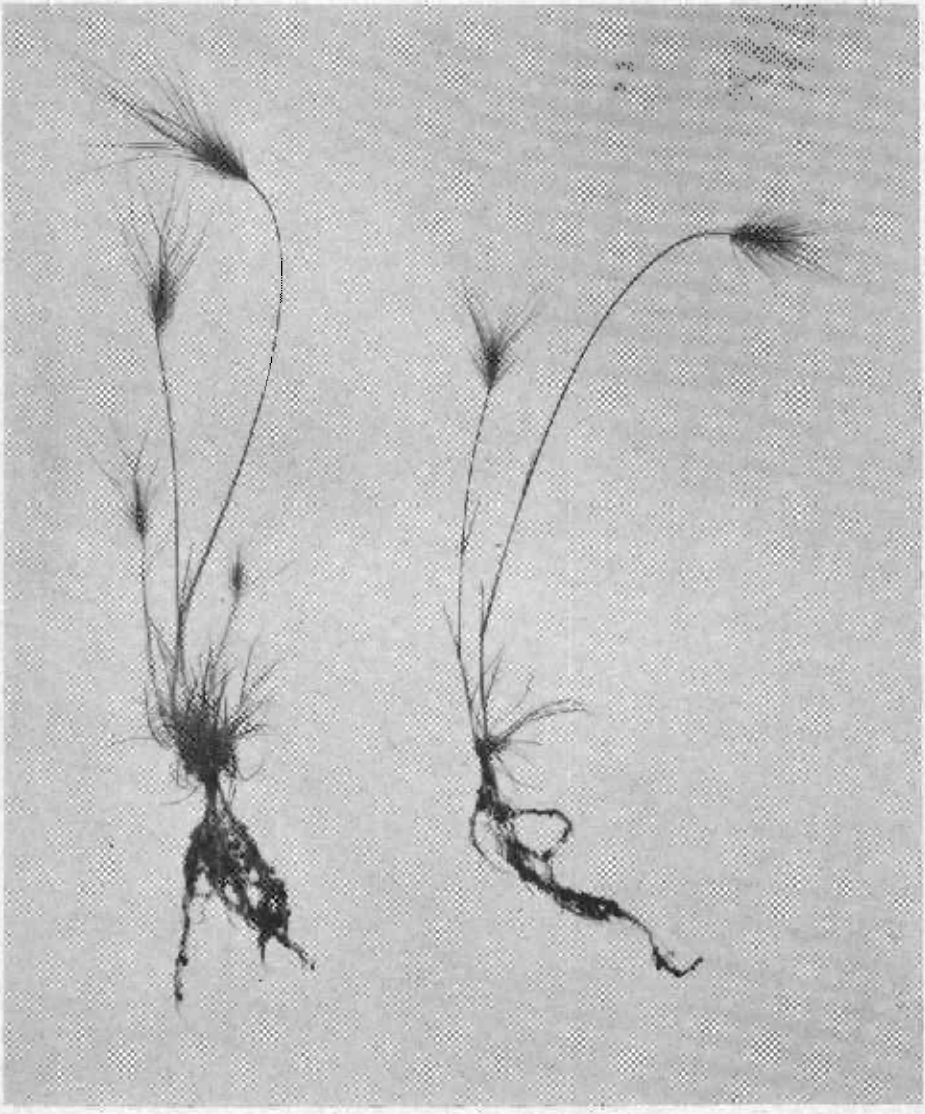

**FIGURE 2. Mature medusahead plants.**

wise prevent seed germination of cheatgrass and other annuals. Occasionally, litter becomes so deep and thick that even medusahead fails to grow for a few years. After decomposition reduces the litter, however, these patches once again produce medusahead.


**FIGURE 3. A mature spike of medusahead showing seeds, awns, and glumes.**

# Medusahead and Its Environment

## Climate

Medusahead grows over a rather wide range of climatic conditions. Major (1959) has indicated from data collected in California, Oregon, Idaho, southern Europe, northern Africa, and central Asia that the species grows where winter frost occurs, but where extended periods of great cold are lacking. Moreover, some of these climates are extremely hot. Major, et al. (1960) reported that the weed grows where annual precipitation is distributed over fall, winter, and spring. Parish (1956) indicated that seasonal distribution of precipitation is of greater significance than total precipitation in meeting the moisture requirements of this weed.

In Oregon, medusahead has been observed growing within a mean annual precipitation range from a minimum of 11 inches to an upper limit of 40 inches. Sharp, et al. (1957) and Torell, et al. (1961) reported that the weed grows in a precipitation zone of from 10 to 20 inches in Idaho. According to Major, et al. (1960) the upper limit for growth of the species is about 50 inches annually, determined largely by factors such as temperature and competition from plants which utilize moisture more effectively.

## Soil

Soil conditions suitable for growth of medusahead are somewhat variable. According to Sharp, et al. (1957) the weed grows in Idaho on a variety of soil types such as those high in clay content, well-developed loams, and scabland. Moreover, Torell, et al. (1961) reported that growth occurs on soils of widely variable depth, subsoil characteristics, and profile development. Furthermore, they indicate that under laboratory conditions medusahead was able to grow on soils varying widely in textural and chemical composition. Major, et al. (1960) indicated that in California medusahead is best adapted to soils high in clay content, either throughout the soil profile or as a clay layer below the surface, rather than to light-textured, sandy soils. It seldom occurs on the latter and never on soils that are continually moist throughout summer. These investigators infer that a low level of soil fertility favors medusahead, owing to reduced growth of other vegetation.

There is much to be learned about soil conditions in Oregon where medusahead will grow. Generally, the weed has been observed on clay loams and heavy clays which have a high water-holding capacity. These vary considerably in depth and some are exceedingly stony.

## Root development

The nature of root development of medusahead is of considerable importance and interest, especially in relation to the ability of the species to compete aggressively with cheatgrass and newly established, perennial grasses. Hironaka (1961) made a comparative root study and reported no significant difference in root length between medusahead and cheatgrass during any period of their life cycles. Both species made considerable root growth during the winter months, which placed them at a competitive advantage over perennial seedlings for utilizing available spring moisture. Since medusahead matures two to three weeks later than cheatgrass, its

roots remain functional for a longer period.

Based on these findings, Hironaka has speculated: "It appears likely that a stand of cheatgrass would be able to resist invasion by medusahead in situations where soil moisture was sufficiently limiting that cheatgrass was able to utilize nearly all of the available moisture for its development, leaving an insufficient amount for medusahead to complete its life cycle."

If the above speculation is correct, there are probably a number of sites in Oregon and elsewhere where precipitation is adequate for cheatgrass but not for medusahead. Providing this is true, one could assume that the ecological amplitude, or site adaptation, of cheatgrass extends beyond that of medusahead into areas of progressively drier climate.

The maximum depth of medusahead roots measured by Hironaka was 40 inches. Vertical development of the primary root was conspicuous during the winter, followed by much lateral development in the spring.

It has been observed from studies of dense stands of medusahead growing on Oregon soils that roots are commonly abundant down to and below 30 inches, where soils are of such depth. In shallower or more stony soils, roots are abundant nearer the surface or concentrated in stony pockets.

### Seed production

Medusahead is a highly prolific seed producer. Sharp, et al. (1957) reported an instance where 133 tillers were counted on one plant. They found an average of 3 to 5 tillers per plant where the stand had been thinned. In dense stands, they noted from 1,500 to 2,000 plants per square foot on valley bottom soils, and 500 per square foot on scablands. The average number of seeds per head for these two sites was 8.7 and 5.6, respectively.

Of the great number of seeds produced, viability is high. Murphy and Turner (1959) obtained germination tests of 98%. They noted, however, that an after-ripening dormancy persisted for at least 90 days before any seeds would germinate. According to Major (1958) medusahead requires a cold treatment and possibly a light stimulus after germination in order for seed formation to occur. Bovey (1959) was successful in obtaining seed formation after exposing seedlings to nightly temperatures of 37° F. for 14 days in the field, followed by maturation in the greenhouse.

There is need for a better understanding of the longevity of medusahead seed. Sharp, et al. (1957) found that 10% of the seed buried for one year remained viable. They noted that this small percentage is significant owing to the large amount of seed produced. Hironaka (1957) reported that seeds retained viability after two years of burial in the soil, under field conditions. Lehrer and Tisdale (1956) found that seed collected in the fecal material of rabbits and sheep remained viable.

Seed may spread by several means. Animals transport heads and seeds in their wool, fur, hooves, and feces. Machinery and automobiles often snag seed heads on their underparts. Locally, wind is a transport agent of much importance. "Dust devils," or "whirlwinds," often pick up heads with the stems breaking off at the first node. Strong winds, too, are thought to blow heads over the landscape for considerable distances.

## Medusahead's Impact on Range Economy

The low palatability of medusahead greatly reduces livestock grazing capacity of range lands. Hironaka (1961) has estimated reductions of 50 to 80% in some areas within a period of only a few years. Higgins and Torell (1960) have estimated that monetary loss on Idaho ranges amounts to about $3,500,000 annually. Torell, et al. (1961) stated that the loss of spring and fall use of cheatgrass range, when overtaken by medusahead, poses a catastrophic threat to range livestock operations. Unless adequate steps in range improvement are taken, these and similar statements may well prove conservative for all areas where medusahead poses a threat. Range deterioration has fostered the problem, and rehabilitation followed by proper range management is the only lasting solution. Determination of the most economic and lasting improvement alternatives constitutes one of the primary challenges in medusahead research.

Bovey, et al. (1961) reported the weed to be unpalatable to livestock at all stages of growth. Accordingly, chemical studies were made to better understand the basis for the low forage value. They found that medusahead was comparable to cheatgrass and many desirable grass species in all nutrients except ash, which, in medusahead, was much higher in silica content. They gave the high silica content (11.3% in medusahead compared to 4.4% in cheatgrass) as the possible explanation for the low palatability of medusahead to livestock and its slow rate of decomposition.

Mechanical injury to grazing animals resulting from the long, barbed awns and sharp seeds is another detrimental effect of medusahead. Injured tissues of the eyes and mouths of sheep and cattle and of the flanks of sheep are the seat of secondary infections by microorganisms.

The accumulation of slowly decomposing litter along with the current year's growth of ungrazed medusahead add considerably to the fire hazard on infested rangeland. Torell, et al. (1961) referred to a Bureau of Land Management expenditure in excess of $10,000 to control a 22,000-acre medusahead fire.

Purchasers of ranch property stand to lose considerably on their investment when they unknowingly obtain land infested by medusahead. Caution should be used, especially by those unfamiliar with the weed. Prior to seedhead formation, the bright green, lush appearance of the grass can mislead an unsuspecting buyer. The cost involved in "living with the weed" can be considerable; hence, a thorough search for infested patches before purchasing new ranch property might be well worth the time and expense.

Medusahead, with its many detrimental characteristics, has one outstanding quality. The accumulation of slowly decomposing litter considerably safeguards the loss of soil by wind and water erosion in areas that are overgrazed and susceptible to erosion. In this respect, the snake-haired grass might be considered by many as a "blessing in disguise."

## Control and Management

Control of medusahead is by no means a simple process, especially in well-established, large stands where economics and physical conditions of sites limit certain practices. Small spot-infestations can be eradicated effectively, but generally at a relatively high cost per unit area. The total cost is of little consequence, however, if the infested patches are of diminutive size and number.

### Control on large areas

The problem which exists on large areas is two-fold: first, to eliminate or reduce medusahead by some efficient means; and secondly, to obtain a good stand of perennial vegetation. Unless the latter is attained, the first is fruitless.

It appears unlikely that complete control of medusahead will ever be possible on a regional basis. As with most other range weeds, a concerted effort must be made to learn to live with this new one. Such efforts can prove successful. To bring this about, however, drastic changes in present management practices are often required. Frequently, grazing areas must be given a rest during various periods in a carefully worked out management scheme. In the battle against medusahead, the most effective weapon is perennial vegetation. Although the weed competes very strongly with other annuals, it does not have the ability to compete effectively with vigorous, well-established, perennial grasses and legumes. Any means of favoring perennials, whether they be native species or introduced by means of artificial seeding, will hinder the growth, reproduction, and spread of medusahead.

Torell, et al. (1961) reported that in Idaho "Past research failures to obtain satisfactory stands of forage grasses on medusahead sites have shown that a single operation to control the weed prior to the seeding of the forage species is not adequate. Sufficient medusahead seeds have remained to provide a stand of the weed so dense that the forage seedlings cannot survive." Accordingly, their more recent investigations involved the control of two successive medusahead seed crops by various combinations of plowing, discing, herbicide treatment (dalapon), and burning. They reported encouraging results which indicate that sufficient control can be achieved to permit the establishment of perennial seedlings. Their study had not, however, progressed long enough at the time of publication to determine the success of stands beyond the seedling stage.

Presently known practices which offer some degree of control include tillage, seeding, burning, application of herbicides, and grazing management. Until further research and management experience reveals more efficient and reliable means of medusahead control, the ingenious application of these practices offers a possibility of success. These practices are discussed separately below.

### Tillage practices

Plowing, discing, or similar mechanical treatments are applicable on restricted sites which are not too rocky or steep and on which seeding of perennial vegetation is to follow. Hence, sites should have the inherent productive potential for successful establishment of an adapted

species. The danger of exposing soil to water erosion warrants concern on areas of rough topography.

Careful consideration, experience, and good judgment are important in deciding whether cultivation and seeding are the most desirable treatment on tillable soils which have a fair cover of native perennials. A change in management which would favor the increase of the native, perennial vegetation might be the better approach.

On the other hand, where the residual stand of perennials is poor and the soil tillable, this practice should result in reduction of medusahead competition and insure establishment of seeded perennials. Unfortunately, practice is not proving out with theory. Either more research needs to be done or more care exercised in timing cultivation to effect the necessary reduction of medusahead. Elimination of competition and preparation of a good seedbed are essential to successful establishment of seeded grasses. Simple as it appears, the benefits of good tillage are often difficult to realize. A sufficient number of medusahead seeds frequently germinate to cause competition which results in failure of subsequent seeding. Cheatgrass, when present with medusahead, often compounds the problem. Tillage must, therefore, result in maximum reduction of seed production of these annual grasses or severely restrict their germination. Timing and choice of equipment used in the tillage operation hold the key to successful reduction of competition.

The best time for tillage is in the spring after medusahead has reached 100% germination and before cheatgrass has produced viable seed. A follow-up treatment concurrent with fall or spring seeding may be beneficial if germination of medusahead indicates that a moderate to heavy stand survived the initial tillage.

Plowing with a "rangeland plow" is generally the most economical and practical means of tillage on range lands, especially those which are somewhat stony. Moldboard plowing is generally possible only on limited areas, even though it is considered a better practice than discing because of more effective burial of undesirable seed.

Tillage is, finally, an expensive operation; but if carefully done, the initial cost may be amortized over the long life of a successfully established stand of high producing forage. Under these conditions, the net cost per unit of feed produced can be relatively low and medusahead control incidental to a normal range improvement program.

### Seeding

Range seeding, when properly combined with other practices such as tillage, burning, or the use of herbicides, seems to be the most positive and sure control measure for medusahead. Without seeding perennial forage, any of the eradication practices mentioned above are a waste of time and money, except possibly on extremely small, isolated patches where the objective is to reduce or slow the rate of spread of this weed.

When coupled with a well-planned and diligently executed range and livestock management program, these two practices—range seeding and effective livestock management on the range—will become the basis for ultimate solution of the medusahead problem on both seedable and nonseedable acreages.

The secret of medusahead reduction through natural range improvement on rough lands not subject to seeding may lie in the development of forage re-

serves which permit flexibility in the use and management of nonseedable portions of each range management unit.

Because of the voluminous literature on range seeding, techniques are only superficially covered in this discussion. One should always observe the cardinal principles of range seeding, paramount among which are: (1) Preparation of a good, firm seedbed, (2) elimination of competition, (3) proper timing of seeding, (4) selection of adapted species, (5) proper planting depth and seed coverage, (6) protection in the seedling year or years, (7) wise subsequent management which integrates use of the new seeding into the effective management of the feed supply for the entire year, and (8) recognition that the natural frequency of subnormal precipitation in eastern Oregon plays a major role in seeding failures.

Decisions on species or strains to use and establishment practices in seeding are intimately tied to the characteristics of the site. Practices vary tremendously between eastern and western Oregon; and even within these geographic regions, the exact species selected will depend on local soil and site conditions and on overall management objectives or needs. Thus, it is impossible to cover adequately the necessary detail on species selection and establishment practice in this publication. Because of the importance of these decisions and the numerous alternatives available, the reader is referred either to more specific, published recommendations or to local representatives of the Extension Service and Soil Conservation Service in planning each range seeding where medusahead control is one of the objectives.

### Control by burning

The use of fire has been given considerable attention in the control of medusahead because it may be a relatively low-cost operation compared to chemical or cultivation treatments on large infestations. Moreover, it can be applied on areas which are too rough or stony for the use of ground equipment.

The main objectives of burning are these: (1) To reduce the number of viable seeds present in litter, (2) to destroy seed crops prior to maturity, and (3) to reduce heavy litter accumulations preparatory to other treatments such as tillage or herbicide application and seeding.

Results of burning trials and experiments have been highly variable; and, used alone, it is doubtful whether satisfactory results can be attained in the control of medusahead.

Investigations by Furbish (1953) in California suggest that burning can be a highly efficient means of controlling medusahead under certain conditions. A controlled burn effectively removed medusahead, and one year later, desirable annual species had naturally replaced the weed. According to Murphy and Lusk (1961), who also studied burning under California conditions, a medusahead stand can be substantially reduced during the following growing season where burning is properly accomplished.

Again, in California, Murphy and Turner (1959) determined the efficiency of burning medusahead by conducting germination studies of medusahead seed collected from burned locations which varied in time of burning, fuel density, general maturity of medusahead, and elevation. Seeds collected and tested from eight of nine locations showed signs of fire damage

which was indicated by burned awns and charred seed coats. No germination resulted with medusahead seeds from these eight locations. Seeds collected at one burned location showed no signs of fire damage and yet only 5% of these seeds germinated. Seeds from an unburned control sample gave 98% germination. None of the above investigations reported on the reestablishment of medusahead.

Although encouraging results have been attained, there are severe limitations to burning which deserve consideration. Not all areas can be burned with the same degree of effectiveness. A site containing fairly deep soil within a 40-inch annual precipitation zone in California or western Oregon will produce considerably more fuel for a successful burn than will a shallow soil in eastern Oregon which receives little more than 11 inches annually. Furthermore, the amount of fuel produced during a droughty period in eastern Oregon will vary greatly from that of an above-normal period. It follows that a more successful burn would result from the latter. Particularly in eastern Oregon, the continuity of adequate fuel is often broken up by stony swales, stringers of shallow soil, rock outcrops, and escarpments, and by the "biscuit and swale" microrelief patterns common throughout much of the area. Under these conditions, a complete and uniform burn is difficult to attain even under the most ideal growing conditions. If the possibility of a spotty burn is high, this practice should not be used because the unburned spots will leave a seed source for rapid reinfestation of the area.

### Studies of burning

From their studies in Idaho, Torell, et al. (1961) found that a single burn did not destroy a sufficient amount of medusahead seed to permit the successful establishment of wheatgrasses. Sharp, et al. (1957) report that burning destroys many viable seeds, but sufficient numbers remain uninjured to result in only a temporary reduction in density. Furthermore, they state that burning may destroy seed of desirable species and weaken some of the desirable perennial plants which are present. These investigators tested germination of medusahead seed from scorched and unburned heads collected from a burned area and obtained germination values of 0 and 87%, respectively. Seeds from the scorched heads had their awns consumed by the fire, and the tips of the lemmas were charred.

According to Major, et al. (1960) fire should be properly timed for maximum seed destruction in order to eliminate or reduce the stand of medusahead. They recommend two seasons for burning, either early, before medusahead has matured but when associated species have ripened sufficiently to provide fuel for the fire, or late in the season, when medusahead has matured but has not dropped any of its seeds. A disadvantage of early burns occurs when dense patches of green medusahead remain undamaged.

Murphy and Lusk (1961), working in California, suggest the possibility that early maturing, desirable annuals present in a medusahead stand can be favored by timing a burn after their seeds have shattered but while medusahead. seeds are still attached. Hence, a later rather than earlier season burn would accomplish this objective to a higher degree.

It can be noted from past evidence in Idaho and eastern Oregon that naturally occurring fires after seed

maturity offer no advantage for reducing medusahead. The year following a fire, a vigorous stand of medusahead again dominates the site. *Proper timing of a burn is, therefore, essential* for effectively reducing stands of medusahead. Burning must be done before any medusahead seeds have shattered.

In addition to proper timing, Murphy and Turner (1959) indicate that a fire should burn slowly and sufficiently hot to consume as many seeds in the head as possible. This can be achieved by burning downhill and into the wind. This tends to avoid rapid flash-fires which leave many seed heads undamaged.

Torell, et al. (1961) refer to unpublished data from L. C. Erickson at the University of Idaho which suggests that medusahead seed has a relatively high thermal death point as compared to other grass species. In order to devitalize the seed completely, a temperature of 232° F. over a period of 7 minutes was necessary.

McKell, et al. (1962) also determined that medusahead seed viability was reduced after the seeds were exposed to a temperature of 392° F. for 90 seconds. Moreover, an interaction was noted between high moisture content of the seeds and high temperature, which together were more effective for destroying seed viability than were high temperature and low seed moisture. These investigators further stated that the most effective medusahead control resulted from burning in late afternoon when the fire burned slowly into a mild wind and when medusahead seed was in the soft-dough stage of development.

Major, et al. (1960) stress the importance of deferring grazing on areas to be burned so that a maximum amount of fuel will accumulate to cause a hot fire. Moreover, grazing animals tend to shatter seed which then becomes less susceptible to destruction by fire.

Small spot infestations of medusahead may be adequately controlled by means of a weed burner. Since this tool can be used when vegetation is still green and moist conditions prevail, the need for a fire guard and a stand-by crew can often be reduced or eliminated.

### Hazards of burning

The hazards which accompany burning require carefully planned precautionary measures. The liability incurred from an uncontrolled, catastrophic fire might out-weigh many times the loss in range productivity due to the presence of medusahead. Indeed, a law-suit resulting from fire damage could easily lead to bankruptcy for the responsible party. A burning permit, careful planning, a well-prepared fire guard, and a sufficient stand-by crew are essential in order to maintain control of a burn. Owing to the unpredictable nature of factors of fire behavior, there is some degree of danger even with apparently adequate fire control and careful planning.

A permit may be obtained from a local district fire warden if he is assured that proper conditions for a controlled fire are established. *Burning should never be attempted without a permit.*

Burning is hazardous from the standpoint of soil erosion, especially where slopes are steep and surface runoff may lead to sheet and gully erosion. The use of fire should, therefore, be restricted to sites which pose no threat from forces of erosion.

On the basis of present knowledge, burning should never be used as the

only medusahead control practice in Oregon. It is feasible only in conjunction with subsequent drilling of adapted species; and, if complete tillage is contemplated, the risks probably do not justify the use of fire. Too many unknown variables affect the outcome to justify the use of fire as an aid to natural improvement of medusahead-infested ranges without seeding.

### Use of herbicides

In the battle against medusahead, it is evident that the use of herbicides will come to play a major role. The possibilities for using chemicals in range management are many and varied. The surface has just been scratched by range scientists in developing these possibilities. Much additional investigation is needed to explore the effects of new herbicides and plant growth regulators, and to determine how they may be most effectively used in a medusahead control-management program.

Some of the possibilities for the use of herbicides include: (1) Eradication of small patches of medusahead, (2) chemical fallow on medusahead and cheatgrass sites which are to be seeded, (3) selective removal of medusahead and cheatgrass from old established seedings, (4) selective removal of medusahead and cheatgrass from stands which have a reasonable number of native perennials, thus stimulating natural increase of desirable perennials, (5) use of chemicals in combination with other control methods, such as burning, tillage, or grazing, (6) destruction of viable medusahead seed, (7) aerial application on sites which are too rough or stony for other control methods, and (8) development and/or maintenance of fire guards by removing all vegetation.

The use of herbicides is presently limited because of the high cost, especially on areas where the inherent productivity is too low to constitute a good investment. While the cost per unit area may be high, the over-all cost is reasonably low if only a few patches are in need of treatment. A high initial cost is well justified if a large scale invasion can be prevented or slowed down while a general program of range improvement is effected on the most susceptible sites. In the future, the cost of chemicals is likely to decrease as a result of large-scale use and more efficient means of application.

In general, the effectiveness of chemicals has proved to be quite variable and unpredictable because of the effects of time of application, stage of plant development, soil moisture, precipitation patterns, temperature, amounts and kinds of carriers and wetting agents used, spraying equipment, differences between geographical regions, amounts of litter, pretreatment burning, etc. As experimentation progresses and the effects of these variables are understood, the predictability of herbicide effectiveness will be increased.

### Current herbicide studies

Several herbicides are currently being investigated under Oregon conditions. Three are now available on the market, *but have not as yet been given clearance by the Federal Food and Drug Administration* for safe use under range conditions where grazing livestock have access to treated areas. These three are dalapon (2, 2-dichloropropionic acid), atrazine (2-chloro-4-ethylamino-6-isopropylamine-s-triazine), and isocil (3-isopropyl-5-bromo-6-methyl uracil).

Results from studies in eastern Oregon indicate that dalapon and atrazine give adequate control of medusahead at rates of 2 pounds of active chemical[4] per acre.[5] Major, et al. (1960) recommended that 4 pounds per acre of dalapon should be applied on California range lands to control medusahead.

Isocil has given encouraging results in the control of annual grasses at low rates per acre. It has been tested to a limited extent in the control of medusahead, and results under eastern Oregon conditions indicate that one pound per acre of active chemical gives satisfactory control.

Experimental studies in Oregon have shown that dalapon at 3 pounds per acre may cause damage to perennials, especially bluebunch wheatgrass (*Agropyron spicatum* (Pursh.) Scribn. and Smith), crested wheatgrass (*Agropyron desertorum* (Fisch.) Schult.) and Sandberg's bluegrass (*Poa secunda* Presl.). Two pounds per acre also resulted in considerable damage. These undesirable side effects are to be avoided in the interest of range improvement.

Atrazine at rates of 2 pounds per acre or less showed little damage to established wheatgrasses. Sandberg's bluegrass, however, was damaged considerably at this rate.

The damaging effect of isocil on perennial grasses is not well understood at present. Recent investigations on deteriorated bunchgrass ranges in eastern Oregon indicate that injury is from slight to severe for Sandberg's bluegrass treated at 1 pound per acre.

Since atrazine was found to cause no injury to crested wheatgrass, it appears suitable for application on old, established artificial seedings of this species which have declined in productivity and currently are infested with medusahead. A rate of 1 pound per acre of active ingredient is sufficient for reducing medusahead in old seedings.

No selective herbicides have been found to date which are suitable for speeding natural recovery of partially deteriorated native ranges infested with medusahead in eastern Oregon. All those which have been investigated injure Sandberg's bluegrass at rates which are required to control medusahead. It is important that Sandberg's bluegrass be left in vigorous condition to help close the community against the reinvasion of medusahead and other annuals.

Unfortunately, there are no presently known herbicides which control medusahead and yet are free of soil sterilizing activity. Hence, seeding cannot immediately follow chemical control of medusahead and cheatgrass. Dalapon has a rather short residual activity; but even with this chemical, several weeks must elapse before perennial seedlings can survive. The residual activity of atrazine and isocil is considerably longer than for dalapon, lasting for at least a year.

The most desirable time to apply herbicides in eastern Oregon varies, depending upon the particular chemical used. Atrazine is usually more ef-

[4] Rates of chemical per acre may be based on the weight of the commercial product or calculated from the amount of active material in the commercial product. For example, atrazine and isocil contain 80% active material and 20% inert material while dalapon contains 74% active material. All rates referred to in this paper are calculated on the basis of active material.

[5] Water carrier rates are 10 gallons per acre for dalapon and 40 gallons per acre for atrazine and isocil.

fective as a soil treatment than as a foliar treatment. Hence, application at any time after fall rains have begun should be satisfactory. As a foliar treatment, atrazine, dalapon, and isocil should be applied as soon as possible after the flush of germination has occurred.

### Grazing management

Although numerous reports have indicated that medusahead is unpalatable to all classes of livestock, Lusk, et al. (1961) have shown that sheep will consume the weed by free choice as long as it is green. Moreover, they observed that sheep ate some medusahead after it had headed out and cured. These investigators found that heavy grazing in spring resulted in a thinned stand of medusahead; whereas light or no grazing resulted in a dense stand. Here is another area in need of considerable experimentation. Plant composition might possibly be shifted in favor of remnant perennials where medusahead ranges are *grazed heavily* for a short period in spring, after soil is firm and prior to seed-head formation. If the practice is to be successful, this period of heavy grazing should be followed by complete deferment while the resident perennials are maturing.

Van Dyne (1962), working in California, compared cellulose digestion of alfalfa meal, mature medusahead, immature medusahead, and mature mixed annual range forage—primarily wild oat (*Avena barbata*), soft chess (*Bromus mollis*), ripgut brome (*Bromus rigidus*), and nitgrass (*Gastridium ventricosum*). He determined relative digestibility of these feeds by using an artificial rumen technique. Periods of digestion by inoculum from a cow fed alfalfa hay were for 12, 24, and 48 hours. Two trials of each of these were performed. Of all feeds tested in one trial, immature medusahead had the highest digestibility of cellulose at each time period. In the second trial, immature medusahead had the highest digestible cellulose of all feeds except for the alfalfa meal at the 12-hour period. The cellulose digestibility of the mature medusahead was lower than the alfalfa meal and mixed range forage at the 12-hour period, but generally higher at the 24- and 48-hour periods.

### Range fertilization

Range fertilization, especially with nitrogen, offers a possible means of improving the palatability of medusahead in order to encourage its use by grazing animals. Bovey, et al. (1961) studied the influence of nitrogen application on the utilization of medusahead by cattle and horses in Idaho. The animals had free access to treated and check plots. Two rates of nitrogen were applied at 20 and 160 pounds per acre. The animals consumed 90% of the medusahead at the higher rate and 40% at the lower. Use was not discernible on the check plots. They noted that control of medusahead at even the high nitrogen level was not adequate, since 10% of the plants developed viable seed. McKell, et al. (1959) applied moderately high rates of nitrogen and phosphorus on annual grass range in California which contained medusahead. The added nitrogen resulted in a greater production and earlier maturation of the forage. Moreover, the nitrogen application removed more soil moisture and the depletion occurred earlier in the spring. Lusk, et al. (1961) also reported that utilization of medusahead was higher on fertilized than on unfertilized plots. They applied 60 pounds of nitrogen and 75 pounds of phosphorus per acre.

Fertilization not only increases consumption of medusahead, but quality of forage is also improved. Bovey, et al. (1961) reported a significant increase in protein on nitrogen fertilized plots. It should be recognized, however, that the economics of this practice have not been worked out.

Bovey, et al. (1961) also attempted to force utilization of medusahead silage by supplementing with additives of molasses, beet pulp, and molasses plus beet pulp. None of these improved the appetite of hungry sheep for medusahead, as none of the samples were utilized.

## Conclusions

Medusahead poses a difficult problem for ranchers and resource managers in Oregon and neighboring states. Once the menacing weed becomes established on depleted ranges, productivity is even more drastically reduced. It behooves each livestock operator and federal or state resource manager to critically appraise his own situation and outline feasible practices which will minimize his individual medusahead problem.

First concern should be the recognition of the weed so that spot infestations may be reliably identified. *A program of early treatment of these spots* may mean the difference between a full-scale invasion of medusahead into virtually all ranges presently dominated by cheatgrass or other annuals and successfully "living with" this weedy grass.

*Rehabilitation of cheatgrass ranges* by seeding adapted perennials before medusahead takes over is the best prevention against further loss of productivity. However, range seeding is not, in itself, the final or only solution. A well-planned system of *proper range use and management* is an essential part of a successful program to combat medusahead.

All of the states known to have medusahead threatening their rangelands are conducting some research in an attempt to combat this weed. In Oregon, current work is centered around the control of medusahead by means of herbicides, fire, and tillage, followed by seeding and establishment of perennial vegetation. Investigations are also being made to better understand the basic ecological, physiological, and genetic factors which may have a bearing on the problems of controlling and learning to live with this enemy of the range. Additional grazing management studies will eventually be required to gain a better knowledge of vegetative influences and livestock habits, particularly those of sheep and cattle under range conditions where medusahead has become established.

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