SPECIES: Taeniatherum caput-medusae

Choose from the following categories of information.

INTRODUCTORY

SPECIES: Taeniatherum caput-medusae

©Craig Thornsen, California Dept. of Food & Agriculture, Botany Laboratory

AUTHORSHIP AND CITATION:
Archer, Amy J. 2001. Taeniatherum caput-medusae. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2007, September 26].

ABBREVIATION:
TAECAP

SYNONYMS:
Elymus caput-medusae L.
Taeniatherum asperum Nevski [59]

NRCS PLANT CODE [114]:
TACA8

COMMON NAMES:
medusahead
medusahead wildrye

TAXONOMY:
The currently accepted scientific name of medusahead is *Taeniatherum caput-medusae* (L.) Nevski. There are 3 subspecies found in Europe: *Taeniatherum caput-medusae* ssp. *caput-medusae*, *Taeniatherum caput-medusae* ssp. *cinitum* (Schreb.) Meldris, and *Taeniatherum caput-medusae* ssp. *asperum* (Simk.) Meldris. The entity occurring the United States is *Taeniatherum caput-medusae* ssp. *asperum* [40,53,65].

LIFE FORM:
Graminoid

FEDERAL LEGAL STATUS:

No special status

OTHER STATUS:
California - C list (noxious weed) [111]
Colorado - A list (noxious weed); C list (noxious weed; not yet widespread or causing economic impact) [110]
Nevada - Y list (noxious weed) [112]
Oregon - B list (noxious weed of economic importance that is regionally abundant but may have limited distribution in some counties) [112]
Utah - noxious weed [113]

DISTRIBUTION AND OCCURRENCE

SPECIES: Taeniatherum caput-medusae

GENERAL DISTRIBUTION:
Medusahead is native to the Mediterranean region of Europe. It was introduced into the U.S. in the 1880s [25,29,42,45] but did not spread rapidly until the 1950s [49]. Medusahead is now established throughout the U.S. and Canada [66]. It is most common in the western U.S. from British Columbia south to California and east to Idaho [16,36,57,98,99,105,118,123]. The PLANTS database provides a distributional map of medusahead in the United States.

ECOSYSTEMS [43]:
FRES21 Ponderosa pine
FRES22 Western white pine
FRES23 Fir-spruce
FRES24 Hemlock-Sitka spruce
FRES25 Larch
FRES26 Lodgepole pine
FRES29 Sagebrush FRES34 Chaparral-mountain shrub
FRES35 Pinyon-juniper

STATES:

AL	AK	AZ	AR	CA	CO	CT	DE	FL	GA
HI	ID	IL	IN	IA	KS	KY	LA	ME	MD
MA	MI	MN	MS	MO	MT	NE	NV	NH	NJ
NM	NY	NC	ND	OH	OK	OR	PA	RI	SC
SD	TN	TX	UT	VT	VA	WA	WV	WI	WY
DC	PR	VI							

AB	BC	MB	NB	NF	NT	NS	NU	ON	PE
PQ	SK	YK							

MEXICO

BLM PHYSIOGRAPHIC REGIONS [8]:
2 Cascade Mountains
3 Southern Pacific Border
4 Sierra Mountains
6 Upper Basin and Range
8 Northern Rocky Mountains
16 Upper Missouri Basin and Broken Lands

KUCHLER [70] PLANT ASSOCIATIONS:
K001 Spruce-cedar-hemlock forest
K002 Cedar-hemlock-Douglas-fir forest
K003 Silver fir-Douglas-fir forest
K004 Fir-hemlock forest
K008 Lodgepole pine-subalpine forest
K011 Western ponderosa forest
K012 Douglas-fir forest
K013 Cedar-hemlock-pine forest
K014 Grand fir-Douglas-fir forest
K015 Western spruce-fir forest
K025 Alder-ash forest
K038 Great Basin Sagebrush
K055 Sagebrush steppe

SAF COVER TYPES [37]:
218 Lodgepole pine
219 Limber pine
220 Rocky Mountain juniper
237 Interior ponderosa pine
238 Western juniper
239 Pinyon-juniper
245 Pacific ponderosa pine
247 Jeffrey pine

SRM (RANGELAND) COVER TYPES [101]:
101 Bluebunch wheatgrass
102 Idaho fescue
104 Antelope bitterbrush-bluebunch wheatgrass
107 Western juniper/big sagebrush/bluebunch wheatgrass
109 Ponderosa pine shrubland
110 Ponderosa pine-grassland
401 Basin big sagebrush
402 Mountain big sagebrush
403 Wyoming big sagebrush
406 Low sagebrush
408 Other sagebrush types
412 Juniper-pinyon woodland
606 Wheatgrass-bluestem-needlegrass
607 Wheatgrass-needlegrass
608 Wheatgrass-grama-needlegrass

HABITAT TYPES AND PLANT COMMUNITIES:
Medusahead and cheatgrass (*Bromus tectorum*), another invasive non-native species, overlap in distribution and habitat requirements. Each can replace other herbaceous vegetation and share dominance with the other. Cheatgrass occupies a larger geographical area than medusahead, which extends to drier areas of the semi-arid western U.S. [29]. Medusahead maintain its dominance on sites where native vegetation has been eliminated or severely reduced by overgrazing, cultivation, or frequent fires [102]. It has invaded seral communities in eastern Oregon and Idaho and replaced cheatgrass as the dominant alien grass [57]. It has invaded fields, dry roadsides, and disturbed sagebrush slopes in British Columbia, Washington, Idaho, Oregon, and California [26,58,60].

Great Basin: On sagebrush (*Artemisia* spp.)-dominated habitats in western Great Basin, medusahead usually invades sites already infested with cheatgrass [77,93,109,117,118]. In California, medusahead colonies often border low sagebrush (*Artemisia arbuscula* ssp. *longicaulis*) communities [11]. Associated grasses in sagebrush-dominated communities with a medusahead component include bottlebrush squirreltail (*Elymus elymoides*), Sandberg bluegrass (*Poa secunda*) [118], foxtail fescue (*Festuca megalura*), bluebunch wheatgrass (*Pseudoroegneria spicata*), and crested wheatgrass (*Agropyron desertorum*) [7,46,49,51,81,99]. Forbs associated with

medusahead in the Great Basin include sunflower (*Helianthus annuus*) [98,118], panicle willowweed (*Epilobium paniculatum*), and gumweed (*Grindelia nana*) [118].

A Nevada study found that sites with sparse native plants are more susceptible to medusahead invasion than more diverse low sagebrush (*Artemisia arbuscula*) or woodland/low sagebrush communities. If the more diverse communities are degraded to a "low" seral state, medusahead can invade and occupy the site. Young and others [119] determined that low sagebrush communities are most susceptible to medusahead invasion, while big sagebrush (*A. tridentata*) communities are more resistant [118].

Pacific Northwest: Forbs commonly associated with medusahead in this region include yellow starthistle (*Centaurea solstitialis*), western yarrow (*Achillea millefolium*), and arrowleaf balsamroot (*Balsamorhiza sagittata*) [7,94,100]. Grasses associated with medusahead include bluebunch wheatgrass and crested wheatgrass [49]. A bristly dogstail grass (*Cynosurus schinatus*)/medusahead association has been described for cattle and domestic sheep rangelands in the Umpqua River Basin of Oregon. Medusahead is also described as a dominant understory species in Oregon white oak/poison-oak (*Quercus garryana*/*Toxicodendron diversilobum*)/medusahead woodlands of the Umpqua River Basin [102]. Northern California study sites from Fall River Mills to Davis Creek, established after a wildfire, showed that medusahead formed extensive colonies on sites formerly dominated by ponderosa pine (*Pinus ponderosa*) or western juniper (*Juniperus occidentalis*) [118].

MANAGEMENT CONSIDERATIONS

SPECIES: Taeniatherum caput-medusae

IMPORTANCE TO LIVESTOCK AND WILDLIFE:
Medusahead is a major concern to the range livestock industry because it can suppress desirable vegetation. It is unpalatable to livestock. When dry, dead vegetation decomposes slowly and forms a persistent dense litter on the soil surface. As the plant matures it develops long barbed awns that can cause injury to the eyes, noses, and mouths of grazing animals [16,51]. Medusahead has little to no feed value to livestock at any stage of growth [13,16,83,106]. However, it has been noted that livestock utilize it when other feed is limited [83].

Medusahead is not important to wildlife forage [13]. It has invadesd and replaced dense stands of cheatgrass [48,78] over large areas in California, Idaho, Oregon, and Washington during the past 40 years [124]. Medusahead herbage is less palatable to ungulates than cheatgrass, and reduces grazing capacity where it replaces cheatgrass [47]. Its seeds are not digestible by upland game birds, which are large consumers of cheatgrass seeds [92]. Medusahead seed appears to be largely indigestible to chukar and other wild birds [79,97]. In a controlled study, chukar in medusahead- infested areas ingested medusahead fruits. However, when diet was limited to medusahead seeds, dramatic weight loss occurred [97]. Rabbits may occasionally graze medusahead [99].

Mule deer generally use medusahead very little. A northeastern Oregon medusahead-rattail fescue (*Festuca myuros*)-soft chess (*Bromus mollis*) community received some spring and summer use. However, despite the extensive stands available, medusahead was still the least preferred forage of mule deer in winter, summer, and fall, and it ranked low in spring. Communities dominated by medusahead were of little value to mule deer, while cheatgrass-dominated communities receive substantial use [14]. The dwarf sagebrush species such as low sagebrush and black sagebrush (*Artemisia nova*) are preferred mule deer browse. Medusahead has established in some dwarf sagebrush communities, and the invasion of such sites by medusahead has increased the incidence of wildfire as reduced cover of dwarf sagebrushes. These sites had previously been considered "fireproof" because of reduced herbaceous vegetation caused by excessive grazing [23].

PALATABILITY:
Palatability of medusahead is apparently variable. Some researchers conclude that the annual grass is unpalatable at all times [11,24,104], while others determine it may be "reasonably palatable" in early vegetative stages with rapid decline in palatability as it matures [42,51,74]. A study in California found that domestic sheep eat medusahead at every growth stage, but use decreases at plant maturity. Percentage of medusahead eaten by sheep dropped from 52% in February to 24% in June [74]. When given free choice, some domestic sheep will eat medusahead when it is green, and when confined to the plant, sheep will eat some even when headed out and dry [68]. In early spring medusahead is grazed limitedly by all classes of livestock, especially if medusahead is associated with more desirable forage. However, infested areas are avoided by livestock as soon as flowerheads appear [42]. Although medusahead remains green and succulent approximately 2 weeks longer than cheatgrass, it is less palatable [24,31,49,50,51], often reducing grazing capacity 50-75% where it replaces cheatgrass [50].

NUTRITIONAL VALUE:
Medusahead has very low forage value, except for a short period in the spring [49,106]. The plant has extremely high silica content, making it unpalatable to livestock [11]. This high silica content may be partially if not entirely responsible for medusahead's unpalatability to livestock and its resistance to decomposition. The total ash of the entire plant contains 72-89% silica [104].

COVER VALUE:
Medusahead-dominated areas have very low species diversity and low value for wildlife habitat [79].

OTHER USES AND VALUES:
No entry

OTHER MANAGEMENT CONSIDERATIONS:
The introduction and subsequent rapid spread of medusahead has caused serious management concern because of its rapid migration, vigorous competitive nature, and low forage value. A study by the BLM found that on public lands administered by the agency, 3.3 million acres of rangeland are classified as cheatgrass and/or medusahead monocultures; nearly 14 million acres are infested with 1 or both; and 62.1 million acres are at risk of invasion by these 2 grasses if disturbance occurs [87]. In some infested areas of southwestern Idaho, it has reduced grazing capacity as much as 80% [28]. Medusahead invasion has shifted the balance from a shrub/perennial grass ecosystem to an annual grass-dominated ecosystem [11].

A healthy stand of perennial vegetation appears to be the best barrier to medusahead invasion [28]. Medusahead invasions are most common on ranges in poor condition. Poor grazing management practices may accelerate the rate of spread, but proper management alone may not prevent invasion [42]. Cultivated areas are susceptible to invasion by medusahead, especially old fields. Livestock avoid medusahead when more palatable forage is available, leading to an abundance of soil-stored medusahead seed [83]. A combination of treatments including grazing, burning, mechanical manipulation, herbicide such as atrazine or glyphosate, and/or reseeding are generally necessary to reduce established stands of medusahead [22,75,79,106].

Mechanical: Spring plowing after most medusahead has germinated has given some control, with optimal results reaching 95% reduction. Besides removing weeds and preparing a seedbed for native herbs, cultivation may bury some medusahead seeds so deeply that they cannot emerge. Spring cultivation eliminates medusahead seedlings, and legumes can then be drilled at a rate of at least 10 pounds per acre [75]. It is best to sow in late autumn or early spring, using a rangeland drill if possible. Killing 2 successive crops of annual weeds helps ensure the survival of seeded species [79]. Cultivation method may not be practical in some terrain, such as the generally steep and rocky terrain of Idaho's medusahead-infested rangelands [79,106].

Grazing and fire: Vegetative manipulation, including fire, may benefit cattle and mule deer on medusahead-dominated sites [77]. Burning medusahead can destroy large amounts of seeds if the seedhead has not disseminated, reducing the stand by 60 to 95% in the next growing season [51]. A slow burn in dense medusahead stands that occur on well-developed soil profiles may reduce seed production. On less developed soil profiles where prescribed fire is not feasible, grazing livestock when plants are actively growing, herbicide treatment, reseeding, or a combination of these methods may be tried [14,77]. See the "Fire management" section of the Fire Effects section of this report for further information on controlling medusahead with prescribed fire.

Reseeding: Revegetation with natives may prevent medusahead from regaining dominance after control treatments [75]. Reseeding of treated sites should be done with species that are competitive, have high vigor, and are adapted to the area [79]. The following may be effective: bottlebrush squirreltail, bluebunch wheatgrass, intermediate wheatgrass (*Elytrigia intermedia*), Thurber needlegrass (*Achnatherum thurberianum*), needle-and-thread grass (*Hesperostipa comata*), Indian ricegrass (*A. hymenoides*), Sandberg bluegrass, and sheep fescue (*Festuca ovina*) [79,106,107]. Bottlebrush squirreltail may be an especially promising candidate for restoring rangeland dominated by undesirable exotic grasses such as medusahead. It germinates readily, self pollinates, rapidly reaches reproductive maturity, and is capable of growth in cool temperatures [4,63]. Bottlebrush squirreltail seedlings appear better able to store sufficient carbohydrate root reserves under competition with annuals than most other perennial grass species in the Intermountain region [56]. Bottlebrush squirreltail is also fire tolerant and has excellent seed dispersal. Since bottlebrush squirreltail typically occurs in early seres, wildfire or prescribed burns may provide opportunities for it to establish [63].

A study in Washington found that 'Secar' bluebunch wheatgrass did not successfully compete with medusahead seedlings on semiarid range sites. The perennial wheatgrass seeds germinate more slowly and the seedlings grow more slowly both in length and mass [44].

BOTANICAL AND ECOLOGICAL CHARACTERISTICS

SPECIES: Taeniatherum caput-medusae

©*Julie Kierstead Nelson*

GENERAL BOTANICAL CHARACTERISTICS:
Medusahead is a nonnative, cool-season annual grass [49]. Plant height ranges from 8 to 20 inches (20-50 cm), depending on the site. Plants produce tillers, but very few leaves [79,83]. Medusahead has a distinctive flowerhead. The inflorescence contains 2 to 3 spikelets per node, and each spikelet contains 1 seed. Plants produce an average of 7.1 seeds per spike [79,83]. Medusahead has 2 types of awns: both are flat, but the longer of the 2 contains barbs that point upward [79]. Plants in dense stands usually produce 1 spike; in open areas the number of spikes per plant typically increases to 3 to 5. An exceptional plant in Idaho produced 133 spikes. Medusahead-dominated stands usually have more than 100 plants/ft^2. Densities of 1,500 to 2,000 plants/ft^2 have been found on a valley bottom in southern Idaho [99,106].

RAUNKIAER [90] LIFE FORM:
Therophyte

REGENERATION PROCESSES:
Medusahead is entirely dependent upon seed production for regeneration. It is an extremely capable seeder because of its large annual production of viable seed, and because its seed maintains viability in litter and soil for at least 1 year [99]. Medusahead maintains a short-lived seedbank [10,62,99]. Plants produce up to 6,000 seeds/ft^2 of soil, propagating dense stands in succeeding years [75]. Medusahead is principally self fertile. Most of the pollen grains are dispersed within the floret and only a moderate number of pollen grains are produced in each of the short anthers [41]. Some cross-pollination is effected by wind [18].

Animals, wind, and water disperse the seed, and spread is rapid [42]. A long, rough awn aids in animal dispersal of seed, and medusahead often 1st establishes along domestic sheep and cow trails [83]. Seeds are dispersed primarily from the coats and intestinal tracts of grazing animals [42,75,99,109]. Germinable seeds have been recovered in fecal material 4 to 9 days after ingestion by rabbits and domestic sheep, respectively [99]. Stiff barbs pointing in 1 direction enable the seeds to work into the duff and top layers of the soil. Seeds may germinate in fall, winter, or spring; fall germination is most common [6,99,116]. Seedlings from all seasons produce seeds by early summer [116]. Seeds germinating in the top layer of litter without soil contact may die during the 1st dry spell [61,75]. Medusahead usually germinates faster than its competitors. Germination has been observed 8 to 10 hours after moistening at 50 degrees Fahrenheit (10 ^{o}C) [49]. Germination rates are often over 90% [99]. Awn removal increases the percentage of germination [85].

A Nevada study found that medusahead seedling emergence and growth is favored by soil movement and pitting of the soil surface because these conditions maintain favorable soil temperatures and moisture levels [35]. Favorable microsites for germination and establishment of medusahead are created when plant litter covers the soil surface. In Nevada, emergence of medusahead germinants under litter was 47 times greater than emergence of germinants on bare ground by the end of March. By the end of the growing season, medusahead yield was 4 times greater under litter than on bare soil [34].

Moderate temperatures may encourage medusahead growth and yield. Maximum dry matter production of medusahead was achieved at a moderate day/night temperature regime of 75/52 degrees Fahrenheit (24/11 ^{o}C). Its yield was reduced by 75% with a high day/night temperature regime of 90/61 degrees Fahrenheit (32/16 ^{o}C), and reduced by 50% with a low day/night temperature regime of 61/41degrees Fahrenheit (16/5 ^{o}C) [29].

SITE CHARACTERISTICS:
Medusahead grows in areas that have relatively mild to cold temperatures in winter but are hot in summer [75,79]. It is generally

found in areas that receive fall, winter, and spring moisture followed by dry summers [108]. It occurs in areas with annual precipitation of 10 to 40 inches (250-1,000 mm), with an upper limit of precipitation approximately 50 inches (1,270 mm) [75,79,99]. Infestations primarily occur in former sagebrush-grass or bunchgrass communities that receive 10 to 20 inches (250-500 mm) of precipitation [79,99]. Areas above 4,500 feet (1,370 m) elevation, and well-drained coarse soils, may be less susceptible to invasion.

Medusahead often dominates disturbed areas on soils with high moisture-holding capacities and slow percolation rates [33]. Sites particularly susceptible to medusahead invasion in the more arid portions of Idaho are either those with well-developed soil profiles, particularly with high clay content either at or near the surface; or those occupying topographic positions that receive additional run-off from adjacent sites. In more mesic climates, moderately well-developed soils are as susceptible to invasion as well-developed soils. Conversely, soils with little profile development, particularly those that are well drained, remain dominated by cheatgrass in early seral stages regardless of whether they are in a more arid or mesic area [28].

In a northwestern California site where medusahead is prevalent, 60% of the vegetation is grassland or woodland/grass. The climate is mediterranean, with cool wet winters and hot dry summers. Mean annual rainfall is 39 inches (980 mm). Soil is fine sandy loam 2 to 3.3 feet (0.6-1.0 m) deep with rapid surface drainage; slope is 10% on a southeast aspect [5,6]. Foothills in southwestern Oregon where medusahead is found have silty clay loam soil, with 1,600 feet (500 m) elevation and 20-30% slope on a west aspect. On southwest aspects, medusahead occurs on 5-20% slopes at 2,000 feet (600 m) elevation. The climate has a mediterranean/maritime pattern with cool, wet winters and hot dry summers and annual precipitation of 20 inches (500 mm) [14].

Medusahead and cheatgrass are often in competition with each other, and soil and topographic factors affect their distribution [28,39]. Each can replace other herbaceous vegetation and share dominance with the other. Cheatgrass occupies a larger geographical area than medusahead, extending to drier areas of the semiarid western U.S. than does medusahead [29]. Cheatgrass will grow in almost any type of soil, although it does best on deep, loamy or coarse-textured soils and it does not grow as well on fine textured soils (e.g. [32,73,125]). Medusahead may be more likely to dominate on fine-textured soils in the Intermountain region [118]. In arid conditions, medusahead is more dependent on additional moisture for survival. This may be because cheatgrass matures when soil moisture is still plentiful in May, and medusahead does not mature until 3 weeks later when moisture is more confined to depressions and clay soils [28,39]. Because medusahead matures approximately 1 month later than cheatgrass, it initially only replaces cheatgrass on soils with sufficient moisture holding capacity, such as clay textured soils, so that some soil moisture remains after cheatgrass matures. Medusahead's root system can exploit all soil moisture in the soil profile [117]. In the Columbia River Basin, medusahead is dominant on soils high in montmorillonite clay within 10 to 12 inches (25-30 cm) of the surface, and on soils low in clay but on with favorable topographic positions. Cheatgrass is dominant on weakly developed soils low in montmorillonite clay.

SUCCESSIONAL STATUS:
Medusahead occurs in seral and late-successional plant communities. It has invaded vast areas formerly dominated by perennial grasses. Medusahead often colonizes portions of range previously dominated by cheatgrass [27,57]. The growth habits, life cycles, and ecological adaptations of medusahead and cheatgrass are similar, and the annuals typically grow in association until medusahead becomes dominant and eventually exclusive [16]. Southwestern Idaho stands in which medusahead was sparse were all seral. In virtually all cases studied, the sites invaded by medusahead had been occupied previously by seral species, mainly annuals, which had replaced perennial bunchgrasses depleted by overgrazing, fire, or cultivation [64,79,102]. Medusahead has potential for successionally replacing cheatgrass in the 11-inch (280 mm) and above precipitation zone in the northern Great Basin and elsewhere [54]. Medusahead litter impedes cheatgrass establishment, and may do better in low nitrogen environments than does cheatgrass [50,51]. Coexistence of cheatgrass and medusahead is most likely in habitats low in both nitrogen and phosphorus. Cheatgrass is likely to have the competitive advantage in more fertile habitats unless other environmental factors (e.g. high clay content) favor medusahead [29]. In the sagebrush steppe of northeastern California, Russian-thistle (*Salsola kali*), tumblemustard (*Sisymbrium altissimum*), and cheatgrass form a seral continuum that closes many sagebrush communities to the establishment of perennial seedlings. Medusahead has extended the seral continuum by replacing cheatgrass on some low sagebrush sites on the Modoc Plateau [118,124]. Cheatgrass usually grows in dense stands and readily ignites and carries fire. After fire strikes a cheatgrass-infested community, cheatgrass usually flourishes. However, medusahead can thrives in the wake of cheatgrass-driven fires [31].

Medusahead is a seral invader after disturbance [102]. Medusahead often grows in dense stands on disturbed sites where climax perennial grasses have been removed, often to the exclusion of other species [51]. The abundance of bluebunch wheatgrass has "significantly" decreased in the Great Basin because of the invasion of introduced annuals such as medusahead [81]. Past heavy grazing of foothills, pastures, and rangelands of southeastern Oregon has resulted in dominance by annual grasses such as medusahead and annual forbs including yellow starthistle [15].

SEASONAL DEVELOPMENT:
Medusahead is a cool-season annual, and temperature is an important factor in controlling its phenology. Medusahead germinates during autumn, late winter, or early spring [25,79]. It usually germinates in October and continues to grow through the winter in mesic climates. During winter, growth is slowed markedly with low temperatures, and the plant resumes active growth when the temperature increases at the beginning of spring [25]. Leaves, stems and roots increase in number through the winter and roots can reach 40 inches (100 cm) depth by early February [51]. This allows medusahead to outcompete desirable grasses such as bluebunch wheatgrass [44,51]. Growth accelerates in the spring; by late May or early June, seeds are in the milk or early dough stage [42].

Seed are generally mature by late June to early July, a few weeks later than most annual grasses [79]. Seeds remain in spikes until dispersal in late summer or early fall [99]. Late maturity and greater availability of soil moisture late in the growing season allow medusahead to reach maturity and produce large amounts of seeds, which might enhance site occupation in subsequent generations [29]. Medusahead phenology was as follows in northern Idaho [16]:

Date	Development
May 9	Leaf
May 23	Flowerbud
June 6	Flower
June 21	Late Dough
July 3	Mature

FIRE ECOLOGY

SPECIES: Taeniatherum caput-medusae

FIRE ECOLOGY OR ADAPTATIONS:
Fire adaptations: Medusahead establishes after fire from the seed bank and from seed dispersed from off-site sources [10,62,99]. Bioassays of burned soil after a rapidly spreading, wind-driven fire in California found viable medusahead fruits within lightly charred litter [10].

Fire regimes: The expansion of exotic annual grasses such as medusahead has substantially increased frequency of fire in the western United States [69]. Medusahead has a fine structure and its herbage dries completely; therefore, its standing dead biomass is extremely flammable. The hazard of wildfire is further increased by considerable litter [41]. Medusahead litter decomposes more slowly than that of most plants [108], therefore making stands of this annual grass a fire hazard [84]. Slow decomposition is a result of its high silica content [77,104]: total ash content of medusahead contains 72 to 89% silica [104]. The long-lasting litter formed by medusahead is easily ignited and burns readily [79]. Invasion can initiate a cycle where a non-native grass colonizes an area and provides the fine fuel necessary for the initiation and propagation of fire. Fires then increase in frequency, area, and possibly severity. Following these grass-fueled fires, non-native grasses recover more rapidly than native species and cause a further increase in fire [27]. Frequent fires destroy the shrub component of the plant community, and potentially part of the bunchgrass community, without destroying "significant" amounts of medusahead seed [79].

The non-native grasses cheatgrass and medusahead have invaded the low sagebrush communities on the volcanic tablelands of northeastern California and northwestern Nevada. When precipitation is adequate, the interspaces between sagebrush plants are completely covered by these invasive grasses. The fine fuels of these plants, and the accumulation of litter of highly siliceous medusahead, create conditions in which fire is easily carried. Negative effects of wildfires in this region include erosion of the thin, coarse-textured, eolian veneer soils [11]. For example, the herbaceous vegetation of a ponderosa pine/Sandberg bluegrass in Modoc County, California, included many other native herbaceous species. After a wildfire, medusahead excluded almost all other understory species [22].

Historically, the Snake River Plains of Idaho was vegetated with shrub-bunchgrass communities. The primary disturbance was patchy stand-replacement fire, occurring every few decades. Fire usually occurred where sagebrush or other shrubs had grown dense, since bunchgrasses did not often provide adequate continuous fuels. With invasion of exotic annuals and increase such as medusahead, historical patterns of postfire succession have been altered. Fire-free intervals have been reduced, and shrub-bunchgrass lands are being converted to annual grassland. According to Peters and Bunting [88], "the landscape has become more homogenous, species diversity has decreased, and burns are larger and more continuous."

Xeric big sagebrush (Artemisia tridentata ssp. xericensis), a subspecies with limited distribution that is sometimes referred to as an ecotype of mountain big sagebrush, is found primarily in western Idaho and eastern Oregon and is restricted to a zone where the annual precipitation exceeds 12 inches, the elevation is less than 4,500 feet, and the summers are relatively warm. Many of these communities are on relatively steep slopes and have a higher potential for human and lightning-caused fires, resulting in repeated burns. These frequently burned areas are often dominated by cheatgrass and medusahead [72].

The range of fire intervals reported for some species that dominate communities in which medusahead occurs are listed below. To learn more about the fire regimes in those communities refer to the FEIS summary for the dominant species, under "Fire Ecology or Adaptations."

Community or Ecosystem	Dominant Species	Fire Return Interval Range (years)
California chaparral	*Adenostoma* and/or *Arctostaphylos* spp.	< 35 to < 100
sagebrush steppe	*Artemisia tridentata/Pseudoroegneria spicata*	20-70 [86]
basin big sagebrush	*Artemisia tridentata* var. *tridentata*	12-43 [96]
mountain big sagebrush	*Artemisia tridentata* var. *vaseyana*	20-60 [3,21]
Wyoming big sagebrush	*Artemisia tridentata* var. *wyomingensis*	10-70 (40)** [115,122]
blue grama-needle-and-thread grass-western wheatgrass	*Bouteloua gracilis-Hesperostipa comata-Pascopyrum smithii*	< 35
cheatgrass	*Bromus tectorum*	< 10
California montane chaparral	*Ceanothus* and/or *Arctostaphylos* spp.	50-100
western juniper	*Juniperus occidentalis*	20-70
Rocky Mountain juniper	*Juniperus scopulorum*	< 35
wheatgrass plains grasslands	*Pascopyrum smithii*	< 35
pinyon-juniper	*Pinus-Juniperus* spp.	< 35 [86]
Rocky Mountain lodgepole pine*	*Pinus contorta* var. *latifolia*	25-300+ [1,2,95]
Sierra lodgepole pine*	*Pinus contorta* var. *murrayana*	35-200
Pacific ponderosa pine*	*Pinus ponderosa* var. *ponderosa*	1-47 [2]
mountain grasslands	*Pseudoroegneria spicata*	3-40 (10)** [1,2]
Rocky Mountain Douglas-fir*	*Pseudotsuga menziesii* var. *glauca*	25-100 [2]
coastal Douglas-fir*	*Pseudotsuga menziesii* var. *menziesii*	40-240 [2,82,91]
California mixed evergreen	*Pseudotsuga menziesii* var. *m.-Lithocarpus densiflorus-Arbutus m.*	< 35 [2]

*fire return interval varies widely; trends in variation are noted in the species summary
**(mean)

POSTFIRE REGENERATION STRATEGY [103]:
Ground residual colonizer (on-site, initial community)
Initial off-site colonizer (off-site, initial community)

FIRE EFFECTS

SPECIES: Taeniatherum caput-medusae

IMMEDIATE FIRE EFFECT ON PLANT:
Fire kills mature medusahead plants. Immature plants may be only top-killed by early-season fire, and regenerate by tillering [79,83]. Fire also destroys many viable medusahead seeds, but sufficient numbers remain uninjured that reduction in plant density is usually temporary [76,99].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT:
No entry

PLANT RESPONSE TO FIRE:
Medusahead increases under frequent fires at the expense of native species and sometimes, cheatgrass. It promotes further frequent fire by increasing fuel loads [27,76]. Accumulated medusahead litter enables stand-replacement fires to occur in ecosystems such as low sagebrush sites that, under "pristine" conditions, may have been fire-resistant [11,116,119,122]. Wildfires in medusahead-infested areas usually minimally damage soil surfaces and soil erosion is limited, but enough medusahead seed survives to produce thinned, vigorous stand of multiculmed medusahead plants the following year. Within a few years, stand densities approach prefire levels [54].

In cheatgrass and medusahead wildfires, accumulation of litter and the rapidity at which the litter combusts lead to soil heating of such short duration that nitrate levels may increase. Wildfire-induced increases in soil nitrate in cheatgrass and medusahead-dominated areas are undesirable: Medusahead is nitrophilic and readily germinates in seedbeds with high nitrate levels. Near Alturas, California, a wind-driven wildfire rapidly spread across a medusahead-dominated area. The litter did not completely ash and there were still viable medusahead fruits in the lightly charred litter. Bioassays of the burned soil found over $6.2x10^6$ germinable seeds of medusahead per acre (unpublished data; R. R. Blank, USDA/ARS, Reno, NV) [10].

Fire eliminates some medusahead seed and removes medusahead litter. It also places the remaining seed in contact with mineral soil where it can germinate and subsequently be destroyed by future treatments such as tillage and herbicide use [108]. Contact with aqueous slurries of heated soil significantly ($p<0.05$) reduced the rate and success of emergence of medusahead seedlings compared with a control [12].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE:
Attempts have been made to destroy medusahead by prescribed burning in soft-dough stage to destroy the seed crop. Medusahead stands in the milk or early dough stage (late May or early June) are cured enough that they can carry a "light" fire that burns through the slender culms and arrests seed development [42]. However, a "substantial" number of seeds are not killed by fire [52]. Burning followed by seeding of perennial grasses may suppress medusahead [17]. If postfire revegetation efforts of medusahead-infested areas are not timely, erosion will expose the clay subsoil that the species frequently inhabits [11]. A controlled burn in early June on a ranch in the Redwood Valley, California, almost completely eliminated medusahead, and the area was still "relatively" free of medusahead 2 years later [42]. Another California study found that medusahead cover was significantly reduced ($p=0.03$) by 74% with prescribed burning in ungrazed prairie. Coverage was greatest with either summer grazing or no grazing and fire exclusion ($p=0.013$) [71].

FIRE MANAGEMENT CONSIDERATIONS:
Wildfires facilitate replacement of native grasses with these annual grasses [38,80]. However, burning may be an effective means of reducing dominance if plants are burned early enough in the season to scorch culms and seeds, preventing seed maturation [30]. Compared to chemical or cultivation treatments, burning provides a relatively economical, although highly variable, means of controlling medusahead [83]. Preliminary results from Oregon indicate that glyphosate treatment and mowing 1 year following summer prescribed burning were equally effective at reducing medusahead and cheatgrass cover [89]. The heat of the fire should be concentrated to burn as many seeds in the head as possible. This can be achieved by having the fire move slowly so as to obtain complete fuel consumption. Slow, "hot" fires kill the greatest number of seeds, and this can be achieved by burning downhill or into the wind [75,77,83].

Early-season burns, conducted before medusahead seeds have ripened, are effective if associated plants have dried enough to provide fuel for a fire [75]. Burning medusahead during the soft dough stage is effective because the high moisture content in the seed increases the effects of burning [77]. Dense patches of green medusahead will often remain unburned unless previously sprayed with oil. Some recommend later-season burns, after medusahead seeds have ripened but before they drop. Seeds of most herbaceous species will have dropped by then, and will be less susceptible to fire damage [75]. An effective management strategy in central Oregon is burning medusahead in late spring or early summer before the seeds have dropped off the plant, and following the next spring with an herbicide treatment of glyphosate after remaining seeds have germinated. However, this herbicide treatment is not recommended when reseeding is required since it is a broad-spectrum non-specific treatment [79]. It is recommended that reburning not occur more than once every 2 to 3 years if an adequate stand of forage plants is to be established [75]. A California study found medusahead burned well at relative humidity of 40 to 50% and temperature 60 to 70 degrees Fahrenheit (16-21 ^oC); however, a temperature of 90 degrees Fahrenheit (32 ^oC) and relative humidity of 30% was considered too severe [42]. In another test, best burning conditions for consuming medusahead were experienced around noon with air temperature of 99 degrees Fahrenheit (37 ^oC), relative humidity 23%, and wind speed of 11 mph (17 km/hr). Other California studies suggest that relative humidity of about 40% is not optimal for igniting dry grass [42,77].

Fire's effectiveness in reducing stands of medusahead on rangeland depends on burning conditions, including time of day and season of burn. Fire can be an effective tool in removing old medusahead litter, reducing density of medusahead stands, reducing the medusahead seed bank, and minimizing damage to desirable associated species. The following are conditions present during burns of medusahead-infested rangeland at the R. E. Shellhammer Ranch in Solano County, California 1959 [77].

Date and time	^oF (^oC)	Relative humidity (%)	Wind velocity (mph)	Fuel moisture (%)	Type of burn	Speed of fire (ft/min)	Duration of fire at pyrometer(sec)
Aug. 26							
7:15 am	65(18)	75	5	8.9	slow/fast	1.2/20	50/22
12:45 pm	102 (39)	20	10	3.0	slow/fast	6/40	20/15
8:50 pm	70(21)	57	15	5.2	slow/fast	6/80	25/10
Aug. 28							
7:20 am	62(17)	92	2	16.4	slow/fast	1/9	35/25

12:30 pm	94(34)	28	5	3.3	slow/fast	6/20	40/10
6:45 pm	84(29)	30	15	3.1	slow/fast	3/40	50/20
Aug. 31							
7:10 am	53(12)	93	3	8.0	slow/fast	3/18	35/20
12:45 pm	102(39)	21	18	5.0	slow/fast	6/144	25/30
6:45 pm	95(35)	20	10	2.0	slow/fast	5/105	27/30
Mean							
7:15 am	60(16)	87	3	11.3	slow/fast	4/53	53/18
12:40 pm	99(37)	23	11	3.5			
7:10 pm	83(28)	39	13	3.5			

Slow, hot fires are most desirable for reducing medusahead. In this study, the most effective control of medusahead was obtained by late afternoon fires that burned slowly (into a mild wind), ignited when seed was in the soft-dough stage [77].

Blaisdell and others [9] suggest that each situation be carefully examined and evaluated before burning can be prescribed as a plant control measure, and emphasize that areas with a poor stand of desirable perennials prior to burning will probably require seeding to provide satisfactory forage production and delay return of sagebrush or other unwanted species such as medusahead, cheatgrass, or halogeton (*Halogeton glomeratus*) [71]. Young and Evans [120,121] determined that 2 perennial grass plants per square foot (2.5 per m2) is the minimum necessary to preempt invasion by nonnative annual species and/or shrub seedlings.

Small roadside burns in southeastern Los Angeles ponderosa pine woodlands often become dominated by medusahead and cheatgrass. These communities often accumulate fuel contributing to repeated and increasingly larger fires. These cycles can be interrupted by immediate seeding in the burned areas with perennials. However, if the annuals are established, competition must be reduced before desirable perennial herbs, shrubs, and/or trees can establish. On sites marginal for conifers, a combination of all 3 is often desirable [22].

Taeniatherum caput-medusae: References

---

1. Arno, Stephen F. 1980. Forest fire history in the Northern Rockies. Journal of Forestry. 78(8): 460-465. [11990]

2. Arno, Stephen F. 2000. Fire in western forest ecosystems. In: Brown, James K.; Smith, Jane Kapler, eds. Wildland fire in ecosystems: Effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 97-120. [36984]

3. Arno, Stephen F.; Gruell, George E. 1983. Fire history at the forest-grassland ecotone in southwestern Montana. Journal of Range Management. 36(3): 332-336. [342]

4. Arredondo, J. Tulio; Jones, Thomas A.; Johnson, Douglas A. 1998. Seedling growth of Intermountain perennial and weedy annual grasses. Journal of Range Management. 51(5): 584-589. [35483]

5. Bartolome, James W. 1979. Germination and seedling establishment in California annual grasslands. Journal of Ecology. 67: 272-281. [28345]

6. Bartolome, James W.; McClaran, Mitchel P. 1992. Composition and production of California oak savanna seasonally grazed by sheep. Journal of Range Management. 45(1): 103-107. [17434]

7. Bell, Jack H.; Lauer, Jerry L.; Peek, James M. 1992. Habitat use patterns of white-tailed deer, Umatilla River, Oregon. Northwest Science. 66(3): 160-171. [19276]

8. Bernard, Stephen R.; Brown, Kenneth F. 1977. Distribution of mammals, reptiles, and amphibians by BLM

physiographic regions and A.W. Kuchler's associations for the eleven western states. Tech. Note 301. Denver, CO: U.S. Department of the Interior, Bureau of Land Management. 169 p. [434]

9. Blaisdell, James P.; Murray, Robert B.; McArthur, E. Durant. 1982. Managing Intermountain rangelands--sagebrush-grass ranges. Gen. Tech. Rep. INT-134. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 41 p. [467]

10. Blank, Robert R.; Allen, Fay L.; Young, James A. 1996. Influence of simulated burning of soil-litter from low sagebrush, squirreltail, cheatgrass, and medusahead on water-soluble anions and cations. International Journal of Wildland Fire. 6(3): 137-143. [27612]

11. Blank, Robert R.; Trent, James D.; Young, James A. 1992. Sagebrush communities on clayey soils of northeastern California: a fragile equilibrium. In: Clary, Warren P.; McArthur, E. Durant; Bedunah, Don; Wambolt, Carl L., compilers. Proceedings--symposium on ecology and management of riparian shrub communities; 1991 May 29-31; Sun Valley, ID. Gen. Tech. Rep. INT-289. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 198-202. [19121]

12. Blank, Robert R.; Young, James A. 1998. Heated substrate and smoke: influence on seed emergence and plant growth. Journal of Range Management. 51(5): 577-583. [29756]

13. Boccard, Bruce. 1980. Important fish and wildlife habitats of Idaho. An inventory. Boise, ID: U.S. Department of the Interior, Fish and Wildlife Service, Oregon- Idaho Area Office. 161 p. [18109]

14. Bodurtha, Timothy S.; Peek, James P.; Lauer, Jerry L. 1989. Mule deer habitat use related to succession in a bunchgrass community. Journal of Wildlife Management. 53(2): 314-319. [6677]

15. Borman, M. M.; Krueger, W. C.; Johnson, D. E. 1991. Effects of established perennial grasses on yields of associated annual weeds. Journal of Range Management. 44(4): 318-322. [16119]

16. Bovey, Rodney W.; LeTourneau, Duane; Erickson, Lambert C. 1960. The chemical composition of medusahead and downy brome. Weeds. 9: 307-311. [493]

17. Britton, Carlton M.; Wright, Henry A. 1983. Brush management with fire. In: McDaniel, Kirk C., ed. Proceedings--brush management symposium; 1983 February 16; Albuquerque, NM. Denver, CO: Society for Range Management: 61-68. [521]

18. Brock, John H. 1998. Ecological characteristics of invasive alien plants. In: Tellman, Barbara; Finch, Deborah M.; Edminster, Carl; Hamre, Robert, eds. The future of arid grasslands: identifying issues, seeking solutions: Proceedings; 1996 October 9-13; Tucson, AZ. Proceedings RMRS-P-3. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 137-143. [29293]

19. Brown, James K. 1970. Ratios of surface area to volume for common fine fuels. Forest Science. 16(1): 101-105. [13270]

20. Brown, James K.; Smith, Jane Kapler, eds. 2000. Wildland fire in ecosystems: Effects of fire on flora. Gen. Tech Rep. RMRS-GRT-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 257 p. [36581]

21. Burkhardt, Wayne J.; Tisdale, E. W. 1976. Causes of juniper invasion in southwestern Idaho. Ecology. 57: 472-484. [565]

22. Christensen, M. Dale; Young, James A.; Evans, Raymond A. 1974. Control of annual grasses and revegetation in ponderosa pine woodlands. Journal of Range Management. 27(2): 143-145. [2712]

23. Clements, Charlie D.; Young, James A. 1997. A viewpoint: rangeland health and mule deer habitat. Journal of Range Management. 50(2): 129-138. [28429]

24. Connor, J. Michael; Willoughby, Bob L. 1997. Effects of blue oak canopy on annual forage production. In: Pillsbury, Norman H.; Verner, Jared; Tietje, William D., technical coordinators. Proceedings of a symposium on oak woodlands: ecology, management, and urban interface issues; 1996 March 19-22; San Luis Obispo, CA. Gen. Tech. Rep. PSW-GTR-160. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 321-326. [29025]

25. Cornelius, Donald R.; Talbot, M. W. 1955. Rangeland improvement through seeding and weed control on east slope Sierra Nevada and on southern Cascade Mountains. Agric. Handb. 88. Washington, DC: U.S. Department of Agriculture, Forest Service. 51 p. [7510]

26. Cronquist, Arthur; Holmgren, Arthur H.; Holmgren, Noel H.; [and others]. 1977. Intermountain flora: Vascular plants of the Intermountain West, U.S.A. Vol. 6. The Monocotyledons. New York: Columbia University Press. 584 p. [719]

27. D'Antonio, Carla M.; Vitousek, Peter M. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual Review of Ecological Systems. 23: 63-87. [20148]

28. Dahl, B. E.; Tisdale, E. W. 1975. Environmental factors related to medusahead distribution. Journal of Range Management. 28(6): 463-468. [728]

29. Dakheel, A. J.; Radosevich, S. R.; Barbour, M. G. 1994. Effects of temperature and moisture on growth, interference and photosynthesis of Bromus tectorum and Taeniatherum asperum. Weed Research. 34: 11-22. [23147]

30. Daubenmire, R. 1968. Ecology of fire in grasslands. In: Cragg, J. B., ed. Advances in ecological research. Vol. 5. New York: Academic Press: 209-266. [739]

31. Devine, Robert. 1993. The cheatgrass problem. Atlantic. 271(5): 40-48. [21022]

32. Doescher, P. S.; Miller, R. F.; Swanson, S. R.; Winward, A. H. 1986. Identification of the Artemisia tridentata ssp. wyomingensis/Festuca idahoensis habitat type in eastern Oregon. Northwest Science. 60(1): 55-60. [815]

33. Evans, Gary Richard. 1967. Ecology of Aristida longiseta in northcentral Idaho. Moscow, ID: University of Idaho. 69 p. Thesis. [3824]

34. Evans, Raymond A.; Young, James A. 1970. Plant litter and establishment of alien annual weed species in rangeland communities. Weed Science. 18(6): 697-703. [877]

35. Evans, Raymond A.; Young, James A. 1972. Microsite requirements for establishment of annual rangeland weeds. Weed Science. 20(4): 350-356. [878]

36. Evans, Raymond A.; Young, James A. 1987. Control, plant succession, and revegetation in western juniper woodlands. In: Everett, Richard L., compiler. Proceedings--pinyon-juniper conference; 1986 January 13-16; Reno, NV. Gen. Tech. Rep. INT-215. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research

Station: 301-304. [29479]

37. Eyre, F. H., ed. 1980. Forest cover types of the United States and Canada. Washington, DC: Society of American Foresters. 148 p. [905]

38. Ferry, Gardner W.; Clark, Robert G.; Montogmery, Roy E.; [and others]. 1995. Altered fire regimes within fire-adapted ecosystems. In: LaRoe, Edward T.; Farris, Gaye S.; Puckett, Catherine E.; [and others], eds. Our living resources: A report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. Washington, DC: U.S. Department of the Interior, National Biological Service: 222-224. [27123]

39. Fosberg, M. A. 1965. Relationship of cheatgrass and medusahead to soils in the Columbia River Basin. In: Symposium on management of cheatgrass on rangelands: Proceedings; 1965 July 27-30; [Location unknown]. [Place of publication unknown]: [Publisher unknown]: 30-32. On file with: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Fire Sciences Laboratory, Missoula, MT. [3700]

40. Frederiksen, Signe. 1986. Revision of Taeniatherum (Poaceae). Nordic Journal of Botany. 6: 389-397. [965]

41. Frederiksen, Signe; Von Bothmer, Roland. 1986. Relationships in Taeniatherum (Poaceae). Canadian Journal of Botany. 64(10): 2343-2347. [966]

42. Furbush, Paul. 1953. Control of medusa-head on California ranges. Journal of Forestry. 51: 118-121. [983]

43. Garrison, George A.; Bjugstad, Ardell J.; Duncan, Don A.; Lewis, Mont E.; Smith, Dixie R. 1977. Vegetation and environmental features of forest and range ecosystems. Agric. Handb. 475. Washington, DC: U.S. Department of Agriculture, Forest Service. 68 p. [998]

44. Goebel, Carl J.; Taze, Mohammed; Harris, Grant A. 1988. Secar bluebunch wheatgrass as a competitor to medusahead. Journal of Range Management. 41(1): 88-89. [2966]

45. Gould, Frank W. 1947. Nomenclatorial changes in Elymus with a key to the Californian species. Madrono. 9: 120-128. [29606]

46. Grey, William E.; Quimby, Paul C., Jr.; Mathre, Donald E.; Young, James A. 1995. Potential for biological control of downy brome (Bromus tectorum) and medusahead (Taeniatherum caput-madusae) with crown and root rot fungi. Weed Technology. 9(2): 362-365. [35196]

47. Hansen, Paul L.; Hoffman, George R. 1988. The vegetation of the Grand River/Cedar River, Sioux, and Ashland Districts of the Custer National Forest: a habitat type classification. Gen. Tech. Rep. RM-157. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 68 p. [771]

48. Harper, K. T.; Sanderson, S. C.; McArthur, E. D. 1992. Riparian ecology in Zion National Park, Utah. In: Clary, Warren P.; McArthur, E. Durant; Bedunah, Don; Wambolt, Carl L., compilers. Proceedings--symposium on ecology and management of riparian shrub communities; 1991 May 29-31; Sun Valley, ID. Gen. Tech. Rep. INT-289. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 32-42. [19092]

49. Harris, Grant A. 1977. Root phenology as a factor of competition among grass seedlings. Journal of Range Management. 30(3): 172-177. [1094]

50. Harris, Grant A. 1990. Cheatgrass: invasion potential and managerial implications. In: Roche, Ben F.; Roche, Cindy Talbott, eds. Range weeds revisited: Proceedings of a symposium: a 1989 Pacific Northwest range management short

course; 1989 January 24-26; Spokane, WA. Pullman, WA: Washington State University, Department of Natural Resource Sciences, Cooperative Extension: 5-9. [14826]

51. Harris, Grant A.; Goebel, Carl J. 1976. Factors of plant competition in seeding Pacific Northwest bunchgrass ranges. Bulletin 820. Pullman, WA: Washington State University, College of Agriculture Research Center. 27 p. [1096]

52. Heady, Harold F. 1973. Burning and the grasslands in California. In: Komarek, Edwin V., Sr., technical coordinator. Proceedings, annual Tall timbers fire ecology conference; 1972 June 8-9; Lubbock, TX. Number 12. Tallahassee, FL: Tall Timbers Research Station: 97-107. [8463]

53. Hickman, James C., ed. 1993. The Jepson manual: Higher plants of California. Berkeley, CA: University of California Press. 1400 p. [21992]

54. Hironaka, M. 1994. Medusahead: natural successor to the cheatgrass type in the northern Great Basin. In: Monsen, Stephen B.; Kitchen, Stanley G., compilers. Proceedings--ecology and management of annual rangelands; 1992 May 18-22; Boise, ID. Gen. Tech. Rep. INT-GTR-313. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 89-91. [24259]

55. Hironaka, M. Tisdale, E. W.; Sharp, L. A. 1956. A study of the medusa-head problem in Idaho. Research Progress Report. Western Weed Control Conference: 19-20. On file with: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Fire Sciences Lab, Missoula, MT. [1163]

56. Hironaka, M.; Sindelar, Brian W. 1975. Growth characteristics of squirreltail seedlings in competition with medusahead. Journal of Range Management. 28(4): 283-285. [1159]

57. Hironaka, Minoru. 1961. The relative rate of root development of cheatgrass and medusahead. Journal of Range Management. 14: 263-267. [1153]

58. Hitchcock, A. S. 1951. Manual of the grasses of the United States. Misc. Publ. No. 200. Washington, DC: U.S. Department of Agriculture, Agricultural Research Administration. 1051 p. [2nd edition revised by Agnes Chase in two volumes. New York: Dover Publications, Inc.]. [1165]

59. Hitchcock, C. Leo; Cronquist, Arthur. 1973. Flora of the Pacific Northwest. Seattle, WA: University of Washington Press. 730 p. [1168]

60. Hitchcock, C. Leo; Cronquist, Arthur; Ownbey, Marion. 1969. Vascular plants of the Pacific Northwest. Part 1: Vascular cryptogams, gymnosperms, and monocotyledons. Seattle, WA: University of Washington Press. 914 p. [1169]

61. Horman, Chad S.; Anderson, Val Jo. 1999. Utah juniper herbaceous understory distribution patterns in response to tree canopy and litter removal. In: Monsen, Stephen B.; Stevens, Richard, compilers. Proceedings: ecology and management of pinyon-juniper communities within the Interior West: Sustaining and restoring a diverse ecosystem; 1997 September 15-18; Provo, UT. Proceedings RMRS-P-9. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 105-112. [30543]

62. Hulbert, Lloyd C. 1955. Ecological studies of Bromus tectorum and other annual bromegrasses. Ecological Monographs. 25(2): 181-213. [1205]

63. Jones, T. A. 1998. Viewpoint: The present status and future prospects of squirreltail research. Journal of Range Management. 51(3): 326-331. [30429]

64. Kaltenecker, Julie; Wicklow-Howard, Marcia. 1994. Microbiotic soil crusts in sagebrush habitats of southern Idaho. Walla Walla, WA: Interior Columbia Basin Ecosystem Management Project. Unpublished report prepared for the Eastside Ecosystem Management Project on file with: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT. 48 p. [26455]

65. Kartesz, John T. 1994. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. Volume I--checklist. 2nd ed. Portland, OR: Timber Press. 622 p. [23877]

66. Kartesz, John T.; Meacham, Christopher A. 1999. Synthesis of the North American flora (Windows Version 1.0), [CD-ROM]. Available: North Carolina Botanical Garden. In cooperation with the Nature Conservancy, Natural Resources Conservation Service, and U.S. Fish and Wildlife Service [2001, January 16]. [36715]

67. Kay, Burgess L. 1963. Effects of dalapon on a medusahead community. Weeds. 11: 297-209. [1312]

68. Keller, Wesley. 1979. Species and methods for seeding in the sagebrush ecosystem. In: The sagebrush ecosystem: a symposium: Proceedings; 1978 April; Logan, UT. Logan, UT: Utah State University, College of Natural Resources; 1979: 129-163. [1322]

69. Knapp, Paul A. 1998. Spatio-temporal patterns of large grassland fires in the Intermountain West, U.S.A. Global Ecology and Biogeography Letters. 7(4): 259-273. [30109]

70. Kuchler, A. W. 1964. United States [Potential natural vegetation of the conterminous United States]. Special Publication No. 36. New York: American Geographical Society. 1:3,168,000; colored. [3455]

71. Langstroth, Robert Peter. 1991. Fire and grazing ecology of Stipa pulchra grassland: a field study at Jepson Prairie, California. Davis, CA: University of California. 75 p. Thesis. [27349]

72. Leege, Thomas A. 1968. Prescribed burning for elk in northern Idaho. In: Proceedings, annual Tall Timbers fire ecology conference; 1968 March 14-15; Tallahassee, FL. No 8. Tallahassee, FL: Tall Timbers Research Station: 235-253. [5287]

73. Link, S. O.; Waugh, W. J.; Downs, J. L.; [and others]. 1994. Effects of coppice dune topography and vegetation on soil water dynamics in a cold-desert ecosystem. Journal of Arid Environments. 27: 265-278. [24107]

74. Lusk, W. C.; Jones, M. B.; Torell, D. T.; McKell, C. M. 1961. Medusahead palatability. Journal of Range Management. 14: 248-251. [1490]

75. Major, J.; McKell, C. M.; Berry, L. J. 1960. Improvement of medusahead-infested rangeland. Leaflet 123. Davis, CA: University of California, California Agricultural Experiment Station. 6 p. [1511]

76. Maret, Mary P.; Wilson, Mark V. 2000. Fire and seedling population dynamics in western Oregon prairies. Journal of Vegetation Science. 11: 307-314. [37727]

77. McKell, Cyrus M.; Wilson, Alma M.; Kay, B. L. 1962. Effective burning of rangelands infested with medusahead. Weeds. 10(2): 125-131. [1617]

78. Meyer, Susan E.; Allen, Phil S. 1999. Ecological genetics of seed germination regulation in Bromus tectorum L. I. Phenotypic variance among and within populations. Oecologia. 120(1): 27-34. [43170]

79. Miller, Heather C.; Clausnitzer, David; Borman, Michael M. 1999. Medusahead. In: Sheley, Roger L.; Petroff, Janet K., eds. Biology and management of noxious rangeland weeds. Corvallis, OR: Oregon State University Press: 271-281. [35735]

80. Miller, Richard F. 1995. Pushing black juniper. Restoration & Management Notes. 13(1): 51-52. [29185]

81. Miller, Richard F.; Seufert, Jamie M.; Hauferkamp, Marshall R. 1986. The ecology and management of bluebunch wheatgrass (Agropyron spicatum): a review. Station Bulletin 669. Corvallis, OR: Oregon State University, Agriculture Experiment Station. 39 p. [6666]

82. Morrison, Peter H.; Swanson, Frederick J. 1990. Fire history and pattern in a Cascade Range landscape. Gen. Tech. Rep. PNW-GTR-254. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 77 p. [13074]

83. Murphy, Alfred H.; Turner, David. 1959. A study on the germination of Medusa-head seed. Bulletin. 48: 6-10. [1721]

84. Mutch, R. W.; Philpot, C. W. 1970. Relation of silica content to flammability in grasses. Forest Science. 16(1): 64-65. [1726]

85. Nelson, Jack R.; Wilson, A. M. 1969. Influence of age and awn removal on dormancy of medusahead seeds. Journal of Range Management. 22: 289-298. [1743]

86. Paysen, Timothy E.; Ansley, R. James; Brown, James K.; [and others]. 2000. Fire in western shrubland, woodland, and grassland ecosystems. In: Brown, James K.; Smith, Jane Kapler, eds. Wildland fire in ecosystems: Effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-volume 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 121-159. [36978]

87. Pellant, Mike; Hall, Christi. 1994. Distribution of two exotic grasses on Intermountain rangelands: status in 1992. In: Monsen, Stephen B.; Kitchen, Stanley G., compilers. Proceedings--ecology and management of annual rangelands; 1992 May 18-22; Boise, ID. Gen. Tech. Rep. INT-GTR-313. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 109-112. [24264]

88. Peters, Erin F.; Bunting, Stephen C. 1994. Fire conditions pre- and postoccurrence of annual grasses on the Snake River Plain. In: Monsen, Stephen B.; Kitchen, Stanley G., compilers. Proceedings--ecology and management of annual rangelands; 1992 May 18-22; Boise, ID. Gen. Tech. Rep. INT-GTR-313. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 31-36. [24249]

89. Ponzetti, Jeanne M. 1997. Assessment of medusahead and cheatgrass control techniques at Lawrence Memorial Grassland Preserve. 1996 Annual Report. [Place of publication unknown]: The Nature Conservancy of Oregon. 17 p. On file with: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT. [43358]

90. Raunkiaer, C. 1934. The life forms of plants and statistical plant geography. Oxford: Clarendon Press. 632 p. [2843]

91. Ripple, William J. 1994. Historic spatial patterns of old forests in western Oregon. Journal of Forestry. 92(11): 45-49. [33881]

92. Robertson, Joseph H.; Pearse, C. Kenneth. 1945. Artificial reseeding and the closed community. Northwest Science. 59(3): 58-66. [2012]

93. Robocker, W. C. 1973. Production potential of four winter annual grasses. Journal of Range Management. 26(1): 69-70. [22404]

94. Roche, Ben F., Jr.; Roche, Cindy T.; Chapman, Roger C. 1994. Impacts of grassland habitat on yellow starthistle (Centaurea solstitialis L.) invasion. Northwest Science. 68(2): 86-96. [23144]

95. Romme, William H. 1982. Fire and landscape diversity in subalpine forests of Yellowstone National Park. Ecological Monographs. 52(2): 199-221. [9696]

96. Sapsis, David B. 1990. Ecological effects of spring and fall prescribed burning on basin big sagebrush/Idaho fescue--bluebunch wheatgrass communities. Corvallis, OR: Oregon State University. 105 p. Thesis. [16579]

97. Savage, David E.; Young, James A.; Evans, Raymond A. 1969. Utilization of medusahead and downy brome caryopses by chukar partridge. Journal of Wildlife Management. 33(4): 975-978. [2067]

98. Schupp, Eugene W.; Heaton, Hoyt J.; Gomez, Jose M. 1997. Lagomorphs and the dispersal of seeds into communities dominated by exotic annual weeds. The Great Basin Naturalist. 57(3): 253-258. [28635]

99. Sharp, Lee A.; Hironaka, M.; Tisdale, E. W. 1957. Viability of medusa-head (Elymus caput-medusae L.) seed collected in Idaho. Journal of Range Management. 10: 123-126. [2118]

100. Sheley, Roger L.; Larson, Larry L.; Johnson, Douglas E. 1993. Germination and root dynamics of range weeds and forage species. Weed Technology. 7: 234-237. [24473]

101. Shiflet, Thomas N., ed. 1994. Rangeland cover types of the United States. Denver, CO: Society for Range Management. 152 p. [23362]

102. Smith, Winston Paul. 1985. Plant associations within the Interior Valleys of the Umpqua River Basin, Oregon. Journal of Range Management. 38(6): 526-530. [2179]

103. Stickney, Peter F. 1989. Seral origin of species originating in northern Rocky Mountain forests. Unpublished draft on file at: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Fire Sciences Laboratory, Missoula, MT. 10 p. [20090]

104. Swenson, Charles F.; LeTourneau, Duane; Erickson, Lambert C. 1964. Silica in medusahead. Weeds. 12: 16-18. [2301]

105. Tisdale, E. W. 1976. Vegetational responses following biological control of Hypericum perforatum in Idaho. Northwest Science. 50(2): 61-75. [11392]

106. Torell, Paul J. 1967. Dowpon--an aid to reseeding medusahead-infested rangeland. Down to Earth. 23: 6-8. [6005]

107. Torell, Paul J.; Erickson, Lambert C. 1967. Reseeding medusahead-infested ranges. Bulletin 489. Moscow, ID: University of Idaho, Agricultural Experiment Station, College of Agriculture. 17 p. [2354]

108. Torell, Paul J.; Erickson, Lambert C.; Haas, Robert H. 1961. The medusahead problem in Idaho. Weeds. 9: 124-131. [2355]

109. Turner, Robert B.; Poulton, Charles E.; Gould, Walter L. 1963. Medusahead--a threat to Oregon rangeland. Special Report 149. Corvallis, OR: Oregon State University, Agricultural Experiment Station. 22 p. [2376]

110. U.S. Department of Agriculture, Agricultural Research Service. 2001. Invaders Database System, [Online]. Available: http://invader.dbs.umt.edu/ [2001, October 22]. [38172]

111. U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine Program (PPQ). 1999. California summaries of exterior quarantines: Noxious weed list. In: National Plant Board, Federal and state plant quarantine summaries, [Online]. Available: http://www.aphis.usda.gov/npb/F&SQS/casq.html [2000, October 17]. [36884]

112. U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine Program (PPQ). 1999. Oregon summaries of exterior quarantines: Noxious weeds. In: National Plant Board, Federal and state plant quarantine summaries, [Online]. Available: http://www.aphis.usda.gov/npb/F&SQS/orsq.html [2000, October 17]. [36883]

113. U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine Program (PPQ). 2000. Utah summaries of exterior quarantines: Noxious weed list. In: National Plant Board, Federal and state plant quarantine summaries, [Online]. Available: http://www.aphis.usda.gov/npb/F&SQS/utsq.html [2000, October 18]. [36888]

114. U.S. Department of Agriculture, Soil Conservation Service. 1994. Plants of the U.S.--alphabetical listing. Washington, DC: U.S. Department of Agriculture, Soil Conservation Service. 954 p. [23104]

115. Vincent, Dwain W. 1992. The sagebrush/grasslands of the upper Rio Puerco area, New Mexico. Rangelands. 14 (5): 268-271. [19698]

116. Young, James A. 1992. Ecology and management of medusahead (Taeniatherum caput-medusae ssp. asperum [Simk.] Melderis). The Great Basin Naturalist. 52(3): 245-252. [20095]

117. Young, James A.; Clements, Charlie D.; Nader, Glenn. 1999. Medusahead and clay: the rarity of perennial seedling establishment. Rangelands. 21(6): 19-20. [33087]

118. Young, James A.; Evans, Raymond A. 1970. Invasion of medusahead into the Great Basin. Weed Science. 18(1): 89-97. [2647]

119. Young, James A.; Evans, Raymond A. 1971. Medusahead invasion as influenced by herbicides and grazing on low sagebrush sites. Journal of Range Management. 24(6): 451-454. [2648]

120. Young, James A.; Evans, Raymond A. 1975. Germinability of seed reserves in a big sagebrush community. Weed Science. 23(5): 358-364. [2654]

121. Young, James A.; Evans, Raymond A. 1978. Population dynamics after wildfires in sagebrush grasslands. Journal of Range Management. 31(4): 283-289. [2657]

122. Young, James A.; Evans, Raymond A. 1981. Demography and fire history of a western juniper stand. Journal of Range Management. 34(6): 501-505. [2659]

123. Young, James A.; Evans, Raymond A.; Eckert, Richard E., Jr. 1969. Wheatgrass establishment with tillage and

herbicides in a mesic medusahead community. Journal of Range Management. 22: 151-155. [2666]

124. Young, James A.; Evans, Raymond A.; Major, Jack. 1977. Sagebrush steppe. In: Barbour, Michael G.; Major, Jack, eds. Terrestrial vegetation of California. New York: John Wiley & Sons: 763-796. [4300]

125. Young, Jim. 2000. Bromus tectorum L. In: Bossard, Carla C.; Randall, John M.; Hoshovsky, Marc C., eds. Invasive plants of California's wildlands. Berkeley, CA: University of California Press: 76-80. [41490]

FEIS Home Page